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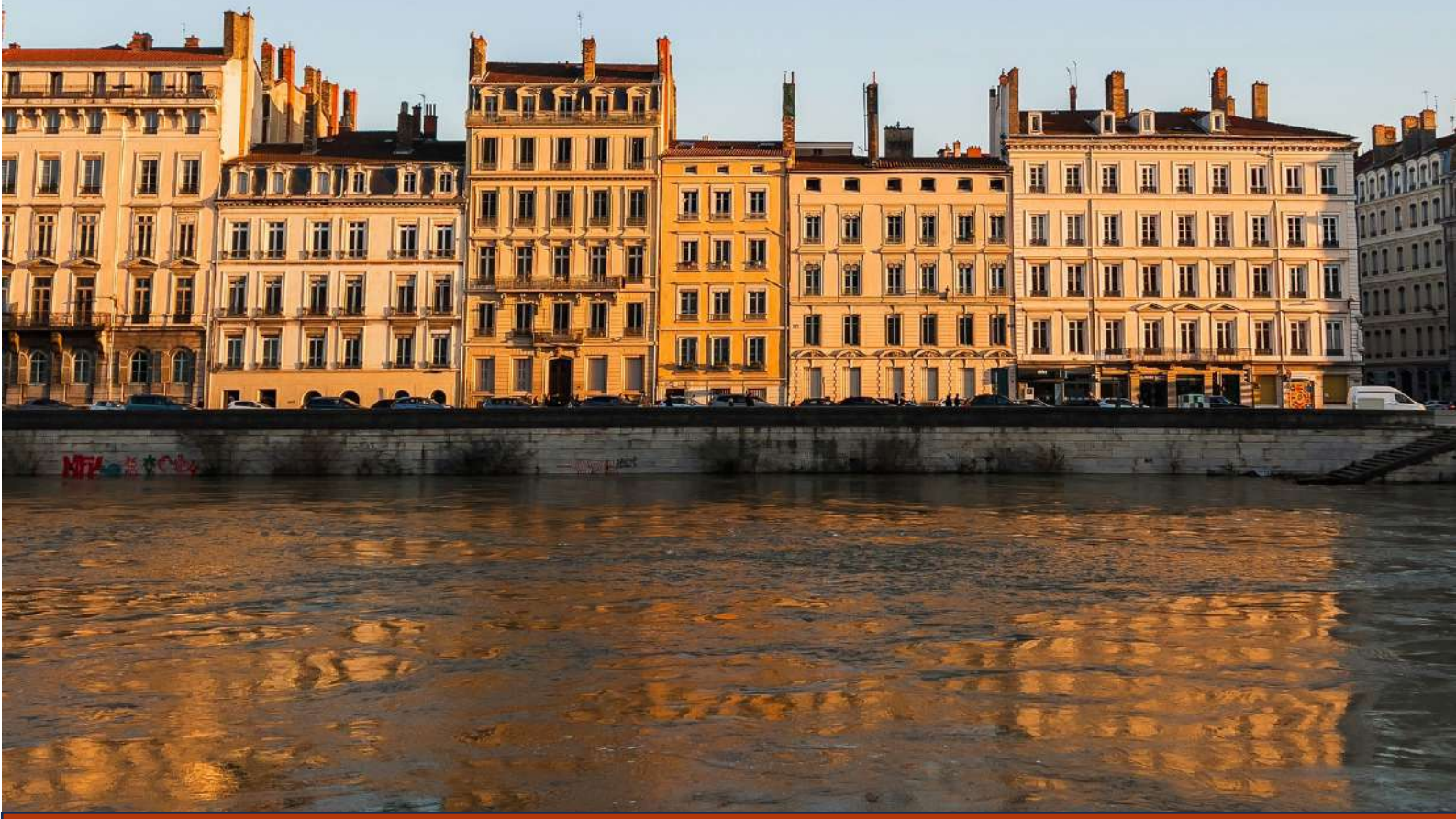

BOOK OF ABSTRACTS

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Structure of mixed valence copper sodium borate biocidal glasses from combined neutron and X-ray diffraction

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Mixed-modifier copper-sodium-borate glasses are used in wood preservatives, exploiting the synergistic biocidal effects of boron and copper, along with favourable intermediate-timescale dissolution rates and long-term retention in the wood. On a fundamental level, the structural behaviour of copper in glasses, especially Cu(I), requires further investigation, as does the effect of copper on the boron coordination and speciation in borate glasses and in aqueous environments. In the present study several glass series were synthesized, nominally xCuO·(20 – x)Na2O·80B2O3 ($0 \leq x \leq 10$), yCuO·(40 – y)Na2O·60B2O3 ($0 \leq y \leq 40$), and zCuO·(100 – z)B2O3 (z = 3, 6, 40, 50). X-ray photoelectron spectroscopy revealed the presence of both Cu(I) and Cu(II) in appreciable amounts in all glasses, with Cu(I) ranging from 15% to 60% of total Cu. Elemental analysis revealed volatile losses of Cu and Na. Whilst most glasses were not significantly contaminated by the seasoned stainless steel crucibles used for glass making, the two copper-rich borates (z = 40, 50) were found to contain iron (up to 6 mol% Fe2O3). Pulsed neutron and high-energy x-ray total scattering diffraction measurements were used as complementary structural probes, neutrons being more sensitive to boron, and x-rays to copper. The neutron diffraction combined with bond-valence methodology enables quantification of the tetrahedral boron fractions ($N4$), which are challenging or impossible to obtain by typical 11B nuclear magnetic resonance methods due to paramagnetic Cu(II) (and Fe(III)). A clear trend for decreasing $N4$ as Cu replaces Na was observed. This observation aligns with expectations based on Raman spectroscopy, as well as sparse available data on Cu(II) borate glasses, and their Mg and Zn analogues. On the other hand, Cu(I) is an analogue of Li in terms of ionic radius and charge, which may have suppressed the effect on $N4$ compared to the hypothetical 100% Cu(II) case. The majority of Cu-O bonds are centred around 1.96(1)Å, but x-ray diffraction reveals additional, longer, Cu-O bonds around 2.14Å, leading to total Cu-O coordination numbers $>$ 4. Further analysis of the Cu environments and their relationship with dissolution studies is ongoing at time of writing.

Keywords: Borate, copper, sodium, neutron, x, ray, diffraction

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Structure and Viscosity of Sulfur-Bearing Silicate Glasses: Influence of Sulfur Speciation and Composition

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Understanding sulfur incorporation in silicate glasses is crucial for optimizing their structural and physical properties in various industrial and environmental applications. Sulfur can exist under different oxidation states, influencing solubility, redox behavior, and network connectivity depending on glass composition. This study examines in detail the effect of sulfur speciation through the incorporation of sources with different oxidation states on the solubility, structure, and rheological properties of glasses. The effect of composition was also assessed by systematically varying the composition, from a multicomponent synthetic glass to a simplified ternary system, in order to also observe the impact of network formers and modifiers on sulfur incorporation and stability. Structural analyses by Raman spectroscopy, coupled with viscosity measurements, reveal distinct mechanisms of interaction between sulfur and the silicate network depending on its chemical form and the nature of the glass matrix. These results demonstrate that sulfur speciation plays a crucial role in network connectivity, melt reactivity, and consequently, the final properties of the glass, thus providing new insights into controlling the behavior of sulfur in silicate systems.

Keywords: Silicate glass, Sulfur solubility, Structure, Viscosity

*Speaker

Probing Densification Mechanisms in Indented Silica Using Brillouin Spectroscopy

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The objective of this work is to investigate and better understand the densification mechanisms occurring in silica glass at the micrometer scale under micro-indentation. When subjected to such localized mechanical loading, silica glass exhibits a remarkably high density increase - up to about 21% - in sharp contrast with conventional oxide glasses, such as float glass, which show only minor densification (1).
Using high-resolution Brillouin light scattering, we obtained detailed maps of the local elastic properties within and around the indentation imprints. The measured variations in sound velocity directly reflect local changes in density. Our results show that densification in silica evolves gradually in the lateral direction, similar to glasses with a high Poisson's ratio. Along the central axis beneath the indenter, however, the profile differs: a highly densified zone lies just below the contact area, followed by a sharp transition to an undensified, purely elastic region.

While Raman spectroscopy provides valuable structural information, its spatial contrast is insufficient to clearly distinguish the densified zone from the undensified region. In contrast, Brillouin spectroscopy offers the sensitivity and spatial resolution required to characterize these subtle mechanical and structural gradients. The results are consistent with recent chemical etching observations (2), which investigate densification within the indentation imprint by measuring local dissolution rates.Together, these complementary approaches contribute to a more complete picture of the structural and mechanical response of silica under localized loading.

Overall, this work refines the description of the indentation imprint in silica, improves our understanding of its densification behavior, and highlights the capability of Brillouin spectroscopy for probing local mechanical responses at the microscale.

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(2) Guin, J.-P et al (2024). *Chemical etching of indented silica: new insights on densification beneath indentation imprints.* **Ceramics International**, 274, 120005. **Keywords:** Silicate glasses,

Glasses mechanic, Vibrational spectroscopies

Probing the Structure of Titanium-Bearing Sodium Phosphate Glasses: Insights into the Short- and Intermediate-Range Order

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Titanium in phosphate bioglasses is acknowledged for enhancing bioactivity and mechanical strength, thereby offering new prospects for biomedical applications. In this context, a detailed structural examination of benchmark titanium-bearing phosphate glasses in the low titanium concentration range can provide valuable insights into the structure-property relationship, while remaining nearly within biocompatible limits. Glass samples were prepared by melt-quenching within the sodium metaphosphate compositional series, incorporating up to 10 mol% TiO2. By combining a suite of standard and advanced multinuclear solid-state NMR experiments (1), the short- and intermediate-range order of these glasses was characterized. As the titanium content increases, P2 structural units progressively incorporate titanium, indicating the gradual formation of P–O–Ti linkages within the network. In contrast, the environment surrounding the 23Na nuclei is not significantly affected within the compositional range investigated. The resulting glass properties are critically examined within this structural framework.
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Reference

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Keywords: Titanium, Sodium Phosphate Glasses, Solid, State NMR, Glass Structure.

Impact of boron on high temperature multicomponent diffusion in alumino-soda-lime silicates.

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Chemical diffusion in amorphous silicates is a process of paramount interest in many fields, including geosciences, nuclear applications, and industrial glass melting. Indeed, chemical diffusion plays an important role at all stages of glass melting and transformation. The particularity of these systems lies in their complex compositions, which contain several network-forming and network-modifying elements, as well as their high degree of polymerization at high temperatures. This complexity implies strong interactions between these elements.
An approach initially developed in geosciences, describing diffusion in glass through the eigenvectors and eigenvalues of the full diffusion matrix, is increasingly being investigated for various industrial glass systems (1–4). The advantage of this approach is its ability to provide a general view of the multicomponent diffusion process within the explored domain using a limited number of experiments. This macroscopic method interprets diffusion as exchange reactions that represent the lowest-energy pathways for material transport, with the rate of exchange quantified by the eigenvalues.

In this study, we aim to investigate the impact of boron on these pathways in the NCAS system and highlight the influence of the presence of several network formers on these exchanges. We correlate these pathways with local structural modifications obtained from spatially resolved Raman measurements.

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(3) Claireaux C. et al (2018), Geochimica et Cosmochimica Acta,
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Keywords: multicomponent diffusion, matrix, exchange reactions, structure

Impact of Fluorine on Silicate Glass Structure and Diffusivity

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The incorporation of fluorine plays a crucial role in determining the behavior of silicate melts across geologic, industrial, and nuclear waste vitrification systems. In addition, there are several outstanding scientific questions regarding the interconnected structural role and diffusivity of fluorine. The speciation and diffusion of fluorine is underexplored across many glass systems and is also important for transport and crystallization processes. It should be noted that fluorine is of recently renewed focus in Hanford Site vitrification efforts due to new regulation changes regarding the lack of pre-treatment. Fluorine addition to three classes of glasses will be discussed: soda-lime silicate glasses, sodium aluminosilicate glasses, and more complex aluminoborosilicate nuclear waste glasses. The impact of F on glass structure will be explored through F K edge X-ray Absorption Spectroscopy (XAS), 19F Magic Angle Spinning Nuclear Magnetic Resonance (MAS-NMR), Raman Spectroscopy, and other nuclei MAS-NMR. The importance of Al-F moieties as well as the presence of controversial moieties such as Si-F will also be discussed. The drastic impact of F on diffusivity will be discussed in the context of viscosity measurements, glass transition temperature changes, and crystallization behavior, as well as in relation to the glass structure. The tendency for immiscibility in high fluorine silicate melts will additionally be covered. Finally, the potential to explore diffusivity through temperature-dependent conductivity and NMR measurements will be mentioned.

Keywords: fluorine, volatiles, viscosity, diffusivity, structure, NMR, XANES

*Speaker

Speciation of Uranium in Simple Oxide Glasses

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Vitrification is a critical technology for long-term immobilization of nuclear waste. While most U from used nuclear fuel is not planned for immobilization in glass, there are certain situations where U and/or Th-rich waste streams may be vitrified. One example is the more than 54 million gallons of nuclear waste at the Hanford Site in the USA, where some actinides remain in certain tanks. When planning for vitrification efforts, understanding the structural impact of different waste constituents is essential for efficient and successful deployment. In addition, U exhibits unique, varied, and under-investigated glass chemistry, through the ready formation for 3 oxidation states as well as the uranyl ion. Finally, the behavior of U in geologic melts and historical glasses is of interest. This talk discusses uranium speciation (oxidation state, uranyl moiety, next nearest neighbors) across a range of binary alkali-former oxide glasses (former = Si, B, P, Te, Ge, Ti, Mo, W) as well as A_2O-BO-SiO_2 glasses with a range of 1+ (A) and 2+ (B) cations. The U speciation is investigated through x-ray absorption spectroscopy (both XANES and EXAFS), the uranyl ν_1 symmetric stretch (Raman), photoluminescence spectroscopy, and UV-Vis spectroscopy. Rich colors are produced ranging from brown to red to orange to yellow to green. A variety of U confirmations are observed and discussed through the lens of glass chemistry. Specifically, U forms across U^{4+} to U^{6+} for melts in air, with a variety of coordination environments. Uranyl (UO_2^{2+}) is a common moiety with variations in equatorial oxygens. The results are contextualized based on overall glass basicity, network polymerization, and the identity of counter cations. The impact of U on glass structure is also probed through Raman spectroscopy, differential scanning calorimetry, and molar volume. Finally, Uranium speciation is compared with Thorium (which is exclusively Th^{4+}). These findings not only advance the fundamental understanding of U and Th incorporation into non-crystalline matrices but also provide guidance for future vitrification endeavors.

Keywords: Uranium, glass structure, X-ray absorption spectroscopy, luminescence spectroscopy, basicity, oxidation

*Speaker

Designing structural disorder in oxide glasses from NMR-driven reverse monte carlo

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Solid-state NMR is now an essential spectroscopy technique for studying oxide glasses, as it offers a wide range of techniques for studying both their structure and dynamics at the atomic scale. However, the information obtained is limited to short-range order (elementary structural motifs constituting the glass network) and medium-range order (connectivity or proximity between these motifs). However, it does not allow three-dimensional structural models to be constructed on its own. To this end, molecular dynamics (MD) is therefore essential for generating three-dimensional the atomic structure of glasses at a larger length scale. Thanks to DFT-NMR calculations, structural models developed by MD can now be directly connected to NMR spectra, (1) which can greatly facilitate the interpretation of experimental data. However, topology of such models are inherently limited by the accuracy of MD force-fields and/or the accessible time-scale to MD.
Reverse Monte Carlo (2) modeling provides an efficient approach to overcome these limitations because it can generate structural models (by random atomic displacements) that reproduce the available experimental data (generally neutron and X-ray structure factors). We will show how NMR information characterizing short- and medium-range order can be integrated into these simulations to produce glassy structures that cannot be produced by molecular dynamics. In the current context of increasingly frequent use of machine learning, these simulations also offer the possibility of producing structures with predefined patterns to effectively libraries of NMR spectral signatures. This is crucial for the development of databases offering a sufficient structural diversity for the development of transferable ML force fields for example. We will illustrate these advances in the development of NMR-driven structural modelling for different oxide glasses, and its combination with equivariant Machine Learning for the prediction of NMR interactions. (3)

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(3) Z. Chaker, M. Salanne, J.-M. Delaye, T. Charpentier Phys Chem Chem Phys. 21, 21709-21725 (2019) ; T. Charpentier, Faraday Discuss., 255, 370-390 (2025)

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Keywords: NMR, Reverse Monte Carlo, Molecular Dynamics, DFT, GIPAW, Machine Learning

Structure-property relationships of transition elements in glasses

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Transition elements exert an important influence on most physical and chemical properties of oxide glasses and melts, in which they possess peculiar structural characteristics, such as unusual coordination states or heterogeneous spatial distribution. Their importance covers technological as well as geochemical applications. The former can be illustrated by the use of transition elements as glass coloring agents, an attractive property of glassy materials since centuries, but also by their influence on glass durability, crystalline nucleation or magnetic properties. The latter encompass the unique information provided by transition elements on natural glasses, including the redox state of natural magmas or the influence of temperature on the structure of volcanic glasses. Emphasis will be put on the local structure and chemical bonding in glasses using the structural information obtained by various spectroscopic methods, among which synchrotron radiation-based techniques play a central role. Spectroscopic properties of transition elements provide a unique harvest of structural information of great scientific and technological significance, spanning various organization scales: at short range scale, mixed valence and mixed ligand organization or unusual coordination numbers such as five-coordination; at medium range scale, distribution of site geometry, clustering or heterogeneous spatial distribution ... Some structural properties revealed by spectroscopic approaches are inherited from the peculiar dynamics of silicate melts, including frozen-in exotic coordination numbers, mixed ligand configuration, thermal expansion of coordination sites or temperature-induced modifications of cationic sites. At medium range scale, transition elements may be linked to specific structural subsets, forming cation clusters such as in volcanic glasses, in which they constitute mixed valence nanolites and magnetic domains.

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In search of an iron-manganese link: a multispectroscopic study of the color of silicate glasses.

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In many cases, the color of glass, whether heritage or industrial, find its origin in the presence of transition metal ions within the glass matrix. Amongst them, iron, which is always present as an impurity and gives a greenish color, and manganese, which generally gives a purple color, are of utmost importance. During the cooling of the glass, these elements react each other according to the simplified equation:
Fe2+ + Mn3+ Fe3+ + Mn2+

Manganese has been widely used to decolorize iron coloured glass and is known as glassmaker's soap. This Fe/Mn interaction is therefore long-standingly studied, but several parameters remain poorly understood, notably the role of melting temperature and the vincinity between iron and manganese ions in the molten state, which affects redox properties.
By performing measurements in the glassy state using several spectroscopic techniques (temperature-dependent UV-Visible absorption spectroscopy, EPR, optical fluorescence), we revealed the presence of an Fe-O-Mn bond which persists at room temperature and which could affect the colouration of heritage glass and the redox property of this glass.

Keywords: redox, manganese, iron, charge transfer, spectroscopy

*Speaker

Structure–Property Relationships in Ag2O-Doped Zinc Aluminophosphate Glasses: Impact of Alkaline Earth Ions on Silver Reduction

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Ag2O-doped (x)RO–(54–x)ZnO–5Al2O3–40P2O5 (x = 5 or 10 mol%; R = Mg2+, Ca2+, Sr2+, or Ba2+) glasses were synthesized to investigate how alkaline earth modifier chemistry influences the silver redox reaction, nanoclustering, and glass network formation. UV–visible spectra revealed a pronounced decrease in transmittance near 415 nm, attributed to the surface plasmon resonance (SPR) of metallic Ag. The SPR intensity increased from Mg → Ca → Sr → Ba, consistent with progressive Ag+ → Ag0 reduction as modifier field strength decreased. X-ray photoelectron spectroscopy revealed a greater contribution of metallic Ag (Ag0) in Ba-rich compositions. High-resolution transmission electron microscopy of the Ba-doped glass confirmed the presence of Ag0 nanocrystallites (_˜2–10 nm) with lattice spacings of 0.23 and 0.20 nm, indexed to fcc-Ag (111) and (200), respectively. To rationalize these observations, optical basicity and oxygen polarizability calculations, together with Fourier transform infrared and Raman spectra, indicated greater reduction and depolymerization with heavier alkaline earth ions. These findings suggest that introducing lower-field-strength cations increases network ionicity and non-bridging oxygen concentration. Consistently, 31P and 27Al magic-angle spinning NMR showed a higher fraction of non-bridging oxygen in Ba2+-doped samples, while Zn and Al shifted toward higher coordination, reducing charge-compensation sites. Overall, lower-field-strength modifiers with higher basicity promote non-bridging oxygen formation, silver reduction, and nanocluster growth, whereas Mg2+ suppresses these processes and maintains optical transparency.

Keywords: Silver redox behavior, Glass structure, Alkaline earth oxide, Phosphate glass

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Molecular Dynamics Simulations of the Environment of Alkali Ions in Mixed Lithium-Sodium Silicates

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The mixed alkali effect, in which there is a non-linear change in the physical properties of, say, an alkali silicate glass when one alkali metal is replaced with another, is well known, having been widely observed experimentally.
Although there have been a number of attempts to provide a theoretical explanation, none has received universal acceptance. In large part, this is probably because the understanding of the structure of glasses at the time was limited to the ideas of e.g. Zacharaiasen, and Warren.

However, the last thirty years or so have seen significant advances in our understanding of the atomic structure of glasses, made possible by developments in, inter alia, x-ray and neutron scattering, solid state NMR and atomistic computer simulations.

We have used molecular dynamics to investigate the structure of several series of mixed lithium and sodium silicates, with the object of elucidating the detailed atomic scale environment of the alkali ions as a function of both Li/Na ratio and silica content. Di-, tri-, and tetra-silicates have been modelled, with the following Li/Na ratios: 100% Li, 95Li05Na, 75Li25Na, 50Li50Na, 25Li75Na, 05Li95Na and 100% Na.

In this presentation, we will focus on mixed (Li,Na) disilicates for which our simulations reproduce the mixed alkali effect. We will discuss the changes in structure as a function of Li/Na ratio with particular emphasis on the immediate local environments of the alkali ions.

Keywords: molecular dynamics, mixed alkali effect, alkali disilicates

*Speaker

Investigation of Mg substitution effects on International Simple Glasses structure and properties

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The International Simple Glass 1 or 2 (ISG-1 or 2)[1] is a standardized composition based on ISG glass, primarily used in research on nuclear waste management[2–4]. In this study, we aim to understand the fundamental relationship between the structure of ISG-type glasses and their physicochemical properties, such as thermal stability, density and more especially chemical durability. Our ISG-type glasses are composed of SiO_2, Al_2O_3, B_2O_3, Na_2O, ZrO_2, La_2O, CaO and MgO. Thus, we substituted Ca by Mg to obtain several ISG type glasses with increasing Mg/Ca ratios[5,6]. The atomic arrangement and the B(III)/B(IV) ratio of the glasses were first determined by performing NMR analyses. This was followed by a Raman analysis to confirm NMR results and obtain more information on the polymerization of the network and percentage of NBO in the glasses. After characterizing the glasses structure, we then measured T_g, viscosity and density to correlate the structural changes observed by Raman and NMR with properties modification. Finally, we measured their initial dissolution rate (r_0) to observe the effect of the Ca by Mg substitution on the chemical durability of ISG-type glasses. This presentation will summarize the results obtained on several ISG glasses to highlight the structure/properties relationship induced by the increasing amount of Mg on the glass.

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Keywords: Borosilicate glasses, structure, properties, alteration rate

Investigation of Network Connectivity in aluminophosphates Glasses via NMR and Molecular Dynamics

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The study presented here aims at investigating the BaO-K_2O-Al_2O_3-P_2O_5 system used in the development of laser glasses. Indeed, despite the commercialization of several industrial products (e.g., LG-770 from Schott, LHG-8 from Hoya), the relationships between the chemical composition and the local and intermediate ranges organization in these glasses are not fully understood. The approach of this work is to combine glass synthesis (melt-quench), property characterization (T_g, density...), structural study (1D/2D NMR, Raman) and molecular dynamic calculations to determine these relationships.

A wide compositional range was explored, including binary (BaO–P_2O_5), ternary (BaO–Al_2O_3–P_2O_5), and quaternary (BaO–K_2O–Al_2O_3–P_2O_5) glass systems. Properties evolution (T_g and density) were observed and related to composition parameters (%Al_2O_3, O/P, Al/P...). Structural analysis was mainly performed using 1D ^{27}Al NMR to identify the (x)Al species and 1D ^{31}P combined with ^{27}Al/^{31}P correlation NMR experiments (REDOR, HMQC) to identify the Q^n_m speciation.

In the binary system, the 1D spectra reveal a progressive evolution of Q^n structural units as a function of composition as expected from the binary model distribution. In the ternary and quaternary systems, the 1D/2D NMR experiments highlight distinct cross-correlations between phosphorus and aluminum nuclei, confirming the presence of P–O–Al linkages within the glass structure. These interactions demonstrate the formation of a mixed alumino-phosphate network in which aluminum tetrahedra bond with phosphate units, thereby enhancing the network connectivity and rigidity.

Overall, this work provides new insights into the composition–structure relationships in mono- and di-valent alumino-phosphate based glasses and will contribute to the rational design

*Speaker

of high-performance laser and optical materials. **Keywords:** Aluminophosphate, NMR

Control of Surface Electrical Potentials on Ge-Sb-S Glasses by Thermal Poling

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Thermal poling is an effective method for immobilizing electric charges in a glass matrix. These charges are fixed both at the surface and within the core of the vitreous network and add a static electrical function to the material. Charge spatial distribution in poled glasses depends on poling parameters and electrode geometry, yet its behavior at the surface is still not fully understood.

In the present work, chalcogenide glasses in the Ge-Sb-S system doped with Na mobile cations were synthesized and thermally poled using different voltages and electrode geometries. Composition modifications induced in the glass matrix were analyzed by Secondary-Ion Mass Spectrometry (SIMS), while structural modifications were examined by Raman microscopy. Charge distribution was evaluated using a combination of Second-Harmonic Generation (SHG) techniques and Kelvin Probe Force Microscopy (KPFM).

Composition analyses revealed that increasing the voltage applied during thermal poling led to a widening of the cation-depleted zone, from 12 μm to 25 μm. SHG analyses of the treated glasses showed different orientations of the induced electric fields, exhibiting both in-plane (along the surface) and longitudinal (towards the cathode) components. KPFM analyses of samples treated with non-structured electrodes displayed an increase in the magnitude of surface electrical potentials with applied voltage, reaching values up to –22 V for the highest applied voltage. Analyses of samples treated with patterned electrodes revealed electrical potentials varying in sign that were accurately patterned at the micrometric scale.

Taken together, these data show that control over the sign and magnitude of surface electrical potentials induced in a Ge-Sb-S glass is achievable by controlling the surface currents that arise during the thermal poling of the glass. These results pave the way for the creation of new multifunctional materials combining optical and electrical functionalities.

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Keywords: Chalcogenide glasses, Thermal poling, Surface Electrical Potential, Glass Structure

Probing Short-Range Structural Disorder and Glass Formation in Hybrid Glasses Obtained from Metal-Organic Frameworks

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Metal-Organic Frameworks (MOFs) have recently emerged as a unique class of glass-forming hybrid materials, challenging traditional classifications of vitreous solids. The transition from the crystalline to the amorphous/glassy state offers compelling advantages, such as monolithic morphology, enhanced stability, and tunable functional properties. However, a major challenge lies in fully understanding the atomic structure and the fundamental amorphization mechanisms in these novel hybrid glasses.
Here, we report on the structural characterization of hybrid glasses derived from MOFs, focusing on both single-metal and mixed-metal imidazolate systems, utilizing advanced Solid-State Nuclear Magnetic Resonance (SSNMR) spectroscopy. In the Cd(Im)2-x(bIm)x (Im = Imidazol, bIm = Benzilimidazol) system, 13C and 1H NMR confirmed the structural integrity and short-range order of the organic linkers upon vitrification. While 113Cd NMR indicated a clear increase in disorder within the metal coordination environment, specialized experiments like 113Cd{1H} REDOR demonstrated that the primary Cd-Im/bIm connectivity remains essentially intact, with disorder arising from subtle geometric distortions.

This insight is further corroborated by complementary studies on mixed-metal imidazolate glasses, such as those incorporating Gallium and Zinc. In these systems, 71Ga SSNMR also reveals that the short-range order surrounding the Ga center is largely preserved after the transition to the amorphous state.
Collectively, these findings highlight the power of SSNMR for probing short-range structural disorder in hybrid MOF glasses. Our results provide critical evidence that **while the long-range order is lost during the glass-formation process, the fundamental coordination polyhedra of both the metal centers and the organic linkers are substantially maintained**, offering crucial insights into the mechanisms of amorphization that are key for the future design and synthesis of MOF glasses with desired properties.

Keywords: Hybrid glasses, MOFs, NMR

*Speaker

Facile and Quantitative Determination of Glass Redox State

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The redox state of glasses is a critical determinant of their optical, luminescent, mechanical, thermal, and electrical properties. Yet, its precise determination remains challenging, as commonly employed techniques are hindered by significant limitations: (i) limited accessibility (XANES, Mössbauer spectroscopy), (ii) the need for extensive prior standardization (ESR, Raman spectroscopy), or (iii) the risk of altering the redox state during measurement (XPS, EXAFS). In this study, we introduce two quick, accessible, yet precise wet chemistry methods for this purpose, relying on simple apparatus and easy-to-use reagents. The experimental protocol is unified across the various redox couples. These methods were validated using analytical standards encompassing diverse chemistry, and subsequently applied to a broad spectrum of redox couples and glass chemical systems. Results demonstrated strong agreement with established methodologies, even enabling the accurate determination of highly reducing (Eu2+) or oxidizing (Tb4+) ionic species typically present in trace amounts in glasses.

Keywords: Redox chemistry, Wet chemistry, High throughput methods, Mixed anion compounds

*Speaker

Influence of Phase Separation on Stress Corrosion Cracking in SiO_2–B_2O_3–Na_2O Glasses

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Phase separated sodium borosilicate glasses have multiple industrial uses: references electrode junctions, desiccants, medical devices, chromatography, catalyst support, filtering impurities from polluted water or air, etc. Patents show that they have an increase in their resistance to crushing, yet their resistance to stress corrosion cracking (SCC) is less well-known in literature. A typical oxide glass SCC curve reveals the crack front velocity (v) as a function of the stress intensity factor (K) and environmental factors (Temperature, Humidity, etc.). The SCC behaviour of homogeneous glasses systematically evidences three regions between two thresholds. The lower and upper thresholds correspond to the environmental limit (below which the crack front does not interact with the environment) and the fracture toughness (after which the velocity of the crack is unstable). Between the two limits, one finds the three regions. In Region I, the log of the crack front velocity increases nearly linearly with the stress intensity factor. The crack front interacts with environmental water, and the limit in this zone is the time for the reaction to occur. In Region II, the log of the crack front velocity is nearly constant with the stress intensity factor. The limit in this zone is the time for the water to reach the crack front. In Region III, the log of the crack front velocity increases nearly linearly with the stress intensity factor. It is commonly recognized that the crack front dynamics does not depend on the amount of water in the environment. However, it does depend on other environmental factors. SiO_2–B_2O_3–Na_2O glasses have a well-defined zone of phase separation. This presentation concerns two glasses from this zone. Initially, the two parent glasses are annealed with varying annealing times and temperatures. This provides varying structures, which are quantified and qualified by AFM, NMR, Raman, Vicker's indentation, etc. Lastly, how altering the two-phase structure influences Region I and the environmental limit will be revealed. **Keywords:** Phase Separation, Stress Corrosion Cracking, SiO_2–B_2O_3–Na_2O Glasses

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Structural study of nanoparticles under pressure: toward a new amorphous phase

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Although glass is a brittle material on the macroscopic scale, plastic deformation, which induces permanent structural changes and a permanent increase in density, is observed under micro-indentation at the microscale or under hydrostatic pressure. However, densification of bulk silica glass requires high consolidation stresses and the elastic-to-plastic transition occurs only above 9 GPa[(1),(2)].

Recent numerical simulations have introduced a new synthesis method based on the consolidation of nanoparticles and suggest that transition to the nanoscale enhances the formation of plasticity sites. Brittle-to-ductile transition could be triggered at pressures as low as 1.2 GPa, depending on the nanoparticle size, figure 1 highlighting how nanoscale structuring facilitates plastic deformation and reduces the transition pressure[(3)]. Experimentally, the ILM team demonstrated an irreversible elastic-to-plastic transition at 2.5 GPa for 15 nm silica particles[(4)]. Using *in situ* Raman and Brillouin spectroscopies in a diamond anvil cell, we probe atomistic rearrangements and the associated increase in sound velocity. Figure 2 shows the ex-situ Raman spectra of bulk silica glass and of nanoglass synthesized by consolidation of 15 nm silica nanoparticles, obtained at several pressures. The narrower main band and the more intense D1 and D2 bands indicate a narrower Si–O–Si angle distribution and a higher population of 4- and 3-membered rings, reflecting surface-induced structural effects. We also discuss the differences in sound velocity and atomic rearrangements between bulk silica glass and the nanoparticle-derived nanoglass, as well as the inhomogeneity of mechanical stresses during compression. We discuss the different regimes of structural reorganization under high pressure and compare them to bulk silica glass.

Our study demonstrates that nanoscale control of silica particles enables a significant reduction of the elastic-to-plastic transition pressure, offering new opportunities for the synthesis of mechanically robust silica glasses with tunable structural and vibrational properties.

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Keywords: Glass, Silica, High pressure, Vibrational spectroscopy, Structure, Plasticity, Nanoparticles

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Mapping Structural Correlations at the Nanoscale in Phase-Separated Glasses Using 4D-STEM

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Despite being one of the most familiar and widely used materials, glass continues to challenge our fundamental understanding of atomic structure and disorder. The intrinsic disorder of the amorphous network, combined with possible compositional heterogeneities at the nanometre scale, makes it difficult to correlate local structural patterns with macroscopic properties. Where traditional diffraction and spectroscopy techniques provide valuable average informations, they inherently lack spatial resolution, preventing direct observation of structural variations within heterogeneous glasses.

Recent advances in four-dimensional scanning transmission electron microscopy (4D-STEM), and in particular data collection and data processing platform such as those developed by the company Nanomegas, have opened new perspectives for the characterization of amorphous materials at the nanoscale. By recording positionally resolved electron diffraction patterns over extended regions, 4D-STEM enables the local extraction of structural descriptors such as the structure factor S(Q) and the pair distribution function (e-PDF).

In this work, we used a phase separated soda-lime-silicate glass as case study to develop a methodology to obtain spatial resolution structural mapping of glasses. This approach enables the visualization of local structural correlations and provides a framework for exploring short and medium-range order variations in amorphous systems. These capabilities open the door for a more detailed and accurate understanding of glass structure and its relationship to composition and properties.

Keywords: Glass, Structure, Transmission Electron Microscopy, Phase Separation

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Potential Drop Method to measure high velocity sub-cracking in oxide glasses

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Glass is widely used for its advantageous properties, yet its brittleness, particularly in oxide glasses, remains a major limitation. Understanding the mechanisms behind the failure of glasses is essential. While dynamic fracture involves fast crack growth (km/s), a more subtle process known as stress corrosion cracking (SCC) occurs at much lower speeds (nm/s - m/s). Sub-critical fracture is typically divided into three regions and an environmental limit, if it exists (1, 2). The environmental limit defines the stress intensity factor below which the crack front stops to propagate, Region I is governed by the chemical reaction between the stretched bonds at the crack tip and environmental water, Region II is governed by the time for the water to reach the crack front, and Region III does not depend on the amount of water in the environment due to a collapse of data for different humidities. Capturing Regions II and III in oxide glasses with conventional imaging methods is frequently inadequate due to experimental constraints and the relatively high crack front velocity. The Potential Drop Method provides an alternative. It employs conductive lines deposited perpendicular to the expected crack path on a glass sample. As the crack advances, these lines break, which causes a measurable voltage drop recorded by an oscilloscope. Currently used for PMMA (3), this technique requires an adaptation for glass, as crack front velocities are significantly higher and crack tip opening displacements are smaller. This adaptation will reveal Region II and III of the SCC curve for oxide glasses. The experimental Potential Drop Method and its adaptation from PMMA to oxide glasses will be presented in the poster.

Keywords: Stress Corrosion Cracking (SCC), Potential Drop Method (PDM), oxide glass

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A new nanometre resolution method for probing densification ratio at nanoindentation sites in glass: Unravelling discrepancies in the literature

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The similarity principle of pyramidal indentation test makes it possible to draw on the same figure all the densification profiles -densification ratio as a function of depth from Raman confocal spectroscopy - under residual indentation imprints (500 mN - 20 N) reported for silica glass in the literature. The later reveals important discrepancies between studies where as a single master curve is expected because of the similarity of the indentation test.
Using a novel chemical dissolution technique the region of permanent densification beneath Berkovich indentation imprints in silica glass is investigated. The use of the similitude regime of sharp indentation testing allows one to record reliable data with a good spatial resolution (i.e. nm) that makes it possible to obtain a single master curve from very low loads (typically below 10 mN) indents and, more importantly, crack-free imprints. The densified zone dissolves more quickly than the non densified regions. The analysis of the results, along the vertical axis, indicates that the densification zone is rather homogeneous with a steep transition to the non densified zone. The size of the densification zone, with respect to the initial free surface, is estimated to be around two times the maximum penetration depth of the instrumented indentation test. These findings are compared with those obtained from Raman confocal spectroscopy studies in the literature. A good concordance between a Raman spectroscopy result and the chemical probe results is found for imprints made with no or few cracking events during indentation testing. Yet in this precise case, this difference can be explained and advantageously used for computing the confocal resolution of the Raman spectroscope. https://doi.org/10.1016/j.actamat.2024.120005

Keywords: Micro, nanoindentation, Plasticity Densification, Raman spectroscopy, Chemical probe

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A convincing demonstration of indenter tip geometry imperfection as the cause of the reported indentation size effect in glass

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Indentation size effect (ISE) is usually defined as a strong increase of hardness with decreasing indentation load. ISE is nowadays considered by the glass community as a material's property and is further satisfactorily described by different models such as Bernhardt, Frohlich, Hays-Kendal, proportional specimen resistance (PSR) and modified PSR.
In this work we first show from an extended literature survey the existence of important discrepancies in reported hardness variation values with indentation load or depth for the same glass (i.e. silica glass). The most recent and numerous studies revealing the absence of an ISE down to nm scale indents.
Then in a second time we demonstrate from geometrical considerations - taking into account imperfections of a real indenter shape such as conjunction line and tip roundness for four sided pyramidal indenters- that the variation of the hardness with indentation load can be analytically expressed and further take the same form as the above reported models, yet parameters solely depending on geometrical imperfections sizes. We further recall that a part of those findings were published several times in the literature over the last 80 years, yet largely ignored by the glass community. Impact of chisel edge length as well as tip weariness (tip radius) on ISE are discussed in the light of nano, micro and macro indentation regimes as defined by 14577 ISO standards.

Obtained Analytical expressions are further compared to experimental data both from our laboratory and from the literature. .
Conclusion are drawn and implications regarding other hard materials are addressed.

Keywords: Indentation size effect, hardness, Vickers hardness, Indenter geometry

*Speaker

Sand dissolution kinetics in pure cullet melts

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In typical batches with primary raw materials, sand grains are chemically attacked and decomposed by special components such as soda for lime-soda-silicate glasses. When increasingly higher cullet contents are used, this process is greatly reduced and a diffusion process in an acidic and viscous oxide melt with low chemical driving force predominates. In this context, the dissolution of sand grains and synthetic quartz crystals in pure cullet melts was studied using high-temperature observation microscopy (HTOM). The HTOM is equipped with an IR imaging furnace that allows temperatures of $>$ 1500 ∘C and high heating/cooling rates, enabling an exact temperature-time curve of the sand-melt system under investigation to be maintained during in-situ observation. The kinetic parameters of sand dissolution were determined from video sequences of isothermal and non-isothermal test series and compared with characteristic times of batch melting from raw materials.

Keywords: dissolution kinetics, cullets, high temperature observation, quartz, melting

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Semi-empirical modelling of Young's Modulus in aluminoborosilicate glasses from Network Chemistry and Topology

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Understanding the relationship between atomic structure and mechanical properties of aluminoborosilicate glasses is essential for optimizing the performance of nuclear waste confinement matrices. In this study, the elastic behavior of Na_2O–CaO–Al_2O_3–B_2O_3–SiO_2 glasses was systematically investigated using nano-indentation and Solid-State Nuclear Magnetic Resonance (NMR) spectroscopy (^{11}B and ^{27}Al). The Young's modulus (E) ranges from 56 to 93 GPa depending on the Na/Ca ratio and B_2O_3 content. Ca-rich glasses exhibit the highest stiffness, reflecting enhanced structural compaction and stronger Ca–O bonds compared to Na–O. The correlation between E and molar volume (V_m) confirms that network rigidity is primarily governed by atomic packing density. NMR spectroscopy provides quantitative information on boron and aluminum speciation, allowing the calculation of Non-Bridging Oxygen (NBOs) fractions. These data reveal three distinct mechanical regimes: 1) Na-rich glasses, where Na^+ acts as a depolymerizing modifier; 2) Ca-rich glasses, where Ca^{2+} maintains network stiffness despite higher NBO content; and 3) mixed Na–Ca glasses showing non-linear and complex elastic behavior. A semi-empirical model was developed to predict E directly from glass composition, based on three physically meaningful parameters: theoretical ionic volume (V_{ion}), dissociation energy per unit volume (D_{ion}), and Cation Field Strength (CFS). Calibrated over 160 compositions, the model achieves $R^2 = 0.80$ with a root mean square error of ± 8 GPa. This approach provides new insight into the interplay between chemistry, structure, and elasticity in complex oxide glasses, offering a predictive framework for designing high-performance vitrified nuclear waste matrices with improved mechanical integrity.

Keywords: Nuclear waste glasses, Mechanical resistance, Young's modulus, glass structure

*Speaker

Structural Role of Nb2O5 in Oxide Glasses: From Network Integration to Invert Glass Formation

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Niobium oxide (Nb_2O_5) continues to attract growing attention as a functional additive in oxide glasses, enhancing optical, dielectric, and thermal performance across a range of compositions. Despite decades of research, the structural role of niobium remains a topic of active debate. While recent studies point to a predominantly network-forming character, the local environment of Nb depends sensitively on composition – especially on the balance between charge-compensating cations and Nb_2O_5 content.

Building on this context, our group has explored a broad family of Nb-containing glasses – including alkali, alkaline-earth, and aluminosilicates, as well as phosphates, borates, germanates, and lead-free optical systems – using multinuclear solid-state NMR and Raman spectroscopy. Across these systems, Nb commonly integrates into the network as octahedral $(NbO_{6/2})^-$ units forming Nb–O–X (X = Si, P, B, Ge) linkages that sustain connectivity.

Intriguingly, in low-silica or highly modified compositions, this behavior changes. Preliminary results show a systematic decrease in both the glass transition temperature (T_g) and the stability window (T_x–T_g) with increasing Nb_2O_5, suggesting a shift toward an "invert glass" regime, where Nb-rich domains dominate but do not seem to entirely decouple from the silicate framework.

This presentation will highlight recent NMR and Raman findings that shed light on niobium's coordination, connectivity, and charge-compensation mechanisms, and their correlation with macroscopic thermal and optical properties. These insights provide new perspectives on how intermediate oxides govern glass structure – and key input for predictive, data-driven models of composition–property relationships. **Keywords:** NMR, structure, optical, Niobium

*Speaker

Tailoring chalcogenide glasses for controlled surface potential via thermal poling

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The increasing demand for advanced sensors in health, safety, and chemo-selective detection has driven research toward multifunctional materials that combine optical and electrical properties. Chalcogenide glasses, well-known for their transparency in the mid-infrared (MIR) region, are promising candidates for such applications. In this work, we focus on developing chalcogenide glasses with optimized optical properties and controlled surface potential via thermal poling. Specifically, we aim to investigate the relationships between glass composition, dielectric and electrical properties, and the efficiency of thermal poling.

Starting from a Ge24.5Sb10S64.5Na1 base system, sulfur was progressively replaced with selenium to obtain Ge24.5Sb10Se64.5Na1 glasses, and sodium was also substituted with silver in the same series. The glasses were synthesized using the melt-quenching technique and characterized mainly by Raman spectroscopy, UV-Vis-MIR spectroscopy, infrared reflection, complex impedance spectroscopy, Kelvin probe force microscopy (KPFM), and electrostatic force microscopy (EFM). Raman analysis revealed significant structural changes, particularly upon sulfur-to-selenium substitution, whereas electrical conductivity exhibited more complex trends. Regarding surface properties, KPFM measurements indicated a uniform surface potential prior to poling, and EFM revealed differences in relative permittivity, notably between sodium- and silver-containing glasses.

Preliminary thermal poling experiments on the optimized compositions yielded encouraging results. KPFM imaging of poled glasses revealed well-defined surface patterns corresponding to induced potential differences, demonstrating effective modulation of surface electrical properties. These findings highlight the potential of tailored chalcogenide glasses as multifunctional materials for next-generation sensing applications.

Keywords: Chalcogenide glasses, thermal poling, electrical properties, near field microscopy

*Speaker

Direct connection between secondary relaxation mode and fracture toughness in alkali-aluminosilicate glasses

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Oxide glasses are intrinsically brittle, lacking sufficient atomic-scale mechanisms that can relax mechanical stresses in the vicinity of a propagating crack. As a result, fracture is typically well-captured by considering local bond rupture at the crack tip. In this work, we demonstrate that the barrier energies associated with the low-temperature γ-relaxation mode in alkali–aluminosilicate glasses are inversely correlated with the fracture toughness determined from standardized SEPB measurements. This relationship holds both across a series of glasses with varying alkali cations (Li, Na, K) and within a compositional series of varying Li concentrations. Raman spectroscopy provides structural insight into the origin of this correlation. These results indicate that a fundamental structural relaxation mode, measurable in bulk specimens, can serve as an effective predictor of fracture toughness in oxide glasses. Additional data for other silicate glasses further support this conclusion.

Keywords: Fracture Toughness, Aluminosilicates, DMA

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Uncovering Hidden Glasses

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Glasses have been primarily made by cooling high temperature liquids fast enough to avoid crystallization. This limits the composition range that can form glasses, the atomic structure and the resulting properties, as only a small portion of the amorphous states can be accessed. Recent studies show that pressure can provide different pathways to uncover hidden glassy states with unique structure and properties that are unattainable from melt quenching. In other words, pressure allows the retention of kinetically stable atomic configurations such as higher coordination states that cannot be formed by using temperature and time as the control variables. Pressure can not only change the structure and properties of glass dramatically, but also tune them continuously for a given composition, thus adding another dimension to vastly expand the glassy states. Attractive properties including high elastic modulus, high hardness, enhanced ductility, high thermal-mechanical stability and reduced optical loss and dispersion, have been observed in pressure-processed glasses. Furthermore, pressure can also be used to consolidate glassy nanoparticles at room temperature to form nanoglass with a microstructure similar to its nanocrystalline counterpart. Nanoglass has nanoscale amorphous cores ("grains") separated by glass–glass interfaces ("grain boundaries"), and provides a unique means to control the composition/structure variation on a much longer length scale than that can be accomplished in monolithic samples. Structure of pressure-processed glasses will be discussed in detail, in comparison to those from melt quenching, to understand their unique properties.

Keywords: pressure processing, glass structure, properties, nanoglass

*Speaker

Understanding the varieties of obsidian: insight into the compositional and structural characteristics

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Owing to their high silica (_˜70 wt%) and alumina (> 10 wt%), obsidian exhibits high viscosity, melting point and glass transition temperature. More crucially, it includes a low but significant amount of volatile components, primarily water (typically < 1 wt%), whose degassing process influences the quenching of the lava. The final glass may or may not contain bubbles and/or crystallized phases, mainly of iron, in the form of nanolites. Typically, the iron content of obsidian does not exceed 2 wt% often only half as much. It is iron that determines the color of the glass. Although obsidian is often associated with a characteristic deep black colour, it can in fact exhibit a great variety of colors, including red, brown, grey, deep blue, and green. This variety is not necessarily the result of different geological processes or chemical compositions, as different obsidians often occur in close proximity of each other. The coloration mechanisms vary: black hues arise from iron-rich nanolite clusters, while the red color is linked to dispersed iron oxide microcrystals. The remaining colors are still a matter of debate. To better understand the complex processes that contribute to the formation and diversity of obsidian, we investigated the composition and crystalline structures of several kinds, mainly of black and red varieties. Specifically, several analytical methods were employed (e.g. EPMA, XAS, Raman spectroscopy, viscosity measurements) to explore the nature of the nanolites, water contents and viscosity to better understand the effect of water in the glass and the iron speciation in both crystals and glass.

Keywords: obsidian, redox, XAS, color, viscosity, volatiles

*Speaker

Chemical Strengthening, Mechanical Properties, and Structural Analysis of SiO_2-B_2O_3-Al_2O_3-Na_2O Glass System for Enhanced Bending Resistance

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Sodium alumino-silicate (SAS) glasses are widely utilized as cover glass for various mobile display devices due to their outstanding thermal and mechanical properties, as well as their ability to be chemically strengthened. However, in recent foldable devices, ultra-thin glass (UTG) with a thickness of less than 50 um is highly prone to damage under conventional impact, and a critical issue remains in the form of creases along the folding axis. To prevent crease formation while maintaining sufficient glass thickness, it is crucial to enhance crack resistance during folding by either reducing the Young's modulus (E) or increasing the compressive stress (CS). Previous studies have reported that SAS glass exhibits excellent ion exchange performance for chemical strengthening when the Al_2O_3/Na_2O ratio is 1, and the addition of B_2O_3 can effectively reduce the Young's modulus acting as a network former. However, there has been limited systematic investigation into glass compositions that simultaneously achieved both low Young's modulus and high compressive stress after chemical strengthening, as well as into the associated variations in physical properties and their structural interpretations. In this study, SiO_2–B_2O_3–Al_2O_3–Na_2O based glasses were prepared with a constant Al_2O_3/Na_2O molar ratio of 1 to investigate the effects of composition variation on chemical strengthening behavior and mechanical properties. While the SiO_2 content was held constant, the contents of B_2O_3 and (Al_2O_3 + Na_2O) were systematically adjusted. Glasses were synthesized using a conventional melt-quenching process in a Pt-Rh crucible, and their thermal and mechanical properties were comprehensively analyzed. Vickers hardness and Young's modulus were determined to assess the mechanical properties, while compressive stress (CS) and depth of layer (DOL) after chemical strengthening were measured using a Surface Stress Meter (FSM-6000). In addition, to clarify the structure–property relationships arising from compositional changes, structural analyses were performed using Raman spectroscopy, solid-state NMR, XPS, and molecular dynamics (MD) simulations.

Keywords: Mechanical property, Chemical strengthened, Alumino borosilicate

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From windows to bioactive glass: structure, viscosity and crystallization of soda lime silicate glasses

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Soda–lime silicate glass is the most common type of glass. Its high-silica compositions are widely used in windows and container glass owing to their low cost and good workability. By lowering the silica content, we reach the compositional range of bioactive glasses for a very different field of application. This study aims to elucidate how the glass structure and properties such as viscosity, sintering and crystallization change as the silica content is reduced from 70 (Si70) to 50 mol% (Si50) while the sodium-to-calcium ratio is kept constant at 1:1.
The viscosity of the glasses was measured using a rotating crucible viscometer and a creep apparatus for the high- and low-viscosity regions, respectively. The Adam–Gibbs equation was used to fit the results while accounting for configurational entropy. The viscosity at a given temperature decreased with decreasing silica content, meaning that the same viscosity can be achieved at lower temperatures, which facilitates glass processing. However, the decrease in silica content also led to poor sintering behavior and a high crystallization tendency, both typical indicators of poor processing ability: heating-microscope measurements showed that Si50 exhibited only about 5% decrease in silhouette area after sintering, while Si70 showed a decrease of more than 20%. Differential scanning calorimetry revealed that both the crystallization onset temperature and the processing window decreased with decreasing silica content, suggesting that these glasses are much more difficult to process without crystallization occurring. Heat-treatment and X-ray diffraction followed by Rietveld refinement was performed to determine the influence of crystalline phases in these differences in sintering. The processing behavior can be explained by the glass structure suggested by solid-state NMR: Si70 is dominated by a three-dimensional silicate network, whereas Si50 contains significant amounts of Q^2 chains. This indicates that the glass network depolymerizes with decreasing silica content in this ternary glass system.

In summary, low silica content leads to a more disrupted glass structure, which lowers the viscosity but also reduces the processing ability of the glass due to crystallization.

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Keywords: bioactive glass, glass structure, viscosity, crystallization, sintering

Structural Role of MgO in Soda Lime Silicate Glasses: Compositional Variations and Spectroscopic Insights

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The structural role of MgO in soda lime silicate glasses remains an area of active investigation, particularly regarding whether it acts as a network modifier or becomes incorporated into the glass network depending on the overall composition. To investigate this, a classical soda lime silicate glass composition was selected as the base, and three series of glasses were designed: MgO substituted for Na2O, MgO substituted for CaO, and MgO added by proportionally reducing all major oxides (SiO2, Al2O3, Na2O, CaO). Structural characterization was performed using Raman spectroscopy, 23Na MQ/MAS NMR, 29Si MAS NMR, and 27Al MAS NMR to evaluate changes in network connectivity and modifier environments. These analyses aim to clarify how Mg2+ ions integrate into the glass network and influence its structural organization. The results provide insight into the compositional dependence of glass structure and lay the groundwork for understanding how MgO incorporation affects the overall behavior of soda lime silicate glasses.

Keywords: Soda lime silicate glass, magnesium oxide, glass structure, network modifier, spectroscopic analysis, NMR, Raman spectroscopy, structural role.

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Glasses of R_2O-B_2O_3-Al_2O_3 systems: study of structure-mechanical properties relationships at the metaluminous joint (R = Li, Na, K).

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Glassy materials have long been considered fragile, exhibiting purely elastic behavior before breaking when subjected to stress (1). However, the advent of fine-scale mechanical characterization techniques, such as instrumented micro-indentation, has revealed that glass can exhibit permanent deformations when subjected to sharp contact loading, induced by the appearance of two mechanisms: densification and shear flow (2). Although developed on a local scale, these mechanisms govern the mechanical properties of glass on a macroscopic scale. Increasing crack initiation resistance therefore requires a highly adaptable matrix, both at short and medium range.
Alkali aluminoborate glasses are of particular interest due to their high flexibility, especially within the first few coordination spheres of the network. In particular, studies of these systems close to the metaluminous joint ($R=Al_2O_3/R_2O=1$) have already shown increased properties when subjected to localized stress (3). This study therefore focuses on the relationships between the concentration of each formative element at R=1 and the mechanical properties obtained. Some of the obtained glasses displayed the highest crack resistance value ever reported for an oxide glass (CR $\approx$ 50 N). The crack initiation resistance results are then correlated with the different structural variations obtained by electron diffraction and RAMAN micro-spectroscopy.

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Effect of alkaline-earth ions on shear localization and crack resistance under indentation tests in aluminoborosilicate glasses

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Understanding the mechanisms behind indentation crack resistance (*CR*) is fundamental for designing stronger and more durable glass products. Densification, which is evaluated by "recovery of indentation depth" (*RID*), has been accepted as one of the important factors to affect *CR* . Densification is considered to reduce residual stress around the imprint, resulting in an increase of *CR*. On the other hand, localization of shear deformation ("Shear bands") is recently considered as another important factor affecting *CR*. It is assumed that intersections of shear bands are a cause of crack initiation and that intense shear bands are negatively affecting *CR*. It was reported that shear bands on an imprint cross-section of calcium aluminoborosilicate(ABS) glass became less distinct with increasing B_2O_3 content, and that glasses with less distinct shear bands tended to exhibit higher *CR*. However, effects of alkaline-earth (AE) type on shear bands formation and *CR* in the AE-ABS glasses remain unclear. In this study, we evaluated densification and shear bands induced by indentation for AE-ABS glasses containing different AEs. The glass composition system to investigate in the present study is: $(75–x)SiO_2–x\ B_2O_3–15Al_2O_3–15RO$ (R = Mg, Ca, Sr, and Ba; $x = 0$ ˜ 25 mol%). *CR* increased with increasing B_2O_3 content, and also increased as the AE ion radius decreased. However, *RID* remains relatively constant regardless of the composition, meaning no clear relationship between *CR* and *RID* in these systems. On the other hand, shear bands varied significantly depending on glass composition: higher B_2O_3 content and smaller AE ions (i.e., higher field strength) made shear bands less distinct. This trend supports the assumption that shear bands may affect to decrease *CR*. However, in glasses with high B_2O_3 content, smaller AE ions exhibited higher *CR* despite all samples showing relatively homogeneous plastic deformation zone without any clearly observable shear bands. The mechanism by which AE ions influence both shear band formation and *CR* will be discussed.

Keywords: indentation crack resistance, shear band, densification, alkaline, earth ion, alumonoborosilicate, indentation cross section

*Speaker

Enhancing Niobate Solubility in Aluminosilicate Glasses through Network Former Addition

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$Na_{0.5}K_{0.5}NbO_3$ ($ANbO_3$) crystallizes in a perovskite structure and exhibits promising properties for energy storage and conversion applications. In this work, we explore the development of transparent glass-ceramics containing $ANbO_3$ within an aluminosilicate matrix, aiming to combine the functional properties of the crystalline phase with the transparency and physicochemical stability of glass. A key challenge lies in extending the glass-forming range of the system to incorporate higher niobate contents. To achieve this, we introduce additional network formers to exploit the positive influence of configurational entropy on glass-forming ability.

Network formers such as P_2O_5 (5.5 and 9 mol%) and B_2O_3 (6 mol%) were incorporated into an alkali aluminosilicate (NAS) composition, followed by the addition of $ANbO_3$ up to its solubility limit. The resulting glasses were characterized regarding their structure and properties. The addition of P_2O_5 significantly increases niobate solubility, whereas B_2O_3 does not show a similar effect. Polarized Raman spectroscopy was used to investigate the mechanisms behind this solubility enhancement by analyzing the interaction between the glass matrix (NAS + P_2O_5/B_2O_3) and the incorporated niobate. P_2O_5, for example, induces a strong interaction and structural reconfiguration upon niobate addition due to the formation of Nb–O–P bonds, which are responsible for the observed increase in niobate solubility. Additionally, we show that network former addition induces complex changes in the thermal properties of niobate-containing glasses. We discuss the influence of these additions on the formation of secondary phases, alongside the desired single niobate perovskite phase formed in a pure NAS matrix.

Overall, the addition of network formers can enhance niobate solubility in NAS glasses but can also alter their crystallization behavior. Polarized Raman spectroscopy proves to be a powerful tool to evaluate the structural changes induced by network former addition and to identify underlying mechanisms behind the observed property variations. **Keywords:** Raman spectroscopy, perovskite glass ceramics, aluminosilicate glasses, mixed networkformers, transparent glass ceramics

*Speaker

A constitutive model for e-beam induced viscous flow in silicate glasses at room temperature

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The effect of electron- irradiation on silicate glasses viscoplastic flow has been attracting more and more attention in the recent years. It started in the 2010s when Zheng et al revealed that amorphous silica exhibits remarkable ductility under e-beam irradiation in a TEM – nanoparticles and nanowires showed large plastic strains exceeding 200 % without heating. Subsequent works confirmed this ductile behavior at the microscale and under lower-voltage irradiation using in situ SEM micropillar compression testing at room and high temperature. In the recent work of (Rusinowicz et al, 2025), we have evidenced an apparent role of the electric charge (i.e. time integral of the current or dose) under mechanical loading in driving the stress relaxation of amorphous silica under electron irradiation. Many groups are clearly on the edge of major findings in this field. The aim of our present work is to propose an original constitutive model that allows to predict plastic flow of silicate glasses under various e-beam and mechanical loadings. This model is built upon the accurate quantification of stress and strain rate as a function of time and electron irradiation conditions, using in situ SEM micropillar compression and relaxation experiments. We observe a one-to-one relation between the creep rate and the injected current. The constitutive model is implemented and checked under various conditions. It makes possible to reproduce fairly the effect of SEM scanning time and magnification on stress-strain and stress relaxation curves. It explains the master curve that relates the electric charge to stress relaxation. This constitutive model yields also good results to simulate the viscoplastic response of amorphous olivine under uniaxial tension in a TEM (Orekov et al, 2025). We believe that this model can be very useful to design new routes for room-temperature shaping of silicate glasses.

Keywords: Plasticity, Viscous flow, Electron irradiation, Micropillar compression, In situ SEM mechanical testing, constitutive modelling

*Speaker

Investigation of the Effect of Fourth Component Addition on the Solubility of ZrO2 in SrO–SiO2 System Glass by High-Throughput Micro-Melting Method

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This study investigates how the addition of a fourth component-specifically ZnO, TiO2, Y2O3, Nb2O5, Ta2O5, or WO3-affects the solubility of ZrO2 within SrO–SiO2 system. Given the infinite compositional possibilities of inorganic glasses, we employed a high-throughput micro-melting method to efficiently screen for vitrification and analyze structural correlations.
Experimental samples were prepared from a 2.2Na2O-30SrO-67.8SiO2 (mol%) parent glass, which was crushed into a slurry using ethanol and mixed with ZrO2 and various additive oxides in 10×10 Pt-Au microwells. These mixtures were heat-treated at 1450 ºC. The resulting samples were analyzed using optical microscopy, XAFS (Zr K-edge), and Raman spectroscopy. Analysis confirmed that while Na volatilized during processing, the Sr:Si ratio remained constant at approximately 3:7.

The results demonstrated distinct behaviors among the additives with respect to glass formation. Co-doping with WO3, Ta2O5, and Nb2O5 significantly narrowed the vitrification range, while Y2O3 narrowed it slightly. Conversely, TiO2 and ZnO maintained the glass-forming range. XANES analysis indicated that Zr exists in a 6-coordinate structure. Notably, Ti and Y ions appeared to influence the local structure of Zr, likely occupying charge-compensation sites within ZrO6 octahedra, thereby facilitating ZrO2 solubility.
Raman spectral analysis, utilizing Non-negative Matrix Factorization (NMF) to decompose 442 spectra into partial Raman spectra (PRS), provided quantitative structural insights. For samples containing Ta2O5 and Nb2O5, the spectral factors associated with Zr incorporation into the network decreased, indicating a reduction in ZrO2 solubility. In contrast, ZnO addition increased factors related to Zr/Zn-bonded structures, confirming that ZnO does not suppress ZrO2 dissolution. The broader glass-forming region observed with TiO2 and Y2O3 correlated with only minor decreases in network-related factors. The limited glass-forming range observed with WO3 was primarily due to the precipitation of WO3 crystals rather than a direct negative effect on ZrO2 solubility. These findings highlight the utility of high-throughput screening in elucidating complex structure-composition relationships in glass materials.

Keywords: glass forming region, high throughput, silicate, ZrO2, Raman, XANES, multivariate

*Speaker

analysis

Intermediate-range order in disordered materials

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Understanding the intermediate-range ordering in disordered materials is essential for unraveling the nature of glass transition. The combination of neutron and X-ray diffraction has been widely used for studying disordered materials since X-rays are sensitive to heavy elements while neutrons are sensitive to oxygen. Moreover, the application of advanced simulation techniques and topological analyses, in conjunction with diffraction experiments, makes it possible to understand 'order within disorder' in disordered materials. We report our recent findings on tetrahedrally coordinated disordered materials with a special focus on the origin of diffraction peaks.

Keywords: Glass, Structure, Diffraction

*Speaker

Analytical Models to Evaluate Stresses in Chemically Strengthened Glass

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Ion exchange induced stress profiles in glass are typically characterized by several simple quantities, some of those being measured directly by an instrument, and some being computed from measured ones. These include (but are not limited to) CS (compressive stress at the surface) and DOL (depth of ion exchange layer), reported by the FSM instrument; CT (central tension), computed from CS and DOL or measured by alternative techniques, and DOC (depth of compression, a depth where stresses cross zero). In this presentation, we will show analytical relations between these quantities for the cases of binary ion exchange when ions have not yet started to arrive to the center of a glass sample and stress relaxation can be ignored. We will also demonstrate an approach to rescale stress profiles with respect to glass thickness for ion exchange that is symmetric through the thickness. We begin with a physical argument for separating complicated aspects of the stress profile, including stress relaxation, into a thickness-independent term, and then identify a thickness-dependent term associated with force balance and giving rise to center tension CT. This physical argument is then rendered with equations that retain the full generality of arbitrary ion exchange conditions. Using the machinery described in this presentation, one would accelerate design of their glass chemical strengthening process and optimize final stress profiles.

Keywords: ion exchange, chemical strengthening, stress profile, modeling

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Phenomenological Understanding of Thermal Conductivity in Complex Crystals and Glass-Like Materials Across Broad Temperature Ranges

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This study presents a comprehensive analysis of the temperature-dependent thermal conductivity, $\kappa(T)$, in a range of complex crystalline and glass-like materials, including organic semiconductors, clathrates, mixed oxides, amorphous alloys, and polymers. Using a two-component theoretical framework—comprising a standard phonon (Peierls) contribution, $\kappa_P(T)$, and a coherence-related term, $\kappa_C(T)$—we model $\kappa(T)$ across wide temperature ranges with high accuracy. Experimental data reveal that while $\kappa_P(T)$ captures low- to intermediate-temperature behavior, $\kappa_C(T)$ becomes essential at higher temperatures, particularly in systems exhibiting vibrational coherence or structural complexity. The fitting results confirm the general applicability of the combined model

$$\kappa_{\mathrm{tot}}(T) = \left[(bT^n)^{-1} + \left(\frac{A}{T} + k_{\mathrm{pl}}\right)^{-1}\right]^{-1} + \kappa_0 \exp\left(-\frac{E}{T}\right),$$

demonstrating its capacity to distinguish between crystal-like and glass-like transport mechanisms. This dual-term approach offers a unified understanding of thermal transport in disordered and hybrid materials, with implications for phonon engineering, thermal insulation, and thermoelectric optimisation. **Keywords:** thermal conductivity, glass, diffusons, propagons

*Speaker

Synthesis and Characterizations of CaO-ZnO-B2O3-SiO2 (CZBS) Glass Ceramic Sealants for Low Temperature SOEC Applications

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The Solid Oxide Electrolysis Cell (SOEC) is one of emerging technology for producing green hydrogen gas through high-temperature electrolysis with a solid oxide or ceramic electrolyte. In order to achieve energy efficiency and low operational energy requirements, demand for SOEC which can be operated at low temperature down to 650 oC is recently increasing., SOEC requires sealing materials that effectively prevent gas leakage at operating temperatures and maintain stable adhesion under prolonged high temperature operation. Therefore, the sealing glass must have a high glass softening point and a coefficient of thermal expansion (CTE) compatible with components such as yttrium stabilized zirconia (YSZ) and FC460 to ensure long-term reliability and efficiency. Previous studies on BaO-containing glass systems have revealed sealing failures caused by volatile crystalline phase formation through reactions between Ba ions and the metal substrate (FC460). To overcome this issue, a new compositional system is necessary to enhance the chemical and thermal stability of SOEC glass sealants. In this study, a quaternary silicate-based CaO-ZnO-B2O3-SiO2 (CZBS) system was explored as a Ba-free candidate for SOEC applications. The compositions was designed to form a hardystonite phase with a proper high CTE. Thermal properties of the glasses were analyzed using differential thermal analysis (DTA) and thermo-mechanical analyzer (TMA). The crystalline phases formed within the glass were confirmed via X-ray Diffraction (XRD) analysis after heat-treatment simulating the sealing and operation conditions. The glass transition temperature, flow button test, and CTE values of the CZBS glass and glass ceramics were systematically investigated. Adhesion tests were carried out by joining glass-sealants with the YSZ and FC460, followed by aging tests at the operation temperature, examining the actual sealing characteristics, reactivity, and stability via Scanning Electron Microscope (SEM) equipped with an Energy Dispersive Spectrometry (EDS) analyseis. The practical feasibility of the obtained glass and glass-ceramics was assessed by hydro-thermal test using an autoclave under SOEC operation conditions.

Keywords: SOEC, CaO, ZnO, B_2O_3, SiO_2, Sealant, Hardystonite, Thermal expansion

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Effect of R Ratio on the Dielectric and Thermal Properties of SiO_2–Al_2O_3-B_2O_3–Na_2O Glasses for Semiconductor Packaging Substrates

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With the rapid expansion of artificial intelligence and high-performance computing, conventional semiconductor packaging technologies are reaching their physical and material limitations, constraining further improvements in processing capability. As a breakthrough solution, glass substrate materials have emerged as a promising alternative to conventional PCB-based packaging substrates, which suffer from high dielectric loss at high frequencies, surface roughness, limited mechanical strength, and insufficient thermal resistance. In addition, glass substrates can be produced in large areas, enabling reduced manufacturing costs compared with silicon interposers. Among various candidates, borosilicate glass has attracted considerable attention owing to its low dielectric constant and loss, as well as its thermal expansion characteristics compatible with silicon. However, systematic investigations into the compositional dependence of physical properties in borosilicate glasses remain limited.
In this study, SiO_2–Al_2O_3–B_2O_3–Na_2O glasses were prepared to examine the effects of the (Al_2O_3 + B_2O_3):Na_2O ratio (R-ratio) on their physical properties while maintaining a fixed Al_2O_3:B_2O_3 ratio of 1:2 and varying the Na_2O content. The glasses were synthesized via the conventional melt-quenching method using a Pt–10 wt% Rh crucible. Their thermal and mechanical properties were characterized, including dielectric constant, Vickers hardness, Young's modulus, and coefficient of thermal expansion (CTE). Furthermore, Raman spectroscopy, nuclear magnetic resonance (NMR), and X-ray photoelectron spectroscopy (XPS) were employed to elucidate the structural origins of the observed property variations with composition.

Keywords: Borosilicate glass, Low Dielectric constant

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Kinetics Issues of Ion Exchange in Silicate Glasses

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Ion exchange is a well-established technology in silicate glass processing, where the underpinning physics is widely known, even though some particular issues are still debated in the scientific glass community. By its nature, Ion exchange in glass is a kinetic process that occurs in a non-equilibrium system. The open systems thermodynamic analysis of ion exchange identifies the equilibrium conditions and the driving forces that activate the mutual exchange of alkali ions from a silicate glass to a molten salt reservoir. On the other hand, Thermodynamics cannot detail how the incoming ion concentration evolves in the glass; this is a kinetic interdiffusion problem. The solution to the interdiffusion kinetic problem depends in a critical way on the boundary conditions at the glass/ion reservoir interface. The classical approach is based on the assumption that an interface equilibrium is established on a time scale much shorter than the overall contact time. There is evidence in the literature that this condition is indeed an approximation. A simple, full kinetic model is proposed for the description of ion exchange, where a key role is played by the introduction of a surface saturation time at the ion-reservoir/glass interface. The conditions under which this new approach merges into the classical one are critically discussed. Further discussion is focused on an interdiffusion problem between two heterogeneous phases (the Ion reservoir and glass) where equilibrium conditions at the interface are treated in the classical way. The analysis puts in evidence the effect of ion mobility in the ion reservoir on the interface equilibrium and residual ion concentration in glass.

Keywords: Ion Exchange, Thermodynamics, Kinetics, Diffusion, Interface Equilibrium

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Effect of MgO Content on the Dissolution Behavior of Soda Lime Silicate (SLS) Glasses in Alkaline Conditions

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The chemical durability of soda lime silicate glasses in alkaline environments is a key factor for their performance in packaging applications, particularly under conditions such as dishwasher exposure. This study investigates the impact of MgO on the short-term (14 days) dissolution behavior of soda lime silica glasses in a controlled alkaline medium (pH 10.5) – emulating the dishwasher conditions. Accordingly, three series of glasses were synthesized based on a reference soda lime silicate composition: MgO substituted for Na2O, MgO substituted for CaO, and MgO added by proportionally reducing all major oxides (SiO2, Al2O3, Na2O, CaO). Dissolution experiments were conducted under controlled conditions, and the concentration of released elements into the solution was monitored over time using ICP-OES analysis. Normalized elemental losses were calculated to evaluate the dissolution kinetics and compositional dependence. The results reveal that MgO content and its substitution significantly influence the dissolution rate in alkaline conditions. These findings provide insight into the role of MgO in modifying the glass network and its impact on chemical durability.

Keywords: SLS, MgO, alkaline dissolution, chemical durability, ICP, OES analysis, glass corrosion, short, term dissolution, compositional effect

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Tuning Eu2+ Emission in Oxynitride Glass-Ceramics

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In recent years, there has been growing attention on developing new luminescent materials doped with rare-earth ions for energy-efficient light-emitting diodes (LEDs). Among these materials, oxynitride glass-ceramics offer unique advantages over conventional oxide systems due to their enhanced network connectivity, as well as improved thermal and chemical stability. However, systematic investigations of Eu^{2+} photoluminescence in Na_2O-modified oxynitride glass-ceramics remain limited.

In this work, Eu-doped oxynitride glass-ceramics in the Na-Ca-Mg-Al-Si-O-N system with varying Na_2O content (0–12 wt.%) were synthesized by spark plasma sintering (SPS) to elucidate the influence of sodium-induced structural evolution on Eu^{2+} emission. Although europium was introduced as Eu_2O_3, the reducing SPS conditions stabilize Eu^{2+} as the dominant luminescent center. Structural changes were characterized by X-ray diffraction with Rietveld refinement and Fourier-transform infrared spectroscopy, while photoluminescence spectra and CIE 1931 chromaticity coordinates were used to quantify optical responses.

XRD reveals a Na_2O-driven amorphous-to-crystalline transition, with crystalline phase fraction increasing from about 18 vol.% (Na-0) to approximately 60 vol.% (Na-12), accompanied by the formation of multiple nanocrystalline silicate and aluminosilicate phases embedded in a residual oxynitride glass matrix. Progressive Na_2O addition causes a systematic red shift of the Eu^{2+} emission maximum from 481 to 499 nm and spectral broadening (FWHM from 113 to 138 nm), directly correlating with increasing crystallinity and the coexistence of distinct Eu^{2+} coordination environments. FTIR analysis confirms Na_2O-driven depolymerization of the silicate network, supporting the luminescence trends. The emission intensity exhibits a non-monotonic

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dependence on Na_2O content, with a maximum for the intermediate composition (Na-3, ∼31 vol.% crystalline), indicating an optimal balance between crystallization-enhanced Eu^{2+} coordination and the onset of concentration-dependent quenching.

These results establish a clear quantitative structure-property relationship linking Na_2O-induced crystallization, local Eu^{2+} coordination environments, and emission characteristics. Na-modified oxynitride glass-ceramics thus emerge as versatile host materials for broadband UV-excited phosphors with tunable emission bandwidth, peak position, and color, offering strong potential for next-generation solid-state lighting, display technologies, and advanced photonic applications. **Keywords:** oxynitride glass, ceramics, Eu^{2+} photoluminescence, CIE chromaticity

Superposition Method for the Analysis of EXAFS Spectra from Ni Ions in Molten Glasses

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X-ray Absorption Fine Structure (XAFS) spectroscopy has been used for local structural analysis of glass materials for long time. Because of lack of long-range order, short-range order (SRO) as well as medium-range order attract scientific attentions. Especially, XAFS spectroscopy is effective way to elucidate SRO around transition metal ion in glasses.
For the extended XAFS (EXAFS) regime, conventional analyses frequently (i) impose symmetric, gaussian-like bond length distributions (BLD) and (ii) assume a single local structural geometry; conventional fitting method usually assumes a Gaussian-like harmonic oscillator distribution of bond length, and deviations from this are expressed by the Debye-Waller factor, and the Cumulant expansion. The assumption (i) and (ii) are fragile in structurally and thermally disordered systems. Eventually, unnatural fitting result are sometimes observed.

We therefore adopt a non-parametric approach, named "Superposition method" which can be applicable to disordered systems, where well-ordered systems with Gaussian assumption are no longer legitimate. Theoretically, the method is similar methodology to Monte Carlo approach modeling complicated three-dimensional structure. Instead of modeling whole structure of disordered system, we reproduce BLD, or radial distribution function around absorption atom. We take advantage of the EXAFS equation that explain EXAFS oscillation is the summation of each scattering paths. We apply this concept to the 1st shell itself: EXAFS oscillation of 1st shell around element M can be reproduced from liner combination of single-path oscillation χ(k, R) of different M-O distances. Practically, FEFF8 is used to simulate χ(k, R) as the basis oscillations over the grid of M-O distances R, and the measured EXAFS signal is reconstructed as a linear combination of these basis oscillations. This inversion yields a physically variable BLD without imposing symmetry or a particular coordination geometry, enabling representation of distortion, asymmetry and temperature-dependent broadening.
We used "Superposition method" for fitting of EXAFS spectra of Ni in aluminosilicate molten glass. Finally, we obtained BLDs of molten glasses, which was challenging using conventional fitting method. BLDs of melts showed skewed shape compared to glass and crystals. The

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method provides broad perspective of short-range order of molten glasses as a general toolkit for quantifying local structure in disordered systems.

Keywords: XAFS:EXAFS, melt, local structure

Local Structure of Ni ions in Na2O-MgO-Al2O3-SiO2 Glasses and Melts: Speciation of Ni Polyhedra along with Optical Basicity and Temperature by Optical Absorption and EXAFS Spectroscopies

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Aluminosilicate glasses are widely used from the base glass for glass-ceramics and bioactive glasses to the matrices for immobilizing high-level radioactive wastes because of their outstanding optical/mechanical performance, chemical resistance etc; high-quality grades are required for display substrates as well. These compositions are also studied in geoscience as quenched analogues of silicate melts and as model materials for the Earth's mantle. Herein, incorporation of MgO enhances mechanical and chemical durability, providing its local structure as a key variable. Because the ionic radius of Ni ion is comparable to that of Mg ion, Ni might become as a sensitive structural probe of Mg. Ni ion in glass is known to show coordination-dependent colors varying from purple to green, and it may also become reference data of local structure of Mg ion.

We investigate the local structure of Ni ion in NiO-doped Na2O-MgO-Al2O3-SiO2 (NMAS) glasses at room temperature (RT) and high temperatures (HT) using UV-Vis-NIR and X-ray absorption fine structure (XAFS) spectroscopies. At RT, UV-Vis-NIR and XAFS reveal that the glasses contained Ni-centered polyhedra of square-pyramidal (SP), trigonal-bipyramidal (TBP) and tetrahedral (Td) geometries. These polyhedra were found to correlate systematically with the glass optical basicity, suggesting a compositional control over the ligand field. Comparison between RT and HT data indicates that the local structure of Ni ion at RT partially inherits features of the melt; compositions with high MgO and Al2O3 content exhibit anharmonic Ni-O bond-length distributions and retention of disordered characteristics strongly after quenching.

Methodologically, we demonstrated this extraction of structure contributions on UV-Vis-NIR absorption spectra by applying non-negative matrix factorization (NMF) to deconvolute the spectra into the components with not only the mathematical but also individually physical

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meaning. In EXAFS analyses linear-combination FEFF fitting was applied; EXAFS oscillations with respect to Ni-O bond length distribution. These results provide a consistent structural picture on the distribution of Ni coordination polyhedra, linking to the composition (optical basicity), temperature history (melt inheritance) and also offering the guideline for tuning color and structure in Ni-containing aluminosilicate glasses, and the insight into structural role of Mg ion.

Keywords: Aluminosilicate, EXAFS, Optical Absorption, melt, Ni, local structure

Mixed network former effect in barium borosilicate glasses: structural and mechanical implications

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Barium borosilicate glasses are widely used for optical systems dure to their high refractive index or their ability to host large amount of rare earth elements. They can be also found as filler in classic dental composites. They are also used in LTCC and sealants for solid oxide fuel cells. Therefore, their mechanical and thermal properties need to be better known. Moreover, due to the presence of Ba, liquid-liquid phase separation limits the compositional range where homogeneous glass formation is possible. Therefore, a glass series near the edge of the decomposition region were synthesized with approximately 30 mol% BaO while changing the network former ratio, SiO2/B2O3, along the disilicate–diborate join allowing a good coverage of the system and to investigate the link between structure and properties.

On the structural side, the effect of the SiO2/B2O3 ratio on both B coordination and network polymerization were quantified using Raman, IR and NMR spectroscopies and molecular dynamic. All these results converge to show IIIB, threefold coordinated boron, increase linearly with boron content, at the expense of IVB. The kQ3 equilibrium constant decreases slightly with boron addition up to 37 mol%, whereas at greater B2O3 contents, the silicate network rapidly polymerizes. These trends are reinforced by theoretical results which show that the average connectivity, polymerization, and ring size are directly related.

On the property side, if the glass transition temperatures increase monotonously with the silica content, the elastic moduli measured from Brillouin spectroscopy show a local maximum at 37 mol% B2O3 and 33 mol% SiO2. This maximum in the mechanical moduli correspond to the maximum in the atomic packing density found to be _˜0.6. Naturally the mechanical moduli are linked to the underlying structure and the role of mixing boron to increase the moduli of a silica-rich network will be emphasized. The relationship between the structure and packing density will be then compared to previous studies and extrapolated to the entire BaO-B2O3-SiO2 ternary.

*Speaker

Keywords: borosilicate glass, Raman, NMR, infrared, Brillouin, elastic moduli, packing density, molecular dynamic

Fracture toughness of calcium aluminosilicate glasses

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A major limitation of oxide glasses is their low fracture toughness, leading to premature failure as a result of critical flaws. A thorough understanding of how fracture toughness is linked to the glass composition and structure still needs to be developed. Here, we investigate the fracture toughness of the important family of calcium aluminosilicate glasses by means of the Single-Edge Precracked Beam (SEPB) method. We connect the glass structure to the fracture toughness by investigating glasses with varying silica contents and alumina/calcia ratios, encapsulating both percalcic and peraluminous compositions. By molecular dynamics simulations, validated by X-ray total scattering, we correlated the fracture toughness to specific structure features. We infer that local coordination changes of aluminum, so-called bond switching, correlate positively with the fracture toughness. We further extend our investigation to include hardness, crack initiation resistance and elastic moduli, finding that various structural features should be considered to understand each of these mechanical properties within the calcium aluminosilicate glass family.

Keywords: CAS glass, calcium aluminosilicate, mechanical properties, fracture toughness, single edge precracked beam, SEPB

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Stabilizing Unusual High Oxidation States of Transition Metals in Glasses

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Transition metal ions have been coloring glasses since the dawn of glass making. Many of these 3d ions are known to be present in glasses in the divalent or trivalent state. We were able to stabilize unusual high oxidation states of transition metal ions such as Co^{3+} (yellow to brown), Ni^{3+} (blue), Mn^{5+} (blue), Mn^{6+} (deep green) and possibly Fe^{4+} (brown) in cesium-barium silicate (CBS, e.g., $40Cs_2O$–$10BaO$–$50SiO_2$, mol%). Favorable glass compositions for the stabilization of these high oxidation states were of exceptionally high optical basicity ($\Lambda = 0.72 - -0.81$), values also reached in Cs(Ba)-ortho-borate glasses [**?**].

The high valent ions were confirmed by UV-Vis, photoluminescence (PL), and Raman spectroscopy. Raman spectroscopy showed resonance enhancement for hexavalent MnO_4 tetrahedra near 800 cm^{-1}, allowing the identification of Mn^{6+} even at dopant concentrations of only 0.01 mol%. Mn^{5+} shows a strong NIR emission at 1190 nm, sparking interest in the development of more stable glasses for photonic applications that rely on NIR light emission, such as temperature sensing or bio-imaging. Since many of these glass samples were of high hygroscopicity, more stable glasses were designed [**?**, **?**].

Even though trivalent transition metal ions are not unusual for many 3d elements, cobalt and nickel have traditionally been designated as divalent in glass. However, after quenching from high melting temperatures, Co^{3+} can be confirmed in pyrex-type glasses, or after irradiation, Co^{3+} and Ni^{3+} can be found in other technical silicate or phosphate glasses [**?**].

It was found that the Mn^{5+}/Mn^{6+} ratio in our glasses is very sensitive to variations in the glass composition, which resulted from synthesis, such as crucible dissolution or cesium oxide evaporation.

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(3) Möncke, Ehrt, Radiation-induced defects in CoO- and NiO-doped fluoride, phosphate, silicate and borosilicate glasses, Glass Science & Technology 2002, 75(5):243-253 **Keywords:** optical basicity, high

oxidation state, Raman resonance, spectroscopy

Vibration Function of Disk-type Glass Actuator based on Ion-conductive Phosphate Glass

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Mechanical responses of materials to the applied electric power have been investigated and used as "actuator". Conversion of electric energy to mechanical one in materials has been evaluated in terms of electrostrictive effect, and glass has been classified to have low conversion efficiency. Recently, our group investigated "Glass actuator" using ion-conductive glasses, where cantilever-type actuator device was fabricated and showed vibration of electrostricvtive effect under low AC voltage with various frequency at room tempearture. This means that glass materials are good candidate for actuator elements to induce electrostrictive function
Ag2O-WO3-P2O5 (AWP) glass was prepared by melt-quenching method. Transparent glass, weakly colored with green, was obtained. Mold press instrument was originally designed to prepare AWP glass element for actuator. Typical dimension of the element was 15 mm-O.D. x 0.2 mm-t, glass disk.

The glass actuator is composed of 5 layers; electrode/cladding layer/glass/cladding layer/electrode. Our group employed a-TiO2 for cladding layer. a-TiO2 layers were deposited on the AWP glass element by Puled laser Deposition (PLD) method. TiO2 poly-crystalline target was irradiated by KrF excimer laser pulses in vacuum chamber. In order to suppress oxygen deficiency, O2 gas was introduced around glass element. deposition time was 1-2 h. RHEED and XRD analyses were conducted to confirm amorphous state of the deposited films. O2 assist increased optical transmittance in visible to infrared wavelength region, showing the reduction of oxygen defect in the film.

After depositing of Au layers as electrodes, the glass actuator elements were placed on the special sample holder jig, and subjected to the actuator evaluation analysis. AC electric field was applied between electrodes with the amplitude around 1.5 V with the frequency range of 1 – 3000 Hz at room temperature.
Vibration behavior was monitored by Laser Doppler Vibrometer. By scanning the laser spot (532 nm) on the actuator device, the vibration behavior of the disk-type glass actuator was confirmed. In the presentation, detailed results will be shown.

Keywords: glass actuator, phosphate glass, ion conduction, electrostrictive effect

*Speaker

Effective Thermal Strengthening of Glass by Enhanced Configurational Entropy at its Supercooled State

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Physical strengthening (thermal tempering) induces surface compressive stress, and its magnitude is largely proportional to the difference in thermal expansion coefficients between the supercooled liquid (al) and glassy (ag) states, denoted as Da. We aimed to enhance strengthening by designing glasses with a maximized Da while maintaining a conventional ag.
We investigated the SiO2-B2O3-Na2O system. We found that while ag primarily depends on Na2O content, $a$ht (representing al) shows a significant peak when the molar ratio R = (Na2O)/(B2O3) approaches 1. MAS-NMR analysis confirmed this anomalous expansion is driven by a drastic increase in configurational entropy above Tg. This transition involves the dissociation of stable BO4 and Si(Q4) networks into looser BO3 and Si(Q3)units.
Based on this mechanism, we developed an optimized glass (SBBN) with ag similar to standard sodalime (SL) glass but a much larger Da. Tempering demonstrations confirmed that SBBN achieved more than double the compressive stress of SL glass under similar conditions. This demonstrates that controlling configurational entropy in the supercooled liquid state is an effective strategy for enhancing thermal strengthening. Furthermore, it was noted that the resulting fragment density upon fracture did not necessarily follow the order of the stored internal stress, suggesting complex fracture dynamics.

Keywords: thermal expansion, ttempering, configurational entropy at supercooled state

*Speaker

Intermediate-range structure of P2O5 glass revealed by a combination of quantum beam diffraction and topological data analyses

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P2O5 is a representative network-forming oxide with Q3 tetrahedral motifs, in which three bridging oxygens (BOs) and one non-bridging oxygen (NBO) are bonded to a phosphorus atom. To elucidate the intermediate-range structure of P2O5 glass manifested by diffraction peaks, we constructed a three-dimensional structure model that is consistent with neutron and X-ray diffraction data by combined reverse Monte Carlo and classical molecular dynamics simulations. Partial structure factors of the structure model indicated that a doublet first sharp diffraction peak of P2O5 glass originates from the Q3 network composed of two different length scales formed by P–BO and P=NBO bonds. The intermediate-range structure extracted from the three-dimensional structure model via topological analyses and the origins of the diffraction peaks of P2O5 glass are addressed.

Keywords: Intermediate, range structure, diffraction, network forming oxide

*Speaker

Alkaline earth – borate systems: thermodynamic modeling & key experiments

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Solid and liquid/amorphous alkaline earth borates are important in many industrial applications. At the same time, experimental information on phase diagrams and thermodynamic properties are not abundant. Only the CaO-B_2O_3 system is well characterized. Data on the other systems with MgO, SrO and BaO are more limited and sometimes contradictory.

In this contribution we report on new experimental and theoretical results for the binary alkaline earth – borate systems. The ground state properties (structure & heat of formation) as well as the heat capacities of the solid compounds were calculated using density functional theory (DFT). Heat capacities at constant pressure, the glass transition temperatures as well as the liquidus temperatures were measured for selected glasses using differential scanning calorimetry (DSC).

All new data together with the available literature information were used to perform a consistent thermodynamic modeling of these systems using a third generation Calphad approach. The heat capacity of the solid compounds were modeled as a function of temperature using a multiple temperature Einstein function. For the liquid phase, two different model approaches were used: the associate model and the modified quasi-chemical model in order to reproduce a correct description of the short-range order observed in these systems. **Keywords:** Alkaline earth borates,

Calphad modeling, Phase diagrams

*Speaker

Structure of Hydrated Borate Glasses

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Understanding the structural role of water in glasses is important for a range of phenomena, including the mechanical properties. For example, water can lead to stress corrosion, but more recent work has shown that steam treatment of some glass compositions can lead to improved crack initiation resistance, including in borate glasses. In this study, we therefore study the structure of xH2O(1-x)B2O3 glasses with x = 0.1, 0.2, 0.33, and 0.4 by melting B2O3 with varying amount of water in closed containers to incorporate water in the bulk borate glass structure. We characterize the structure through solid state NMR and x-ray and neutron scattering measurements. Particularly, we explore the hydrogen coordination environments by taking advantage of the different scattering lengths of the hydrogen isotopes. That is, we prepare glasses with either 1H, 2H, or a combination thereof to obtain a null-scattering isotope composition of hydrogen, allowing the use of the isotope difference method to separate the hydrogen contributions from the borate network structure. We correlate the observed structural changes with the measured density and glass transition temperature.

Keywords: Borate glass, water, neutron, x, ray, scattering, NMR

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Interfacial tension and thickness in phase separation of RmOn-SiO2 systems

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Liquid-liquid immiscibility occurs in rare earth or alkaline silicate systems among others. The kinetics of the phase separation in such systems is a complex phenomena needing an accurate knowledge of the thermodynamic state functions and the interfacial energy. Due to difficulties to experimentally determine the last property, theoretical models are needed. To be able to compute the interfacial energy, molar Gibbs energy with a Redlich-Kister excess potential is determined for various binary systems with monotectic line or subliquidus metastable miscibility gaps. Thermodynamic data are assessed by a determination of critical conditions and the miscibility gap for each system. Using Gibbs energy minimization, a first method similar to Butler's theory is used to determine the interfacial energy. The dependence on reduced temperature T/Tc is determined. A clear difference appears between the systems with a liquid-liquid phase separation and systems with a sub-liquidus phase separation. Using the Cahn-Hilliard theory, the interfacial energy can be also determined by an integration over the solute molar fraction between equilibrium states. The ratio of the two predictions of the interfacial energy provides an estimation of the interfacial thickness. For the various systems, this thickness depends on the temperature becoming infinite in the critical condition. The typical size of the thickness is around few nanometers comparable to experimental data.

Keywords: thermodynamics, phase separation, Cahn, Hilliard theory, binary systems

*Speaker

Properties and structure of glasses along the join x Na2O-(x/2) Al2O3-(x/2) B2O3-(100-x) SiO2

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The glass system Na2O-B2O3-SiO2 (NBS) is the basis of many industrial applications and therefore one of the most studied ones. Glass formation in this system is possible over a wide compositional range, but there are also ranges of pronounced phase separation and crystallization tendency. Even small addition of Al2O3 can substantially change this behavior. As the Na2O-Al2O3-B2O3-SiO2 (NABS) system is also known as the basis for glasses in strength-relevant applications, the behavior during the transition from the NBS system to the NABS system is of interest. Therefore, a small step melt series in this system was studied using the robotic glass melting system at the Federal Institute for Materials Research and Testing (BAM, Division Glasses). In this work, glasses with composition x Na2O-(x/2) Al2O3-(x/2) B2O3-(100-x) SiO2 with ($18 \leq x \leq 42$) were characterized with respect to density, glass transition temperature, crystallization behavior, coefficients of thermal expansion, elastic constants, and their molar volumes. Additionally, part of the experimental data was compared with their available modeled counterparts. The choice of the studied series was based on the theoretically based assumption that both Al and B could be present in 4-fold coordination. In order to explore this possibility, the structure of these glasses was also investigated via solid-state NMR and Raman spectroscopy in the attempt to identify detailed structure/property correlations.

Keywords: Na2O, Al2O3, B2O3, SiO2 glasses, glass transition temperature, density, structure

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Effect of irradiation and thermal treatment on the stored energy, physical properties and structure of ISG glass

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In France, borosilicate glass, known as R7T7, is used to contain high-level, long-lived nuclear waste generated from spent fuel reprocessing. The resulting glass canisters are destined to be stored in deep geological repository. After several thousand years, groundwater is expected to come into contact with the glass and begin to leach it. However, the glass will have been self-irradiated by the radionuclides it contains. This can modify its structure and properties, and therefore its leaching behaviour.

Insofar as the alteration phenomenon will take place on an expected time scale that is inaccessible, modeling enables to simulate the very long-term glass behavior. In order to better understand the alteration mechanisms of nuclear glasses, this work focuses on a simplified borosilicate glass, called ISG (International Simple Glass). Its simple chemical composition exacerbates some phenomena, such as leaching and irradiation-induced structural modifications, and makes characterization and modeling easier.

In an oral presentation, we propose to focus on the effect of the structural defects created by irradiation in the material which cause constraints in the glass structure and can be represented as an excess of internal energy commonly referred to as 'stored energy'.

In order to simulate the defects created by the recoil nuclei generated by α decays in a radioactive glass, we will study a non-radioactive ISG glass irradiated using external beams. The effects of the recoil nuclei were simulated with multi-energy Au ions (0.5, 1.2, 2.5, 4 and 7 MeV)

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up to 40 MGy (i.e., the nuclear saturation dose). The aim is to determine the energy stored in these samples by calorimetric measurement and to make it vary. We have therefore chosen to proceed by thermal annealing in order to gradually restore some defects and therefore decrease the stored energy.

A study was also carried out to determine the variation of the structure and properties of ISG glass irradiated with Au ions during annealing. Variations of two glass properties (swelling and hardness) with annealing were characterized by interferometry and Vickers hardness, while structural variations were characterized by Raman spectroscopy and solid-state NMR.

Structure of alkaline-earth aluminosilicates and aluminoborosilicates: insights from neutron, X-ray diffraction and MD simulations

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Tolerance to contact damage in silicate glasses is driven by an interplay between plasticity and brittle fracture. Recent works have shown that partial substitution of silica with boron oxide in alkaline-earth aluminoborosilicates (ABS) glasses resulted in a drastic increase of damage tolerance correlated with a transition from non-homogeneous plastic flow (shear banding) to homogeneous plasticity. Moreover, the type of alkaline-earth (AE) ion can also strongly contribute to the contact damage. This investigation aims to elucidate the role of boron and the type of alkaline-earth ion on the atomic structure of a group of ABS glasses. We investigated a series of aluminosilicate AS (70SiO2-15Al2O3-15RO) and aluminoborosilicates ABS (55SiO2-15Al2O3-15B2O3-15RO) glasses with different alkaline-earth cations (R = Mg, Ca, Sr, Ba) using neutron and X-ray diffraction experiments. To gain more details on the atomic structure, we performed MD simulations using a newly-improved version of the SHIK potential. The MD simulations could reproduce well both the observed experimental neutron and x-ray total correlation functions for all the proposed series, confirming the accuracy of the improved potential. The local structure around network formers (NWF) and alkaline-earth cations was evaluated through analysis of the pair-distribution functions in both experiments (neutron and X-ray) and MD calculations. In the AE-aluminosilicate glasses, the results revealed that Mg, Ca, Sr, Ba assume coordination with oxygen between four (4) and eight (8), respectively. The size of the AE ion did not seem to affect the local structure of either silicon (Si) or aluminium (Al), which assumed mostly tetrahedral coordination. In the AE-aluminoborosilicate series, neutron diffraction experiments clearly revealed boron-oxygen correlations assuming mostly 3-fold coordination independently of the AE ion. The local structure of the AE-ion in ABS glass series was like those of the AS glass series, although with slightly lower coordination numbers. The effect of the type of AE-ion and role of boron on the intermediate range order (ring structure and bond angles distributions) will also be discussed. It is proposed that the small coordination number assumed by magnesium ions along with the exclusive 3-fold coordination of boron in these glasses are key features of these damage-tolerant glasses.

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Keywords: diffraction, atomic structure, molecular dynamic, aluminosilicates, aluminoborosilicates

Origins of thermal anomalies in glasses

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Network glasses exhibit universal vibrational and cryogenic thermal anomalies: a "boson peak" corresponding to an excess in the vibrational density of states over the Debye _˜w^2 law, and a plateau in thermal conductivity that remains nearly temperature-independent in the range 1–25 K. These anomalies have so far lacked a quantitative first-principles explanation, owing to the prohibitive computational cost of lattice-dynamics methods for disordered systems and the limitations of classical molecular dynamics at low temperatures. Here, we combine the Wigner formulation of thermal transport with numerical analysis based on GPU-accelerated machine-learning interatomic potentials and optimized tensor-contraction algorithms to compute the anharmonic vibrational spectrum and thermal conductivity of amorphous silica models containing _˜1.5 million atoms-sufficiently large to capture the long-wavelength vibrations active at cryogenic temperatures. We show that the conductivity plateau arises from a balance of two transport mechanisms: temperature-inhibited, anharmonicity-damped propagation of vibrations below the boson peak, and temperature-activated, disorder-mediated "tunneling" of vibrations above it. Our approach opens a pathway to understanding and controlling thermal transport in disordered solids at cryogenic temperatures.

Keywords: thermal conductivity, anharmonicity, simulations

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Study of X-ray induced damage on sulfur in glass during X-ray analyses

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Sulfur is a crucial multivalent element for tuning the properties of glass, existing primarily as sulfide (S^{2-}) and sulfate (S^{6+}) species. Accurate determination of sulfur valence states is essential for understanding and controlling glass characteristics. X-ray analysis is a key technique for determining the valence state of sulfur. However, the techniques such as X-ray absorption fine structure (XAFS) and X-ray fluorescence (XRF) can induce changes in sulfur valence through photo-oxidation or photo-reduction during analysis. This phenomenon complicates the reliable analysis of sulfur speciation and may lead to misinterpretation of the true redox state of sulfur in glass.

In this study, we systematically investigated the stability of sulfur valence states in soda-lime silicate glass under X-ray irradiation, focusing on the effect of conductive carbon coatings as a strategy to suppress X-ray-induced damage as the damage may be caused by surface charging during measurement. Glass samples with a standard composition ($16.5Na_2O$-9.4CaO-$74.1SiO_2$ (mass%) with 0.2 mass% Fe_2O_3 and SO_3, and 0–0.3 mass% carbon as a reducing agent) were prepared by melting and quenching. A certified reference material (SGT10, Society of Glass Technology, UK) was also used. Conductive carbon coatings of varying thicknesses were applied to the glass surfaces.

Our results demonstrate that carbon coatings effectively protects the glass samples from X-ray induced damage and preserve the integrity of the spectral feature, enabling accurate analysis of the original sulfur redox state in S K-edge XAFS measurement. The coated samples exhibited stable XAFS spectra with consistent peak intensities for S^{2-} and S^{6+}, even after repeated measurements and extended irradiation times. This approach also allowed for longer measurement durations, improving the signal-to-noise ratio and revealing minor spectral features. This study provides a simple and versatile solution for controlling X-ray induced damage in glass analysis, supporting more precise determination of sulfur valence states by XAFS. The conductive coating method is applicable to a wide range of glass compositions and analytical conditions. Application of this technique to X-ray fluorescence will be also discussed.

Keywords: X, ray, damage, sulfur, conductive coating

*Speaker

Spatial distribution of modifier cations and tuning its effect on the ionic conductivity of network oxide glasses

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The distribution of modifier cations around non-bridging and bridging oxygen (NBO and BO) atoms in single- and mixed- modifier metaphosphate glasses is investigated using 17O NMR spectroscopy and is correlated to their ionic conductivity measured using electrical impedance spectroscopy. Structural relaxation of these glasses during isothermal aging significantly reduces their ionic conductivity. While the activation enthalpy DHm of ionic conduction remains constant after aging, the entropy of migration DSm decreases, leading to a corresponding reduction in the hopping rate of mobile alkali ions. This behavior is observed to be associated with a spatial redistribution of the modifier cations in the glass structure during aging. These findings, when taken together, suggest that significant increases in the ionic conductivity of a glass can be achieved by raising its fictive temperature. The possible consequences of this effect will be discussed.

Keywords: phosphate, structure, modifier distribution, 17O NMR, ionic conductivity, fictive temperature

*Speaker

Influence of MgO addition on the structure and properties of Zinc phosphate Glasses

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Antibacterial phosphate glasses have attracted growing attention due to their potential to inhibit bacterial growth and reduce infection risks. Zinc oxide (ZnO), in particular, is widely employed as an antibacterial agent because it offers strong antibacterial efficacy against both Gram-negative *Escherichia coli* (*E. coli*) and Gram-positive *Staphylococcus aureus* (*S. aureus*), while avoiding the toxicity and environmental concerns associated with conventional biocides such as silver. Consequently, zinc phosphate glasses have emerged as promising materials for antibacterial and biomedical applications. However, their relatively poor chemical durability remains a major limitation, restricting their long-term stability and use in harsh environments. In this study, we investigated the influence of MgO content on the physical, thermal, chemical durability, dissolution, and structural properties of (50-x)ZnO-7Al2O3-xMgO-43P2O5 (x = 0, 1.5, 3, 4.5, 6, 9) glasses. Distinct changes in density and thermal behavior were observed at 3 mol% MgO, suggesting a compositional threshold affecting the glass network. To interpret these property variations, Raman spectroscopy and molecular dynamics (MD) simulations were employed to establish structure–property correlations. These insights provide a fundamental framework for tailoring phosphate glass compositions with enhanced chemical durability and antibacterial performance for advanced biomedical and environmental applications.

Keywords: Zinc phosphate glass, Antibacterial glass, Molecular dynamics simulation, Chemical durability

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Enhancement of Fracture Toughness in Glasses by Ag Incorporation via Ion Exchange Process

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Our previous work demonstrated that incorporating a small amount of Ag nanoparticles into SiO_2 glass via spark plasma sintering (SPS) significantly enhanced its fracture toughness through crack bridging and plastic deformation at crack tips (Liu & Shinozaki, Mater. Sci. Eng. A, 2021). This finding indicated that even a minor introduction of ductile metallic species can effectively relax local stress and suppress crack propagation within a brittle glass matrix. However, that approach required high-temperature sintering and was limited to bulk composite systems, which are not always compatible with transparent glass fabrication or surface strengthening processes.

To extend this concept to a more versatile and practical strengthening route, the present study focuses on the ion exchange process as a means to introduce silver into glass. This method enables controlled incorporation of Ag ions, clusters, or nanoparticles into the near-surface region at relatively low temperatures, while maintaining optical transparency. Although Ag-ion exchange has been explored for modifying optical and antibacterial properties, its influence on mechanical performance—particularly fracture toughness and the associated toughening mechanism remain poorly understood.

In this work, we systematically investigated the effect of Ag incorporation via ion exchange on the fracture toughness of silicate glasses. Compositional profiling, crack morphology analysis, and indentation-based mechanical evaluation were combined to elucidate the relationship between silver diffusion behavior and local mechanical response. The results revealed that fracture toughness can be enhanced even in the absence of measurable surface compressive stress, suggesting a distinct, stress-independent toughening mechanism such as K-ion exchange. This study thus extends our previous findings from bulk Ag-doped glass composites to a transparent ion-exchanged system, providing new insights into the design of mechanically reliable and optically functional glass materials. **Keywords:** Toughness, Ion exchange, Metallic Nanoparticle

*Speaker

Micrometric patterning of a borogermanate glass containing terbium by thermal poling to manage luminescence and second order optical properties

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Borogermanate glasses containing terbium ions are interesting materials due to their luminescent and magnetic properties. Terbium can present two different oxidation states and the thermal poling technique can be a pertinent way to modulate spatially the oxidation state of these ions. In this work, we demonstrate using a thermo-electrical imprinting process the transfer of micro scaled motifs on the surface of a borogermanate glass containing Tb3+ resulting in a micrometric structuring of the oxidation state of Tb3+/Tb4+ ions. A large change in absorption and luminescence optical properties is observed, arising from the distinct properties of trivalent and tetravalent terbium ions. Correlative micro luminescence, Raman and second harmonic generation measurements were carried out on the patterned poled glass surface. This has demonstrated an accurate concomitant modification of the glass structure accompanying large luminescence changes and the appearance of a second order optical response which could be attributed to a localized space charge implantation. These original results demonstrate how a simple electrical process allows managing multi optical properties but also paves the way to induce static electrical functionalities in a magnetic optical glassy system.

*Speaker

Pressure-Induced Structural Transformations and Electronic Transitions in TeO2 Glass by Raman Spectroscopy

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In this work, TeO_2 glass was studied up to the record pressure of 70 GPa using Raman spectroscopy (1). The Boson peak frequency (ω_b) exhibits a decrease of the $\partial\omega_b/\partial P$ slope at 5–6 GPa, indicating a modification towards a more compact tellurite network. Above 30 GPa, ω_b reaches a "saturation" with a practically constant value up to 70 GPa. In the short-range order, both our experimental and theoretical results indicate that pressure up to 15 GPa induces the transformation of single Te-O-Te bridges to double Te-O_2-Te bridges, leading to a more compact tellurite network. At higher pressures, a new Raman activity develops around 580 cm^{-1} and is associated with the increase of Te coordination to six-fold. Natural bond orbital analysis showed that the formation of double Te-O_2-Te bridges favors the s→d transition, which promotes the increase of Te coordination number at higher pressures through a d^2sp^3 hybridization. This results in the formation of a practically canonical TeO_6 octahedron, in strict difference with crystalline TeO_2 at the same pressure range, and the development of a 3D network that freezes the medium range order. Our study highlights the interplay between pressure-induced electronic transitions and the increase in Te coordination number in the flexible tellurite glass network. Given that our study is the first to record the BP at such pressures, it paves the way for further exploration of this unique in glasses feature at high pressures. The results are discussed in relation to previous experimental and theoretical studies in the field.

References

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Combined X-ray Raman Scattering, X-ray Emission Spectroscopy, and Optical Raman Spectroscopy for in situ Studies of Glasses and Melts under Extreme Conditions

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Understanding the atomic and electronic structure of melts and glasses at extreme temperatures (> 1000 K) is crucial for advancements in planetary science, materials research, and sustainable industrial processes. However, in situ experimental studies are challenging due to possible sample contamination from containers and the difficulty in probing low-Z elements. This presentation introduces a novel experimental setup at the ESRF-ID20 beamline that overcomes these limitations by combining aerodynamic levitation and CO_2 laser heating with a suite of advanced X-ray techniques.

This unique instrumentation enables container-less, in situ analysis of materials in their liquid and supercooled states. We will present the successful implementation and capabilities of the new setup, which integrates X-ray Raman Scattering (XRS) for probing the local environment of low-Z elements (e.g., O, Al, Si), X-ray Emission Spectroscopy (XES) for heavier elements, and supplementary optical Raman spectroscopy.

We will showcase the power of this new methodology with recent scientific results on several systems. First, we investigate the compression mechanisms and structural evolution in oxynitride and fluoride-phosphate glasses. Second, we explore the structure of slags at high temperatures to understand the origin of their properties under extreme conditions. These insights may also be vital for developing more efficient recycling strategies. By providing direct, element-selective structural information not accessible by other methods, this work opens exciting new avenues for research into disordered materials under extreme conditions.

Keywords: Aerodynamic Levitation, X-ray Raman Scattering, High-Temperature Melts, In situ Spectroscopy

*Speaker

Combined X-ray Raman Scattering, X-ray Emission Spectroscopy, and Optical Raman Spectroscopy for in-situ Studies of Glasses under Extreme Conditions at ESRF-ID20

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The presentation will show the implementation of CO2 laser heating and optical Raman spectroscopy for X-Ray Raman Spectroscopy (XRS) /X-Ray Emission Spectroscopy (XES) measurements at ESRF-ID20 to study the structure of low Z-elements under extreme conditions (megabar pressures, $>$ 1000 K). The progress, including the CO2 laser setup and the installed optical Raman system will be presented. The presented scientific results feature XRS/XES on compression mechanisms in oxynitride as well as fluoride-phosphate glasses. This new instrumentation is crucial for planetary science and materials research in general.

Keywords: XRay Raman Spectroscopy (XRS), XRay Emission Spectroscopy (XES), Raman spectroscopy, high pressure, oxynitride glass, fluoride phosphate glass

*Speaker

Composition and structural impact on thermal and mechanical properties of Mg-Al-Si-O-N Glasses

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This study investigates the structural, thermal, and mechanical properties of Mg-Al-Si-O-N glasses. Six compositions with nitrogen content designed to increase as oxygen content decreases were synthesized by melting mixtures of high-purity oxide and nitride precursors, followed by quenching and annealing. Structural analysis via X-ray diffraction and Raman spectroscopy confirmed the amorphous nature of the glasses and highlighted distinct spectral features based on the Mg/Al ratios, providing insights into glass network changes and the presence of different Si-O and Al-O linkages as nitrogen levels rise. The effects of nitrogen incorporation on glass density, molar volume, atomic packing density, glass transition temperature, and thermal expansion were systematically examined, revealing strong correlations. Measurements of elastic moduli, hardness, and fracture toughness underscore the role of nitrogen and the Mg/Al ratio in enhancing mechanical properties. The findings demonstrate that increased nitrogen content results in denser and more rigid glass networks, leading to improved thermal and mechanical properties. Additionally, regression models for these properties align well with experimental findings, highlighting the significant role of nitrogen and the Mg/Al ratio in improving material performance.

Keywords: Fracture toughness, oxynitride glasses

*Speaker

Heat Capacity Measurements of Molten Glass by Using a Mercury-Free Drop Calorimeter

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Accurate heat capacity data of molten glass are essential for thermal simulations of industrial glass furnaces, evaluation of melting energy, and thermodynamic modeling including phase equilibria. In a previous study (1), we developed a mercury-free drop calorimeter that employs only water as the working fluid. This setup allows for environmentally safe operation while maintaining the ability to accurately measure the heat released by a sample when it is heated to a specific temperature and dropped into a well of the ice calorimeter. The released heat can be determined by measuring the decrease in volume of the ice in the calorimeter that has been frozen beforehand.
In this work, we apply the mercury-free calorimeter to determine the heat capacities of several multi-component glasses for which heat capacity data have been reported using mercury-based calorimeters. We compare the obtained values with previously reported data in order to validate the present measurement method. The results demonstrate that the measured heat capacities show good agreement with existing thermodynamic reference data within experimental uncertainty. The comparison highlights the capability of the mercury-free calorimeter to reproduce temperature dependent trends in heat capacity. These findings confirm the validity and practical utility of the developed mercury-free calorimeter for high-temperature melted glass systems. Measurements of more complex industrial glass compositions are currently underway and will be also discussed.
(1) GOMD2025

Keywords: Drop calorimeter, Mercury, free, Enthalpy, Heat capacity, molten glass

*Speaker

Mechanochemically synthesized Na_2S-based glasses as promising electrolytes for all-solid-state sodium batteries

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Sodium-based solid electrolytes are attracting increasing attention as promising alternatives to liquid electrolytes for all-solid-state batteries, owing to the abundance of sodium and the improved safety resulting from the absence of organic solvents. Among these materials, glassy sulfide electrolytes stand out for their potentially high ionic conductivity. However, many compositions within this family remain unexplored.

In this presentation, we first describe the synthesis and characterization of new Na_2S-based glasses, prepared by mechanochemical processing, with compositions that have not yet been reported in the literature. Their structure was analyzed by X-ray diffraction and Raman spectroscopy, while scanning electron microscopy (SEM) was used to evaluate morphology, homogeneity, and composition. Differential scanning calorimetry (DSC) revealed a characteristic glass transition, confirming the amorphous nature and thermal stability of the samples. The ionic conductivity, measured by electrochemical impedance spectroscopy between 10 °C and 60 °C, reached values up to 10^{-5} S·cm^{-1} at room temperature, with the temperature dependence following an Arrhenius behavior.

The most conductive glass was selected as solid electrolyte, and its electrochemical properties were further investigated. The electronic conductivity, determined by DC polarization, was found to be very low ($\approx 10^{-12}$ S·cm^{-1}), confirming the predominantly ionic nature of the material. At the end, we report on the development of an all-solid-state sodium battery operating at ambient temperature and 80 °C. The different stages of battery assembly as well as the first electrochemical tests will be presented. **Keywords:** Chalcogenides, Ionic conductivity, Solid electrolyte, Solid state battery

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Mixed alkaline earth effect on the structure and dielectric properties of aluminoborosilicate glass

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The rapid advancement and application of 5G/6G systems, has increased the demand for low dielectric glass fibers in high-frequency semiconductor chips and systems. In fact, challenges remain in optimizing glass structure to improve the thermal compatibility and performance at GHz frequency ranges. This study focused on SiO2-Al2O3-B2O3-RO-TiO2 alkali-free aluminosilicate glass and investigated the effect of mixed alkaline earth oxides (CaO and MgO) on the glass structure. Furthermore, the relationship between the structure and properties were analyzed. Several techniques such as X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and magic angle spinning nuclear magnetic resonance (MAS-NMR) were employed to conduct both qualitative and quantitative analyses the structure of glass. The study also evaluates the glass transition temperature, coefficient of thermal expansion, high-frequency dielectric properties (ranging from 0.6 to 10 GHz), density, and chemical stability of this aluminosilicate glass. The results indicate that when the CaO/MgO ratio is 1:4, the glass exhibits an optimal performance, achieving the lowest coefficient of thermal expansion (α =2.97 $\times$ 10–6 /∘C) and the lowest dielectric constant (4.36 at 10 GHz). Both the FTIR and MAS-NMR results reveal that the introduction of mixed alkaline earth metals optimizes the tetrahedral network structure of this glass, leading to an enhanced performance. This study highlights the role of the alkaline earth oxides mixture effect in adjusting the glass composition, providing valuable insights into the critical structure-property relationship of low-dielectric, low expansion glass fibers and contributes to both high-frequency applications and practical production.

Keywords: Alumino, borosilicate glass, mixed alkaline earth effect (MAEE), glass network structure, thermal stability, dielectric properties

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Influence of doping on the properties of fused quartz glass

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Fused quartz glass is the preferred crucible material used in the production process of monocrystalline silicon ingots. The crucible is used to hold the silicon melt during the Czochralski process. Due to the global increase of PV installations, there is a need for increased production yield of the silicon ingots used for the solar panels. One factor limiting the yield of the Czochralski process is the crucible lifetime- with increased holding time, the viscosity of the crucibles decreases, leading to sagging and deformation. Due to the cristobalite phase transformation, the crucible material is not reusable, and there is no commercial recycling process available yet. Therefore, extending the crucible's lifetime would lead to both improved production yield and less waste, making the process cheaper, more sustainable and environmentally friendly.
In our previous work, we have used various characterization techniques to assess the crucible properties, such as their viscosity, OH-content, bubble growth etc. The results have revealed inhomogeneities in the crucible, affecting its behavior during the Czochralski process. We have also looked at how the addition of Al affects the same properties and concluded that doping with small amounts of Al leads to lower OH content and increased viscosity and hence better stability during the Czochralski process.

In the current study, we look at fused quartz glass doped with varying amounts of different doping elements. Both the doping and the fusion processes are performed at laboratory scale. We present how the different levels and types of doping affect the glass' viscosity, OH content, fictive temperature, glass transition temperature and possibly also the glass structure.

Keywords: glass doping, glass transition temperature, viscosity

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Structure and properties of peraluminous sodium aluminoborosilicate glasses

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The system $Na_2O \times Al_2O_3 \times B_2O_3 \times SiO_2$ (NABS) has been studied extensively because it exhibits interesting regions of phase separation or crystallization. Aluminoborosilicates can thus be found in many modern applications. Glasses with higher Al_2O_3 content are also used for waste applications, as Al2O3 is known to improve not only the mechanical but also chemical properties. In this study, the role of network formers with varied (Al2O3)/(SiO2) ratio was investigated for glasses with an Al_2O_3 content of $>$ 20 mol%. For this purpose, a model glass series of 20 Na_2O-(x) Al_2O_3-5 B_2O_3-(75-x) SiO_2 (with 20

*Speaker

Unraveling the correlation between populated site energies, activation barriers and saddle point energies in solid ion conductors

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Transport phenomena in disordered materials, particular in solid-state ion conductors are governed by a complex potential energy landscape that includes a distribution of local energy minima (sites), saddle point energies and local energy barriers (activation energies). Long-range transport and local hopping take place in the same complex energy landscape but may visit different regions of it. A detailed understanding of the correlation between site energies, saddle point energies and local activation energies is therefore essential to unravel the transition between local hops and long-range transport.
This work presents a comprehensive, multi-methodological approach to establish a quantitative link between the populated site energy distribution (PSED), the distribution of barriers and the saddle points of the potential energy landscape. The PSED is experimentally determined by the Charge Attachment Induced Transport (CAIT) technique that yields concentration dependent diffusion coefficients and activation energies by comparison of measured concentration depth profiles to profiles gained by Nernst-Planck-Poisson modeling (1,2). The CAIT method looks at long-range transport where a specific saddle point energy is rate determining and transport properties are dominantly determined by the distribution of local energy minima. For Li3B7O12, the FWHM of the PSED is determined to be 250 meV (3). On the same material, the distribution of local activation energies, g(Eact), is probed through Nuclear Magnetic Resonance (NMR) measurements and a FWHM of 500 meV is found for the energy distribution of barriers (4). These findings suggest that the apparent energy distribution of saddle points, SPD, which is a convolution of PSED and g(Eact), must be even broader, i.e. approximately 550 meV. The findings provide an important contribution to the understanding of the energetic landscape in disordered ion conductors and shed light on the mechanisms underlying macroscopic transport processes.

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*Speaker

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(4) M.A. Badgragheh, E. Winter, M. Vogel, unpublished results

Keywords: ion transport, ion hopping, potential energy landscape, transport theory

Structure–Property Correlations in (Ge33As12Se55)1-xAgx Chalcogenide Glasses: Influence of Network on Ionic and Optical Behavior

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The addition of silver to chalcogenide glass networks offers a powerful route to tune both ionic transport and optical functionalities for infrared photonics and solid-state electrochemical applications. In this work, the structural, ionic, and optical behavior of (Ge33As12Se55)1–xAgx (x= 0 to 20 at%) glasses is systematically investigated to establish clear structure–property correlations across the composition range. Raman spectroscopy and thermal analysis reveal that Ag incorporation progressively modifies the host Ge–As–Se network by depolymerizing rigid backbone units, forming Ag–Se/Ag–As bonding environments, and increasing free-volume pathways. These structural changes directly manifest in enhanced ionic conductivity, driven by the creation of mobile Ag+ species and a more flexible network framework. Concurrently, optical measurements show composition-dependent variations in refractive index, optical bandgap, and infrared transmittance, governed by changes in mean coordination number and network polarizability. Together, these findings demonstrate how controlled Ag addition enables simultaneous optimization of ionic and optical properties through targeted network engineering.

Keywords: chalcogenide glasses, refractive index, ionic conductivity, glass transition temperature, infrared transmission

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Glass formulation of CaO/SrO-La2O3-Al2O3-ZrO2 system using In-Flight Melting Method

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Conditional glass formation of CaO/SrO-La2O3-Al2O3-ZrO2 system was investigated using container-less In-Flight Melting method, where the raw materials particles is injected into hydrogen/oxygen combustion burner flame and melted. Wide range of composition showed glass formulation and the spherical glass particles were obtained.
This glass system is expected to show wide optical transmission window and high mechanical toughness and also interesting optical properties. However, due to high melting point of the constituent oxides, glass formulation have not been well reported. Hydrogen/oxygen combustion burner flame provides extremely high temperature. In-Flight melting promises rapid heating at T> 2000 degree-C.

By referring to the phase diagram of La2O3-Al2O3-ZrO2 system, various composition of raw fine materials were mixed with the addition of appropriate CaO/SrO, and heat-treated once to form sintered materials. After crushing and classification, the raw materials particles were injected into the burner flame. After flying in flame about 30 cm for several 10 ms, the formed molten droplets were suddenly quenched in air, and collected. From the injection to quenching, the materials were held in air without contact to other material.

The collected glass particles were observed by optical microscope, and their structural information were obtained using Powder X-ray diffraction, thermal analysis, and Raman and EXAFS spectroscopies. From optical microscope observation, transparent spheres were confirmed although those devitrified were also observed which were considered not to have been heated well depending on the irregular flight course in flame.

EXAFS analysis focused on the coordination environment of Zr. We employed two measurement techniques; ordinary XAFS on powder pellet and micro-XAFS on each sphere. Combing with other structural information using other spectroscopies, the relationship between the composition and structure is discussed from the point of view of glass forming tendency and properties.

*Speaker

Keywords: Glass formation, In flight melting, CaO/SrO, La2O3, Al2O3, ZrO2

Li-Ion Transport and Mechanics of Li–S–P–B–I Glassy Electrolytes

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Glassy sulfide and halide based electrolytes are promising candidates for all-solid-state lithium batteries owing to their high ionic conductivity and good processability. Their ionic transport and mechanical properties depend on the complex local structure, but structure-property relations are not yet fully understood. This work employs molecular dynamics simulations with a machine learning force field (MLFF) to reveal how the competition between flexible B–S and rigid P–S networks governs the properties of Li–S–P–B–I (LSPBI) glasses across a full composition range ($0P_2S_5$ to $100P_2S_5$). The developed MLFF accurately reproduces *ab initio* reference data and enables large-scale simulations to explore dynamics and mechanics mechanisms. The distinct roles of B–S and P–S bonding networks govern both ionic transport and mechanical response in the glassy Li–S–P–B–I electrolytes. B–S bonds tend to form more flexible and reconfigurable local structures, which facilitate Li-ion migration through transient bond rearrangements. In contrast, the stronger and more directional P–S bonds generate a rigid network that suppresses Li mobility. Under external stimuli, the out-of-equilibrium interactions between Li and its S-coordinated neighbors promote local bond-switching events in B–S environments, while P–S frameworks resist such rearrangements. This compositional contrast explains the simultaneous variation of ionic conductivity and fracture resistance as the relative proportions of B–S and P–S units evolve. This work provides atomistic insight into how chemical composition governs transport and mechanical properties in Li–S–P–B–I glass electrolytes, offering guidance for the design of robust and high-performance solid electrolytes. **Keywords:**

Lithium, ion batteries, Glassy electrolytes, Machine learning force field, Ionic conductivity

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Revisiting the rate-dependent hardness of glass

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Over 75 years ago, Taylor first reported the formation of permanent imprints on glass surface following Vickers indentation.[1)] Five years after Taylor's report, Ainsworth[2)] observed that the mean diagonal length of Vickers imprint on glass depended on the loading conditions, such as the duration time and the contact speed of the tip. More precisely, the mean diagonal length of Vickers imprints on glass increased as the indenter tip's contact speed ($\gtrsim$ 20 mm/s) was increased. However, using a recent dynamic indentation apparatus ($\sim 10^3$/s) such as Split-Hopkinson pressure bar, an inverse relationship was also reported for several types of glasses.[3)] (i.e. the larger contact speed results in the shorter diagonal length.) This conflicting evidence may be due to differences in the experimental conditions, compositions, and cracking, which affect the determination of the diagonal lengths. In this study, therefore, the dynamic indentation hardness of soda-lime and borosilicate glasses was evaluated by using three different set-ups (pendulum test, belt-slider test, and universal mechanical testing apparatus) with blunter diamond pyramid indenters. The blunter indenter enabled crack-free, larger imprints to be obtained, which reduces the uncertainty in measuring the diagonal length of imprints. The results of these dynamic indentation tests show that the dynamic hardness of soda-lime and borosilicate glasses is lower than their quasi-static hardness. This is because the deformation mechanism under the indenter changes from permanent densification to shear flow as the contact duration time increases. A longer contact duration time or slower penetration rate results in a larger contribution of shear flow. Since the yield stress for shear deformation of glass may be greater than for densification, the quasi-static hardness should be higher than the dynamic hardness.

1) E. W. Taylor, Nature, 163 (1949) p.323.
2) L. Ainsworth, J. Soc. Glass Tech. 38 (1954) p.479.
3) For example, R. J. Anton & G. Subhash, Wear 239 (2000) p.27. **Keywords:** Hardness, Rate, dependence, Densification

*Speaker

Ionic conductivity enhancement in Li2O-P2O5 glasses by AlCl3 addition

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The effect of halide incorporation into the glass structure to enhance ionic conductivity in phosphate and borate glasses is already known. However, in these previous studies, halide ions were introduced through lithium halides, thus also enhancing lithium concentration. In this presentation, we will discuss the effect of introducing halide ions by incorporating AlCl3 into the x Li2O – (100–x) P2O5 (x = 55, 60, and 64.5) glass system, thereby avoiding the incorporation of extra Li+ charge carriers. The highest chlorine content, as determined by chemical analysis, is found in the glass with the highest Li2O/P2O5 ratio, i.e., for x = 64.5. The introduction of AlCl3 increases the glass transition temperature, Tg. Nuclear magnetic resonance (NMR) reveals that the incorporation of aluminum into the glass structure occurs via the expected replacement of P–O–P linkages by new P–O–Al bonds, whereas the incorporation of chlorine results in minimal apparent structural changes. The rise in ionic conductivity is clearly found to follow the increase in chlorine content for all three series of glasses.

Keywords: Ionic conductivity, solid electrolyte, halides salt, phosphate glass

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Multi-Scale Structural Origins of Rare-Earth Luminescence in Glasses

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Disentangling how structural disorder at different length scales governs rare-earth luminescence remains a fundamental challenge in optical materials science. Although local coordination environments are widely regarded as the primary determinants of rare-earth emission, growing evidence indicates that structural organization beyond the first coordination shell can also play a critical yet insufficiently understood role. In crystalline materials, however, the intrinsic requirement of long-range periodicity severely constrains the introduction and independent control of disorder, limiting systematic investigations across multiple structural length scales.

Glasses provide a unique structural platform to overcome this limitation, as they inherently combine long-range disorder with tunable short- and medium-range organization. In this work, Ce^{3+}-doped borosilicate glasses are employed as a model system to investigate the distinct roles of short-range and medium-range structural disorder in regulating rare-earth luminescence. By systematically varying the B/Si ratio, the glass network structure is modulated in a controlled manner, enabling selective tuning of different structural regimes.

Advanced structural characterization, including synchrotron-based pair distribution function analysis, reveals contrasting structural responses at different length scales, highlighting the non-trivial evolution of medium-range order within the disordered glass network. Complementary optical and temperature-dependent spectroscopic measurements demonstrate that the observed luminescent behavior cannot be fully accounted for by local coordination effects alone. Instead, it reflects a coupled response to structural organization extending over multiple length scales. In particular, variations in medium-range structural flexibility are found to correlate with distinct thermal response characteristics, suggesting an important role of non-local structural effects in governing non-radiative relaxation processes.

Together, this study proposes a hierarchical perspective on rare-earth luminescence regulation, in which short-range and medium-range structural disorder play fundamentally different yet cooperative roles. These findings provide new insight into disorder-sensitive luminescence mechanisms in glasses and offer general guidance for the rational design of luminescent materials through controlled structural complexity. **Keywords:** Multiscale structure, Structure, property relationship, pair distribution function

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Pressure-induced densification of vitreous silica: Insight from elastic properties

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In situ high-pressure Brillouin light scattering experiments along loading-unloading paths are used to investigate the compressibility of vitreous silica. Below 9 GPa, the equation of state obtained from the sound velocities corrected for dispersion agrees with volume measurements. Conversely, huge anelastic effects are observed in the range 10–60 GPa, unveiling the reversible transformation from the fourfold-coordinated structure to the sixfold one. The associated density changes correlate with the average Si coordination number. Decompression curves from above 20 GPa reveal abrupt backward coordination changes around 10–15 GPa and significant hysteresis. Contrary to common wisdom, the residual densification of the recovered silica samples can be figured out from changes in elastic properties along pressure cycles, ruling out a plastic description of the latter process. **Keywords:** Silica glass, high pressure, polyamorphism, Brillouin scattering, structure, densification, elastic properties

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Thermal conductivity of oxide glass-ceramics

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The thermal transport in oxide glasses and glass-ceramics is poorly understood despite their importance for the development of new materials, either for fast heat transport or thermal insulation. The disordered structure of glasses complicates the prediction of thermal conductivity, given the lack of periodicity compared to crystalline materials. However, the thermal conductivity of glasses may be described similarly to that of their crystalline counterpart (for glasses with crystalline stoichiometry), with the main difference being the mean free path causing a change in phonon scattering. Thus, the conversion of crystals into glasses results in a better insulating material. In this presentation, the effect of crystallization on thermal conductivity in silicate glasses will be discussed. The formation of glass-ceramic materials is expected to result in thermal conductivities that fall between those of the amorphous and crystalline endmembers. However, we have demonstrated that partial crystallization suppresses the thermal conductivity before it increases towards crystalline values. This anomalous behavior is emphasized by an initial decrease in thermal conductivity of approximately 20 % compared to the virgin glass, occurring at a relative crystallinity of around 15 %, followed by an increase in thermal conductivity as the relative crystallinity increases. The initial drop is attributed to an enhanced scattering effect of the glass-crystal interface compared to that of the amorphous structure itself. Besides the relative crystallinity, the size of crystallites in the glass-ceramics plays a significant role in the thermal conductivity. Lastly, the possibility of introducing the anomalous behavior into insulating materials will be discussed to enhance the insulation properties of construction materials for low-energy buildings in the future.

Keywords: Thermal conductivity, Silicate glass, Glass, ceramic, Crystallinity

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Quenching Rate and Composition Combined Effect on Structural Properties and Microstructure in Magnesium Aluminosilicates

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As the energy demand increases worldwide, a need appears for ever-bigger and ever-efficient wind turbines, largely placed at sea, far from shores, to harness stable winds and lack of obstacles. To meet this demand, necessary materials must be ever-lighter (low density), ever-cheaper and ever-stronger (high Young's modulus). For a few decades, fiberglass composites have met all those criteria. Where polymer resins bring chemical resistance, it encases fabrics of woven fiberglass that bring rigidity and mechanical resistance to the blades. It is thus of interest to increase, to the best of our abilities, the mechanical resistance of those fibers.

A proven way to do so is to dope fibers with rare earths. To understand the link between rigidity in glass fibers and rare earths composition, we studied the effect of a few molar percent of lanthanum and yttrium on the structure of bulk and fiber glass. Notably the effect of the quenching rate on the structure and mechanical properties has been studied through ^{27}Al NMR and molecular dynamics. Studied quenching rate ranges from 10^2 K/s (dip quench) to 10^{13} K/s (via molecular dynamics). While it has been shown that both rare earths promote 5- and 6-coordinated aluminium species (1), the relationship between the concentration of rare-earth and the concentration of 5-coordinated aluminium is very dependent on the quench rate. Thus, where it has been shown in bulk glasses that an increase of the mean coordination of aluminium (Z_{eff}) leads to an increase in rigidity, higher quench rate seems to promote lower Young's modulus.

*Speaker

The origin of this effect was studied through RE K-edge EXAFS, Electron Paramagnetic Resonance (EPR) and Raman spectroscopy on three experimental sample sets with different quenching rates and a fourth simulated one to get a multi-scale understanding of the effects of both quenching rate and rare-earths insertion on the glass network.

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Keywords: quench rate, rare, earths, nmr, structure, modulus

From Two-Phase to Porous: Surface and Electrical Characteristics of Sodium Borosilicate Glasses

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Porous glass nanocomposites based on sodium borosilicate (SBS) glasses offer a promising platform for incorporating various ions or nanoparticles into their internal pore networks. SBS glasses are particularly suitable as host matrices because they remain structurally and chemically stable after embedding, while their irregular pore distribution allows them to host a wide range of guest materials. In this work, Broadband Dielectric Spectroscopy (BDS) is used to determine the electrical properties of the materials and to analyze relaxation processes observable both in phase-separated (two-phase) glasses and in their porous counterparts. Dielectric measurements also reveal how the electrical response evolves because of structural changes induced in two-phase glasses during chemical treatment. Additional characterization included mercury porosimetry technique to determine the average pore size, pore-volume distribution, and overall porosity of the samples. Complementary X-ray Photoelectron Spectroscopy (XPS) measurements will be used to identify differences in the surface structure of phase-separated (two-phase) and porous glasses. These structural insights will help to better understand the origin of the electrical properties observed in dielectric measurements and clarify how chemical treatment modifies the glass surface and, consequently, its electrical behavior.

*Speaker

High temperature non-Newtonian rheology: case of nuclear glass melts

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Nuclear industries produce radioactive waste that must be immobilized to prevent the dispersion of radionuclides into the environment. In France, high-level radioactive waste is calcined and then vitrified in an industrial furnace at temperatures typically ranging from 1000 to 1250 ∘C, using an industrial glass frit. The molten glass is poured into a steel container, forming a monolithic block whose chemical composition depends on both the waste and the frit used. Understanding the rheological behavior of the molten glass is critical for industrial processing. Homogeneous melts behave as Newtonian fluids, with their flow characterized by a single viscosity. The temperature dependence of viscosity can be modeled using empirical equations such as the Vogel-Fulcher-Tammann model. However, more complex compositions may exhibit non-Newtonian behaviors, including thixotropy, yield stress, and viscoelasticity.
A rotational rheometer coupled with a cylindrical furnace was used to investigate the rheological properties of systems representative of nuclear glass compositions. The sample is placed in a geometry consisting of a rotating and a static part. The device applies torque to the sample and measures its angular displacement, enabling the calculation of shear stress and shear rate, and thus the determination of apparent viscosity at various shear rates. The geometries were calibrated using model Newtonian oils in a Couette analogy method.
In addition to homogeneous Newtonian melts, three systems of interest for nuclear glass were studied. First, certain waste compositions introduce insoluble particles of platinum group metals (RuO_2, Pd, Rh) into the melt, altering its rheology. These particles induce shear-thinning behavior, well described by the Sisko model, due to their disaggregation under high shear. Rapid re-aggregation upon flow cessation results in thixotropic behavior. A second case involves partial crystallization of the melt at processing temperatures. Isothermal experiments under constant shear revealed an increase in viscosity during crystallization, attributed to changes in the suspending fluid's composition and hydrodynamic interactions caused by crystal presence.Finally, a glass system exhibiting phase separation was analyzed. The phase separation temperature was estimated by the onset of non-Newtonian and thixotropic behavior at decreasing temperatures. The behavior of the second-phase droplets under various shear conditions was also investigated.

*Speaker

Keywords: Rheology, Nuclear, Suspension, Crystallization, Phase separation

Solid-State Vitrification of Li and Al Phosphates Through High Energy Mechanical Milling

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New glassy states of several phosphates (LiPO3, LiCa(PO3)3, Al(PO3)3) were obtained at room temperature from their respective crystalline phases via solid-state mechanical processing in a planetary ball mill. We demonstrate the feasibility to reach a glassy state by mechanical methods starting from a state of low energy, the crystal phase, instead of the quenching of the melt. The products of milling were analyzed using XRD, 31P, 7Li, 27Al NMR, and DSC. The mechanically amorphized materials show DSC signatures of glass transition and crystallization to the original phase. These glasses are produced in excited structural states, relaxing the excess of enthalpy through an exothermic process below Tg, akin to hyperquenched glasses. The collapse of the crystal structures as a function of the milling time was monitored by 31P-NMR, revealing the disappearance of resonances from P-crystallographic sites and the appearance of structural disorder. The crystal-to-amorphous transition seems to proceed as a continuous process developed by accumulation of defects and bond distortions during the early stages of milling ($<$ 5 h). During this period, progressive increases in local disorder around PO4 groups and in the excess of enthalpy are observed, but no glass transition is defined yet. Above that time, structural and thermal parameters are stable and a glass transition is clearly observed. For Al(PO3)3, a system very difficult to vitrify by conventional methods, 31P-NMR indicate the disruption of the 4-membered rings of PO4 tetrahedra in the crystal and the formation of long chains or large rings in the amorphous state. 27Al-NMR shows the change in the coordination of Al, from octahedral in the crystal to a distribution of 4, 5, and 6-fold coordination in the amorphous state. From 7Li-NMR, it was concluded that Li+ mobility is similar in glasses produced by melt-quench and mechanical process. Glasses obtained from mechanical process are less stable than their melt-quenched counterparts, showing lower Tg, Tc, Tc -Tg, and crystallization enthalpy. Structurally, they show more Qn-disproportionation, suggesting differences in middle-range order. Conversely, the milling of melt-quenched glasses causes increases in glass stability and disproportionation, suggesting an accumulation of distortions over the structure of the glass.

Keywords: structure, relaxation, mechanochemistry, NMR, phosphates

*Speaker

On the nature of the glass transition in metallic glasses studied via fast scanning calorimetry

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Only recently, the development of fast differential scanning calorimetry (or chip-calorimetry) has allowed us to characterise in situ the glass transition response of metallic glasses during cooling from the liquid over a wider range of time scales employing scanning rates from 100 K/s up to 50,000 K/s. The generally accepted description is that the vitrification kinetics should exhibit the same temperature dependence as the relaxation time for the alpha-process. However, we have recently observed that vitrification at deep undercooling may occur with a milder temperature dependence than the alpha-relaxation (1-2). The slower the system is cooled the more pronounced is the decoupling between these vitrification kinetics and the atomic mobility. As a consequence, vitrification can occur at fictive temperatures lower than those which would be obtained only accounting for the alpha-process. This apparent decoupling of the time scales for the vitrification kinetics from the time scales for the alpha-relaxation process is more pronounced at deep undercooling and for small sample sizes. This is of most importance because, it advocates a heterogeneity of cooperative atomic rearrangements, where faster mechanisms for atomic mobility that apparently are not contributing to the alpha-relaxation process, are maintaining the undercooled liquid system in (metastable) equilibrium and delay vitrification to lower temperatures.

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Keywords: Glass transition, calorimetry, metallic glasses

*Speaker

Fragility Dependence of Relaxation Dynamics in Silicate Glasses Near the Glass Transition

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Fragility of glass-forming liquids is a critical factor in glass relaxation processes, governing the connection between metastable equilibrium and nonequilibrium regions. It is typically quantified using a unitless index that characterizes dynamic behavior near the glass transition. While the fragility index is widely used to analyze the composition dependence of relaxation dynamics, some estimation methods rely on assumptions, including the equivalence of activation energy for enthalpy relaxation and viscous flow. Recent studies have revealed that these relaxation processes can decouple in certain glass compositions. A systematic investigation of relaxation processes across a wide range of fragility values could provide insight into this decoupling mechanism and its relationship to fragility. This study examines the fragility dependence of various relaxation mechanisms near the glass transition in different silicate glass families over a broad range of fragility index values.

Keywords: relaxation, fragility, supercooled liquids, viscosity, enthalpy, calorimetry

*Speaker

Probing glassy dynamics and local elasticity in dense colloidal suspensions: insights from single-particle experiments

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We study experimentally the nature of the colloidal glass transition, drawing from several single-particle studies. We show how stirring at the particle scale in supercooled colloidal liquids uncovers heterogeneous dynamics and slow relaxation processes. Next, we discuss direct measurements of local elasticity near the glass transition, highlighting significant spatial variations in viscoelastic properties and their connection to microscopic particle motion. Finally, we describe experiments using forced probe particles to reveal nonlinear responses and signatures of dynamic arrest as the colloidal suspension approaches a glassy state. Together, these experiments provide a comprehensive view of how localized perturbations and microscale measurements elucidate the emergence of glassy behavior and dynamic heterogeneities in dense colloidal systems.

Keywords: Colloidal glass transition, colloidal suspensions, local perturbation.

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Simultaneous memory effects in the stress and in the dielectric susceptibility of a stretched polymer glass

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We study the molecular dynamics of relaxation processes during plastic flow of glassy polymers up to the strain hardening regime by Dielectric Spectroscopy.
We consider various histories of deformation from the onset of the non-linear regime up to large amplitude deformation.
In particular we show that the relaxation time evolves non-monotonously. The dynamics is accelerated by the applied stress and is the fastest in the stress softening regime then slows down in the strain hardening regime, whereas the width of the relaxation time distribution gets narrower first and then broadens in the strain hardening regime. We consider then more complex deformation histories.
In a second set of experiments, we stop the deformation at some point during the strain hardening regime and maintain fixed the deformation.
The stress remains high. It allows to study the ageing of the same in this regime. Then, we resume the deformation at constant strain rate and study
the evolution of the distribution of relaxation time. We do similar studies in a third "unloading protocole" with the difference that the stress is set almost to zero during the arrest step.
We consider the evolution of the distribution of relaxation times. We conclude that the presence of a stress allows the samples to age by structural relaxation.
The effect of changing the the stress level on the dynamics is very fast, either upon increasing the stress (acceleration of the dynamics) or upon decreasing the stress
(slowing down of the dynamics). On the other hand, our experiments point to the fact that strain hardening is associated to modifications which are very slow to relax. This slow relaxation
process is responsible for the memory effect of polymers in the strain hardening regime and we attribute them to chain orientations. Jérôme Hem, Caroline Crauste-Thibierge, Thomas C. Merlette, Florence Clément, Didier R. Long and Sergio Ciliberto Microscopic Dynamics in the Strain Hardening Regime of Glassy Polymers Macromolecules 55 (2022) 9168.

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Thomas C. Merlette, Jérôme Hem, Caroline Crauste-Thibierge, Sergio Ciliberto, Florence Clément, Paul Sotta and Didier R. Long Theory of Plasticity and Strain Hardening of Glassy Polymers Macromolecules 56 (2023) 6510.

Keywords: Memory effects, Polymers, Dielectric Spectroscopy, Strain, hardening

Unified theory of phonon in solids with phase diagram of non-Debye anomalies

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The classical Debye model successfully predicts the phononic contribution to the specific heat of solids in the continuum limit. However, as the phonon wavenumber increases, their vibrational density of states gradually deviates from the Debye prediction and eventually manifests as the Van Hove singularities for crystals, and a boson peak for glasses. To date, there is still much controversy over whether these two non-Debye anomalies are equivalent or not. In this talk, we propose a unified model and demonstrate that it describes the vibrational density of states in both crystals and glasses. We achieve this by treating the vibrational excitation of solids as the elastic phonons resonating with local modes. Our modeling enables the construction of a phase diagram of non-Debye phonon anomalies. We clarify that the Van Hove singularity and boson peak can evolve as two variants of the same entity when the dispersion displays continuous softening; otherwise, they emerge separately due to resonance-induced extra acoustic softening, further proved by their coexistence. The model is supported by a comparison with experimental heat capacity data over a wide range of real solids, including 143 crystalline and glassy substances. These findings provide a unified picture of the Van Hove singularity and boson peak, and deepen our fundamental understanding of continuum elasticity of real solids.

Keywords: Phonon, Vibrational density of states, scattering, Van Hove singularity, Boson peak

*Speaker

Modeling viscoelastic behaviour of a nonequilibrium glass

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Two processes related to the relaxation of the structure of a glassy material are discussed:

- the relaxation of the structure to the equilibrium state described with the use of internal variables which evolve to the equilibrium values;
- corresponding stress relaxation since the viscosities depend on above variables.

A viscoelastic material is modeled as the Maxwell material consisting of an elastic element and two viscoelastic elements. The viscosities of dashpots in the second and the third Maxwell elements depend on the internal variables which characterize how far the material is from the equilibrium state. It is assumed that the free energy of the first element is a quadratic function of the elastic strain equal to the total strain, while the energies of the second and the third elements are the quadratic forms of elastic strains and the internal variables with cross effect.

The dependencies of the total stress on the total strain and kinetic equations for the internal variables are formulated based on the Clausius-Duhem inequality. The cross-terms in the free energies make additional contributions to the stresses induced by the nonequilibrium structure represented by internal variables and have the meaning of internal stresses. Then the internal variables were specified as fictive temperatures. Finally the derived system of equations for the internal variables and viscous strains was solved to describe the stress relaxation and evolution of the viscosity to the equilibrium value in the case of uniaxial tension.

Two sets of material parameters were chosen for which it was shown that:

- The stress relaxation and structure relaxation characteristic times can be the values of the same order. In this case one can observe the direct dependence of the viscosity on stress, i.e. so called nonlinear viscosity;
- If the stress relaxation time is much less than structure relaxation time then the influence of stress on viscosity and structure relaxation is noticeable only at short times, while the relaxation of the structure and, thus, the viscosity to equilibrium values continues after stress relaxation.

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Keywords: Viscoelasticity, nonequilibrium glass, fictive temperature, stress relaxation, structure relaxation, generalized Maxwell model

Nonequilibrium Viscosity and Structural Relaxation Kinetics in PbSiO3 Glass

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Viscosity above 10ˆ12 Pa·s in the glass transition range is intrinsically time dependent, as structural relaxation proceeds toward metastable equilibrium. Despite its fundamental importance for glass dynamics, systematic measurements of nonequilibrium viscosity below Tg remain scarce. In this work, the time-dependent viscosity of PbSiO3 glass was quantified using penetration viscometry under constant load in the temperature range 375–395 ∘C, below Tg = 408 ∘C. The penetration depth h(t) was continuously monitored during isothermal holds, and the instantaneous viscosity η(t) was calculated from the time-resolved penetration rate. The η(t) increased with time, approaching a steady plateau corresponding to metastable equilibrium. The viscosity evolution at each temperature was accurately described by the Kohlrausch–Williams–Watts (KWW) function, yielding characteristic relaxation times
tau and stretching exponents $\beta <$ 1. Although
tau values were comparable to the Maxwell stress-relaxation time, the time required for near-complete equilibration was longer due to stretched kinetics. To account for nonlinear aging effects, the dataset at all temperatures was analyzed using the Tool–Narayanaswamy–Moynihan (TNM) model, incorporating the evolution of fictive temperature. A single set of kinetic parameters described the full temperature range. The relaxation parameters obtained from viscosity closely matched those previously determined from refractive index relaxation in the same glass batch, demonstrating that both observables probe the same intrinsic α-relaxation process. Equilibrium viscosity was described using the Mauro–Yue–Ellison–Gupta–Allan (MYEGA) model and incorporated into the Mauro–Allan–Potuzak (MAP) model to account for the nonequilibrium initial states through their dependence on fictive temperature. Together, the MAP model quantitatively described the initial nonequilibrium viscosity, KWW and TNM captured its temporal evolution, and MYEGA represented the final equilibrium state reached. These results establish a physically consistent connection between nonequilibrium viscosity, structural relaxation kinetics, and equilibrium dynamics in the PbSiO3 system.

Keywords: Glass transition, structural relaxation, aging, penetration viscometry, nonequilibrium viscosity

*Speaker

Memory and recovery effects in the strain hardening regime of glassy polymers : comparison between theory and experiments

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Complex memory effects under applied strain are a defining feature of glassy polymers in the strain hardening regime. We proposed recently a theory for plastic flow and strain hardening as controlled by two contributions to the free energy barriers in glassy polymers submitted to an applied deformation. Free energy barriers decrease under the effect of the stress,which leads to yielding and the onset of plastic flow. Conversely, monomer orientation increases the barriers. These two contributions have very different kinetics. The contribution related to the stress relaxes quickly as a function of the applied stress whereas the orientation contribution relaxes by rotational diffusion, which is very slow at depth in the glassy state. This description could account for the main feature of the Bauschinger effect when considering a stop of the deformation followed by a resuming of the deformation after some waiting time, or for describing deformation cycles, e.g. a tensile test followed by a compression, or the reverse. We show here that the same model allows for interpreting and explaining memory effects in complex deformation histories as regard the distribution of relaxation times, the evolution of tangent delta measured by dielectric spectroscopy and the kinetics of recovery of the reference curve as a function of the waiting time and allows for the interpretation of recent experimental results obtained by small probes reorientation dynamics and dielectric spectroscopy.

Keywords: Polymer physics, glass transition

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Phase Change Materials from the Liquid and Glass Point of View

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Phase change materials (PCM) are highly unstable glass-forming solids that can switch rapidly and reversibly between the glassy and crystalline phase. The high contrast in physical properties between the two phases has led to their use in many technological applications such as optical and electrical memories where binary information can be encoded using the contrast in conductivity or reflectivity of the memory cell. While the crystalline phase of PCM has been extensively studied, the glassy phase has received less attention, yet it exhibits unique physical behaviors due to the extreme quenching rates required for its formation. In particular, it shows very unusual dynamic behavior due to its abnormally low isotructural viscosity resulting from its exceptionally high fictive temperature. Probably their most striking feature is that glassy PCMs can crystallize far below the glass transition temperature in a way analogous to hyperquenced amorphous water. The liquid phase of PCMs is equally unusual as they broadly exhibit liquid-liquid phase transitions accompanied by fragile-to-strong transitions. This presentation will review recent evidence in the relaxation and dynamic behavior of liquid and glassy PCMs and their implication for technological applications in novel fields such as neuromorphic computing.

Keywords: phase change materials, chalcogenides, glass transition, isotructural viscosity, relaxation

*Speaker

Local scale probing of the relaxation mechanisms in a metallic glass-former by calorimetric, mechanic, and structural investigations

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The thermodynamic equilibration of the glass, or physical aging, is a complex phenomenon, recently evidenced to be driven by several relaxation mechanisms, whose molecular origins are still under scrutiny. Despite its known impact on macroscopic properties, physical aging is not fully understood in terms of structural changes, owing to its self-slowing-down character, which leads the relaxation process duration to largely exceed the laboratory timescale. The increase of the relaxation time being even more critical far below the glass transition, the experimental data gathered from long-term storage are precious resources to complement the predictive models.
Metallic glasses offer the advantage to generally situate in the deep glassy state at ambient temperature, that is, where the concomitance of several mechanisms is proved. Besides, their structure can be finely described at the atomic scale. Eventually, they show decent resistance against environmental aggressions, suggesting that their structural changes over time are essentially related to physical aging. It is worth noting that metallic parts target long service time, which makes the physical aging study relevant for applicative purposes as well. Several insights regarding the relaxation features in metallic glasses and the underlying structural mechanisms have been gained during the last decade, offering new foundations to discuss their behavior after prolonged storage.
In this work, the physical aging impact consecutive to ten years of storage is investigated on a magnesium-based glass. Based on the Adam Gibbs theory, a characteristic size of molecular motions, triggered by nanoindentation is evaluated to reveal the heterogenization of glassy dynamics. Meanwhile, the structural evolution over time is studied by atomic probe tomogra-

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phy. Eventually, the relaxation kinetics are investigated from fast scanning calorimetry. The enthalpy loss and the fictive temperature, needed to follow the glass equilibration, are extracted from isochronal and isothermal experiments. Furthermore, step response analysis is used to catch the temperature dependence of the relaxation time in the glass transition vicinity, allowing to estimate the kinetic fragility.

Keywords: physical aging, cooperativity, nanoscale

Oxidation state-induced glass-forming ability of melts with high vanadium content

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The ability to form glasses in the system CaO-V2O5, up to pure V2O5, was studied using conventional melt-quenching techniques, FDSC (fast differential scanning calorimetry) and aerodynamic laser-levitation, while the polyvalence of vanadium (V5+, V4+, V3+) in the obtained glasses was analysed by X-ray Near Edge Structure (XANES) and Raman spectroscopy. The correlation between the oxidation state at elevated temperatures (oxygen partial pressure) and the ratio of vanadium valence states, which is frozen in the glass transition temperature, is discussed with regard to calorimetric and viscosimetric data in order to determine the fragility of V2O5 as a conditional glass-forming oxide.

Keywords: FDSC, Raman spectroscopy, calorimetry, viscosimetry, V2O5, polyvalence of vanadium

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Isomorph Theory as a Framework for Understanding Glass Formation: Insights from High-Pressure Experiments and Simulations

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When a liquid is cooled or compressed into a glass, its dynamics slows down dramatically-changing by many orders of magnitude. This change in relaxation dynamics is accompanied by subtle structural evolution. Isomorph theory predicts that all structural features and dynamics stay invariant along the same lines in the phase diagram; these lines are referred to as isomorphs. The theory works well for simple LJ-type systems in molecular dynamics (MD) simulations, but the question has been to which extend it is relevant for real experimental molecular systems. For more than a decade we have worked on developing and performing experimental tests of the isomorph theory. To probe the dynamics, we combine dielectric spectroscopy and quasielastic neutron scattering, accessing time scales from picoseconds to kiloseconds. This is combined structural studies by X-ray scattering and supported by MD-simulations on realistic molecular-models. Combining all these techniques we have tested a number of different isomorph predictions and established strong evidence that isomorph theory holds for van der Waals bonded liquids and gives some level of insight to ionic liquids and hydrogen bonding liquids as well.

The implication is that any general theoretical description of viscous slowing down and the glass transition must be compatible with the framework provided by isomorph theory. Isomorph theory does not explain the glass transition but simplifies the problem by reducing the thermodynamic phase diagram from 2 dimensions to 1 dimension.

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Keywords: Glass transtion, theory, molecular glasses

*Speaker

Probing the microstructural heterogeneity of metallic glass: Universal understanding of DMA, stress relaxation and creep

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The intrinsic structural heterogeneities of amorphous alloys are closely related to thermodynamics. The state of amorphous alloy is also determined by its thermal and mechanical history. The implication is twofold: the dynamical behavior (such as mechanical relaxation, aging, glass transition, crystallization and plastic deformation) determines the state of the glass, which in turn determines its future dynamical behavior. Furthermore, the structural information is submerged into the out-of-equilibrium disordered long-range structure, which makes it difficult to explore and resolve the features of amorphous alloys heterogeneities. Due to the structurally disordered arrangement of atoms and deviation from thermodynamic equilibrium, the physical and mechanical properties of metallic glasses can vary with time, temperature and magnitude of strain or stress. The current talk provides a theoretical framework based on the hierarchically correlated atomic theory, which allows a quantitative description of the non-elastic deformation in metallic glasses. The defect concentration is adopted as an order parameter, which can evolve with temperature and non-elastic strain owing to correlated atomic movements. Through our hierarchically correlated atomic theory, we derive the characteristic times for local shear events in metallic glasses that entail activation, growth and/or annihilation of flow defects, which however are not accounted for in the previous mean field theories. Finally, we demonstrate that the current theoretical framework can be validated by the dynamic mechanical relaxation, stress relaxation and creep experiments on typical metallic glasses, which in turn provides quantitative insights into the non-elastic deformation mechanisms in metallic glasses.

Keywords: Metallic glass, Stress relaxation, Creep, Microstructural heterogeneity, Physical model

*Speaker

Dynamical Heterogeneity in Inorganic Network Liquids: Temperature and Fragility Dependence

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The atomistic origin of a stretched exponential kinetics for the primary or α- relaxation in supercooled liquids remains a highly debated topic in the literature. However, it is now well-established that the stretching results from a spatio-temporally heterogeneous relaxation with a distribution of relaxation times. In the present study the temperature dependence of the stretching exponent β for a-relaxation is determined for a wide variety of supercooled strong and fragile inorganic glass-forming liquids using a powerful combination of shear-mechanical and neutron spin-echo spectroscopy and dynamic light scattering. While β and fragility are observed to be uncorrelated, a clear pattern emerges when the variation of β is considered as a function of the α-relaxation timescale
$tau\alpha$. In particular, for relatively strong liquids β increases rapidly with decreasing
$tau\alpha$ upon increasing temperature above the glass transition. In contrast, for fragile liquids β remains nearly constant with increasing temperature until
$tau\alpha$ becomes rather short, on the order of nanoseconds. Beyond this point, further increase in temperature results in a rapid increase in β. Possible microscopic origins of these observed patterns in $\beta($
$tau\alpha$) as a function of fragility will be discussed.

Keywords: relaxation, fragility, heterogeneity, stretching, spectroscopy, scattering

*Speaker

Permanent structural modifications of silica glass after laser shock for different impulsion regime

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Understanding the structural and physicochemical transformations of materials subjected to hypervelocity impacts is of great interest in both planetary science and aeronautical engineering. The analogy between laser-induced shocks and real impact events enables the reproduction of those extreme loading conditions in the laboratory, in terms of pressure, temperature, and strain rates (beyond 100 GPa, 5000 K and 10^7 s^{-1}) (1). High-intensity laser facilities make it possible to generate various shock-loading regimes, while associated *in situ* and time-resolved diagnostics provide access to mechanical parameters such as shock and particle velocities.

In silica glass, shock-wave propagation induces structural and atomic rearrangements (2). The subsequent release waves, hydrodynamic decay, and thermal diffusion all contribute to the thermomechanical history of the material. The resulting permanent deformations can be measured and analyzed, particularly through post-mortem Raman spectroscopy.

In this work, different laser pulse regimes (femtosecond, picosecond and nanosecond) were investigated using different laser installations (ELFIE, HERA) for shock experiences on silica glass. Post-mortem investigations (optical, Raman spectroscopy) of the impacted zone were carried on to study structural modifications as a function of depth beneath the impacted zone. Two kinds of investigations were done: 1) from the sample surface; 2) from the side of the sample (along an orthogonal plan to the impacted surface) after cutting it.

*Speaker

Residual permanent structural transformations with depth are presented. Results are finally discussed in terms of structural modifications, permanent densification and laser pulse regimes (i.e., strain rate and thermomechanical history).

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Effect of Na2O/CaO ratio on the Performance of Bioactive Glasses

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Bioactive glasses are used clinically to regenerate bone and fight infections such as osteomyelitis. Bioactive glass reactivity with water is a key step in their biomedical performance, and various studies have investigated the influence of silica content and silicate network polymerization (or network connectivity) on making silicate glasses bioactive or antimicrobial. In the present study, we focus on the network modifiers, by maintaining silica content constant while varying Na2O/CaO ratio. Raman and Si-29 MAS NMR spectroscopy show the network connectivity to remains nearly unchanged, many glass properties changed drastically. was measured using a rotating crucible viscometer and a creep apparatus for the high- and low-viscosity regions, respectively. The Adam–Gibbs equation was used to fit the results while accounting for configurational entropy. Decreasing the Na2O/CaO ratio leads to higher viscosity and glass transition temperature, along with a reduced tendency for crystallization. Density measurements followed by molar volume calculations show that the molar volume decreases with decreasing Na2O/CaO ratio. Lower Na2O/CaO ratios also enhance the chemical durability of the glasses, reflected in slower ion release and less pronounced pH changes upon immersion in physiological testing solutions. These changes arise from the higher field strength of calcium ions compared to sodium and the increased packing density created when Na2O is replaced by CaO (or, rather, when two sodium ions are replaced by one calcium ion).

Keywords: Bioactive glass, network modifier, structure

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Relaxation dynamics in anisotropic orientional glass-formers of planar ring molecules

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Orientational disorder in crystalline phase is known to give rise to glassy properties, quite similar to those of canonical glasses. Planar molecules as hexasubstituted benzene derivatives with similar substitutions as methyl groups or chlorine atoms have previously been described to show orientationally disordered phases, for which the aforementioned methyl and chlorine occupy the crystallographic sites with different occupational factors. Such a disorder within a crystalline framework enables to account details of the dynamics as well as to correlate them with structural properties. In addition to the low-temperature anomalies of these orientational glasses, the dynamics of the disordered phases will be here described by using different spectroscopic techniques, as broadband dielectric spectroscopy and inelastic neutron scattering.

The low-dimensional, highly anisotropic disorder involving these quasi-planar hexasubstituted benzene derivatives have revealed, contrary to what might be expected from a decrease in disorder, a greater complexity of the dynamics: the low-dimensional glass-former actually exhibits a richer landscape, with two distinct whole-molecule (primary) α- and α'-relaxations. The study of the different relaxations will be explored, in addition to the aforementioned experimental techniques, with molecular dynamics simulations, which have enabled to rationally account for their physical origin. **Keywords:** Orientational glass, relaxation dynamics

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Linear Scaling Between Excess Modes and Structural Disorder in Metallic Glasses

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The boson peak-an excess of low-frequency vibrational modes beyond Debye scaling-is a long-standing anomaly of amorphous solids. While structural disorder has been proposed as its physical origin, quantitative evidence remains limited. Here we demonstrate such evidence in realistic metallic glasses by generating amorphous states from unstable in silico glasses to ultrastable regimes. Using a configurational-entropy–based order parameter, we uncover a linear scaling between structural disorder and excess vibrational modes. This scaling reflects competition between a dispersion-less quasi-localized transverse excitations at high wavevector and damped harmonic modes, both controlled by degree of structural disorder. The coincidence of the boson-peak frequency with the Ioffe–Regel limit further supports this mechanism. Our results establish structural disorder as the key control parameter of non-Debye modes quantitatively, reconciling competing theories of vibrational anomalies in glasses.

Keywords: metallic glass, boson peak, configurational entropy, dispersion, less mode

*Speaker

Network Connectedness in Non-Zachariasen Oxide Glasses

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The vast majority of oxide glasses contain atomic structures bound by Zachariasen's rules: (1) oxygen atoms are linked to no more than two network-forming cations, (2) the number of oxygen surrounding a network-forming cation is small, *i.e.* four or less, and (3) the oxygen polyhedra share corners with each other, not edges or faces. The standard analysis for network connectedness in these glasses is the Q^n distribution, which quantifies the number of neighboring network units in a tetrahedral network. Levitation melting enables the vitrification of oxide glasses with atomic structures that defy all of Zachariasen's rules, and the network connectedness of these non-Zachariasen glasses cannot be adequately described using Q^n. Specifically, the network is not strictly tetrahedral, edge-sharing is present and often constitutes 10–30% of the overall linkedness, and a significant fraction of oxygen is triply coordinated to network-forming cations. To better quantify and compare the connectedness of these networks, we introduce a modified definition for connectedness, K^n, to account for this structural complexity. The application and utility of K^n is illustrated with three case studies of levitation melted glasses: rare earth aluminates, rare earth titanates, and unmodified aluminosilicates. **Keywords:** oxide,

network, structure, levitation melting, xray scattering, neutron scattering, EPSR, aluminates, titanates

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Glass transition and glassy state - a new perspective

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Using StepScan DSC, a technique without temperature modulation, the glass transition was studied. When analyzing the results, a key problem of the kinetic theory of the glass transition was identified - the neglect of the always present weak, so-called van der Waals interactions. These interactions are crucial and eliminate the hard-to-accept consequences of the kinetic model, i.e., the idea that glass is a melt that may or may not crystallize at any temperature and time, and if glass does not crystallize, then an entropic crisis, known as the Kauzmann paradox, occurs when the temperature is lowered. It has been shown that the glass transition is a thermodynamically equilibrium process dependent only on the chemical composition. Below the glass transition temperature, only the solid phase exists, either as a thermodynamically stable crystal or a thermodynamically metastable glass. Thus, glass is not a melt and the thermodynamically unacceptable Kauzmann paradox, which is in fact only a theoretical consequence of the kinetic model, is eliminated.

Keywords: Glass transition, van der Waals forces, Kauzmann paradox, StepScan DSC

*Speaker

Thermo-optic response of chalcogenide glasses for fibered infrared devices

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Chalcogenide glasses have emerged as a promising platform for the development of fiber-based mid-infrared (MIR) photonic devices due to their exceptional optical properties (1), including broad transparency, high nonlinearity, and tunable refractive indices. The thermo-optic (TO) response of infrared-transparent glasses is a critical parameter for designing temperature-stable photonic devices. In this work, we systematically investigated the temperature dependence of the refractive index of fiber-drawing compatible glasses of compositions $Ge_{16}As_{24}Se_{15.5}Te_{44.5}$ (GAST45), $Te_{20}As_{30}Se_{50}$ (TAS50), $Ge_{20}Se_{60}Te_{20}$ (GST20), and a polymer: polyethersulfone (PES). Measurements were performed across the 0.5–4 μm spectral range starting at higher temperatures down to the room temperature using spectroscopic ellipsometry technique combined with temperature-controlled stages. The refractive index data were fitted with Sellmeier models, enabling extraction of $\mathrm{d}n/\mathrm{d}T$ values.

The results reveal distinct thermo-optic behaviors: GST20 and TAS50 exhibit moderate positive $\mathrm{d}n/\mathrm{d}T$ values $\sim$(2–3 $\times$ 10^{-5} K^{-1}), while GAST45 shows a strong response $\sim$(20–30 $\times$ 10^{-5} K^{-1}) linked to its high Tellurium content, which is consistent with literature. PES polymer shows negative thermo-optic coefficient $\sim-$(1.2–3) $\times$ 10^{-4} K^{-1} within the considered wavelength range.

Comparative analysis highlights the role of glass composition in governing TO coefficients, with chalcogenide systems offering tunability through change of composition. These findings provide benchmark data for modeling dispersion and show the future possibility to adjust the linear or nonlinear parameters of fibered waveguides. Potential of the simultaneous integration of the selected materials within functional hybrid fibered architectures is discussed.

(1) Fang, Y., D. Furniss, D. Jayasuriya, et al. "(INVITED) Methods for Determining the Refractive Indices and Thermo-Optic Coefficients of Chalcogenide Glasses at MIR Wavelengths." *Optical Materials: X* 2 (May 2019): 100030. https://doi.org/10.1016/j.omx.2019.100030. **Key-words:** Chalcogenide glass, Ellipsometry, Thermo, optic coefficient, Infrared

*Speaker

Cs3TbCl6 Perovskite Nanocrystal-Embedded Silicate Glasses for LED color converter

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Halide perovskite nanocrystals ($CsPbX_3$, X = Cl, Br, I) exhibit narrow emission linewidths of ∼20 nm and high quantum efficiency, making them promising materials for next-generation optoelectronic devices such as LEDs, displays, and photovoltaics. Their commercialization, however, has been restricted by the toxicity of lead (Pb) and their poor stability under air, light and heat. Efforts to obtain a lead-free metal halide perovskite (LFMHP) nanocrystal system, thus, have focused on substituting Pb with lanthanides, actinides, or transition metals. Most reported approaches, however, rely on solution-based methods (e.g., hot-injection, colloidal, solvothermal), which offer insufficient thermal and chemical stability and thus restrict their practical applications. Embedding nanocrystals within inorganic glass matrices provides a promising alternative, as glasses provide excellent robustness with reasonable quantum yield. However, studies on Pb-free perovskite nanocrystal-glass systems have been rarely reported. In this study, silicate glasses were used as the host matrix, where PbO was replaced with Tb_4O_7 to induce the crystallization of robust, lead-free Cs_3TbCl_6 nanocrystals upon heat treatment. Glass preparation and heat treatment conditions have been varied to form the nanocrystals. The successful formation, structure, and morphology of the Cs_3TbCl_6 phase were confirmed by XRD, TEM and SEM. Characteristic luminescence from Tb^{3+} has been observed and its intensity was significantly improved with the formation of nanocrystals. The results demonstrated the potential of Pb-free, nanocrystal-embedded glasses as stable and efficient candidates for next-generation LED and optoelectronic applications. **Keywords:** Lead free perovskite, Nano

crystal, glass, LED, Photoluminescence

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The glass science of optical nonlinearities

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Scaling the output power from optical fiber-based amplifiers and lasers to higher levels is important for a wide variety of reasons. From a technological perspective, the applications of high-power fibers range from machining and manufacturing to directed energy systems. From a scientific perspective, the underlying physics is fascinating and offers insights into new phenomena and a deeper understanding of light-matter interactions. However, the long propagation lengths and small mode sizes that are defining features of modern fibers often exacerbate parasitic nonlinearities and thermal effects prior to the desirably high powers being reached. This talk will focus on the materials physics of light-matter interactions as relevant to mitigating nonlinearities and thermal effects in optical fibers. Put another way, approaches to reduce and potentially negate parasitic nonlinearities materially though the judicious selection of the composition of the fiber core will be reviewed. Additionally, and synergistically, recent advances in the internal cooling of fiber lasers using anti-Stokes fluorescence, including the realization of athermal fiber lasers, will be discussed including the overlapping benefits of internal cooling and intrinsically low optical nonlinearities.

Keywords: optical fiber, glass, nonlinear optics

*Speaker

Structure-Property Relationship and Thermometric Performance of RE3+-Doped High TeO2 Content Glasses

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Tellurite glasses have attracted significant interest for photonic and thermometric applications owing to their high refractive indices, wide optical transparency, and excellent rare-earth (RE3+) ion solubility. In this work, we present a comprehensive structural and optical investigation of pure TeO2 glass compositions doped with Eu3+, Sc3+, and Yb3+. The glasses were synthesized from highly purified precursors to minimize extrinsic compositional effects, enabling the intrinsic structural features of the TeO2 network to be elucidated. Complementary spectroscopic techniques, including Raman, solid-state NMR, EPR, and photoluminescence, were employed to reveal how RE3+ ions are accommodated within the tellurite framework. Raman analysis indicated the formation of non-bridging oxygens upon doping, while distinct vibrational features in Sc3+-doped samples suggested specific structural rearrangements. These results provide new insights into the inherent flexibility and stability of the tellurite network. Building upon this structural understanding, we investigated the potential of RE3+-doped TeO2 glasses for luminescence thermometry. Er3+/Yb3+ co-doped samples exhibited upconversion emission from thermally coupled 4S3/2 and 2H11/2 levels, enabling reliable primary thermometry between _˜250 and 550 K with a maximum relative sensitivity (SR) of 1.1% K-1 at 300 K. Additionally, Eu3+-doped glasses showed temperature-dependent excitation spectra, revealing three distinct intensity inversion regions and SR ≈ 0.5% K-1 at 300 K. The excellent agreement between experimental and modeled temperature data confirms these materials as robust, calibration-free optical thermometers. Overall, the combined structural and luminescence analyses establish high-TeO2 content glass as a versatile model host for understanding RE3+ interactions and for the design of next-generation photonic and thermometric materials.

Keywords: RE3+, doped TeO2 glasses, TeO2 glass structure, Er3+/Yb3+ upconversion, Eu3+ excitation thermometry, Luminescence thermometry

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Optical performance in mechanically improved multicomponent oxide glasses

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Oxide glasses play a central role in advanced materials, both in cutting-edge research and in widely available commercial technologies. They stand out due to their wide chemical flexibility, stability, and relatively simple fabrication routes, which make them suitable for large-scale and cost-efficient production. Their tunable refractive index and ability to combine high optical quality with chemical durability have already enabled applications ranging from lenses and optical fibers to displays and biomedical devices. Furthermore, as emerging technologies demand improved performance and security, oxide glasses continue to attract interest as materials capable of providing mechanical resistance while preserving desirable optical properties.
Despite their relevance, traditional oxide glass families face important challenges, especially regarding brittleness and the need to expand their functional capabilities without compromising transparency, processability, or stability. Recent research to overcome these limitations has focused on exploring chemically complex compositions to unlock improved optical and mechanical behaviors. By tailoring composition through multiple network-forming oxides, it is possible to enhance structural compactness and charge density, ultimately achieving higher refractive indices, an essential feature for many modern optical design.
In parallel, incorporating trivalent rare-earth dopants enables further optical functionality by means of characteristic electronic transitions suitable for sensing, luminescence, and energy-related applications. Rare-earth-doped oxide glasses have shown improved emission efficiencies when embedded in highly polarizable networks, emphasizing the importance of composition engineering. In this work, we investigate multicomponent oxide glasses containing more than five network-forming oxides, focusing on their mechanical behavior and optical viability. Special attention is given to the incorporation of rare-earth ions such as Sc3+, Er3+, Yb3+, and Eu3+ to explore their influence on structural and optical behavior. The motivation is to advance the understanding and development of glass systems that combine enhanced optical performance with mechanical robustness, paving the way for durable, high-index materials suitable for next-generation photonic and sensing applications.

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Keywords: multicomponent oxide glasses, rare earth ions, hardness, Young's modulus

Synthesis and characterization of Ca2Nb2O7 - based glass-ceramics for optical applications

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Lanthanide-doped $Ca_2Nb_2O_7$ offers versatile and tunable luminescence properties. Previous studies have shown that Pr^{3+}-doped and Pr^{3+}/Er^{3+} co-doped $Ca_2Nb_2O_7$ ceramics exhibit non-destructive mechanoluminescence and thermoluminescence and have potential for optical temperature sensing. However, to date, there are very few studies on calcium niobate glass-ceramics, although they would offer excellent temperature resistance, controllable crystallization and high chemical durability.

This study investigates Pr^{3+} single doping and Pr^{3+}/Er^{3+} co-doping in glass-ceramics prepared from niobate-containing calcium aluminosilicate (CAS) glasses. The aim is to obtain glass-ceramics containing $Ca_2Nb_2O_7$ crystals that have the perovskite layered structure and to evaluate their potential as lanthanide hosts.

Glasses with the composition $55CaO–(35\text{-}x)Al_2O_3–10SiO_2–xNb_2O_5$ (mol%, where x = 0, 5, 10) were prepared by melt-quenching, and then doped with Pr^{3+} single doping and Pr^{3+}/Er^{3+} co-doping before controlled crystallization and characterization.

Niobate glass-ceramics containing only $Ca_2Nb_2O_7$ crystals were successfully synthesized. The luminescence properties of both glasses and glass-ceramics were investigated and it is shown that the glasses show intrinsic luminescence and act as self-activators. Furthermore, in the doped glass-ceramics several interesting photoluminescence mechanisms were observed: UV excitation induces charge transfers to the activator ions, Er^{3+} up-conversion from NIR to the visible and Pr^{3+}–Er^{3+} energy transfer, broadening the range of Er^{3+} excitation. Overall, the $Ca_2Nb_2O_7$ host enhances rare earth emission efficiency, demonstrating the strong potential for photonic and energy conversion applications in glass-ceramics. **Keywords:** Energy Transfer, Glass, Ceramic, Niobate, Rare Earth Host

*Speaker

Multi-Angle Optical Characterization of Reflective and Transmissive Scattering Using the Agilent Cary 7000 UMS

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Traditional optical characterization methods often rely on single-angle measurements of specular reflectance and direct transmittance, which can overlook critical angular scattering phenomena. These effects are especially relevant in applications involving optical coatings, surface gloss, diffuse scattering media, and functional optics such as sensors, displays, and solar cells.
This study leverages the Bidirectional Scattering Distribution Function (BSDF) framework-comprising the Bidirectional Reflectance Distribution Function (BRDF) and Bidirectional Transmittance Distribution Function (BTDF)-to quantify angular scattering behavior. While conventional goniophotometers and custom-built setups can perform such measurements, they are typically limited by manual operation and restricted angular coverage.

The Agilent Cary 7000 Universal Measurement Spectrophotometer (UMS) overcomes these limitations through full automation of angle of incidence, detector rotation, polarization control, and sample orientation. It supports a wide spectral range (250–2500 nm) and delivers high precision via automated alignment and detector selection.
We demonstrate the Cary 7000 UMS's capabilities by characterizing both reflective and transmissive scattering across a range of materials. Reflectance measurements compare Lambertian and glossy surfaces, while transmittance studies contrast silica and PTFE samples. The results confirm the system's robustness and reproducibility in BSDF analysis, making it a powerful tool for advanced optical material characterization.

Keywords: BRDF, BTDF, BSDF, optical scattering, Cary 7000 UMS, Lambertian, Specular, Diffuse scattering, PTFE, silica

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Elaboration of an electrode on a chalcogenide glass fiber for operando monitoring of a battery by infrared spectroscopy

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Infrared optical fiber evanescent wave spectroscopy (FEWS) represents an innovative approach for real-time investigation of chemical phenomena and electrodes interfaces in batteries; the knowledge of these two key factors permits to improve the lifetime of Li(Na)-ion batteries. Indeed, FEWS enhances our understanding of these complex processes and paves the way for more durable and efficient batteries.

To study these phenomena in the most effective way, the most appropriate solution would be to integrate the electrode directly onto the fiber. This would make possible to understand the changes in their entirety, rather than being limited to partial information due to the weak penetration depth of the evanescent wave. In this study, for the first time, an electrode is fabricated directly on an optical fiber. To do so, the fiber is made conductive with a 50 nm Indium Tin Oxide (ITO) layer deposited by magnetron sputtering, while preserving its infrared transparency.

Then, a 100 nm of Prussian Blue ($NaFe^{3+}(Fe^{2+}(CN)_6)$) layer is electrodeposited to obtain the positive electrode. The opto-electrochemical sensor thus elaborated is integrated into a functional battery system, allowing real-time monitoring of electrolyte decomposition mechanisms, ion solvation dynamics, and structural evolutions of the electrode material during cycling. **Key-words:** Optical sensors, Chalcogenide fibers, Batteries, Prussian blue

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Integration of active glass with planar waveguide platform

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Erbium-doped waveguide amplifiers (EDWAs) are fundamental for the on-chip integration of active photonic functions onto platforms like silicon nitride (Si3N4) or lithium niobate (LiNbO3), enabling applications in quantum technologies such as lasers, modulators, and memories. However, glass integration using direct bonding techniques at low temperatures is challenging since it requires bonding between the glass and the host platform with minimal damages such as cracking due to coefficients of thermal expansion mismatches or even glass crystallisation. A promising method for scalable material integration and conformal shaping is the slumping of glass. This thermal process leverages gravity and glass viscosity to conform a heated section to the waveguide geometry and the host platform. This procedure is particularly relevant for tellurite glasses because their low glass transition temperatures (_˜280-320∘C) permit low working temperatures during slumping, thus limiting glass and waveguide damages. Furthermore, tellurite glasses are highly valued in photonics for their unique optical properties, including a wide transparency window (0.36 to 6 μm), high rare-earth solubility (_˜10ˆ21 Er3+.cm-3), and the ability to finely tune their refractive indices which are key requirements for efficient waveguide amplifiers. Although slumping offers benefits over other integration methods (sputtering, ionic exchange, pulsed laser deposition), two primary challenges remain the low surface reactivity of the slumped glass which can prevent bonding to the waveguide and the host platform, and the formation of internal stress combined with a narrow processing window prior to glass devitrification may lead to cracking during the subsequent annealing process. In this work, we present our approach for optimizing the slumping process in tellurite glasses with various geometries (bulk, fibres), detailing a force-free integration concept and its progress. Endowing photonic integrated circuits with gain via this method offer an alternative for the robust miniaturization of various on-chip active devices.

Keywords: Glass integration, Tellurite glasses, LiNbO3, Silicon Nitride

*Speaker

Exploring ZIF-62/Lanthanide-MOFs Composites: Structure and Optical Properties

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The field of luminescent metal–organic frameworks (MOFs) has predominantly focused on the crystalline state, despite the significant advantages offered by the glassy phase. MOFs are highly versatile materials with potential for multiple applications, such as photonics, among others. Recent studies have demonstrated the feasibility of producing hybrid glasses with permanent porosity from zeolitic imidazolate frameworks (ZIFs). In this project, we aim to combine the luminescent properties of lanthanide MOFs-which typically exhibit high thermal stability and a wide range of possibilities in the crystalline phase-with the unique structural and porous characteristics of ZIF-derived glasses to develop MOF crystal–glass composites. To investigate these materials, we employed a combination of analytical techniques, including Differential Scanning Calorimetry (DSC), X-ray Diffraction (XRD), luminescence spectroscopy, and Solid-State Nuclear Magnetic Resonance (NMR) spectroscopy, providing comprehensive insights into the structural and functional behavior of the composites. ZIF-62 was synthesized via solvothermal methods, while the luminescent MOF was prepared through a similar solvothermal approach. The materials were characterized using NMR, complemented by analyses of glass transition temperature, crystalline structure, and luminescence properties. DSC analysis revealed the melting temperature of ZIF-62, followed by the identification of the glass transition temperature (Tg) during the second heating cycle, with vitrification confirmed by the absence of diffraction peaks in XRD. Importantly, the resulting ZIF-62 glass was transparent, highlighting its potential for optical applications. Luminescence analysis demonstrated that the characteristic emission of the MOF was preserved within the composite material. Additionally, ^{13}C and ^{1}H NMR spectroscopy revealed chemical shift variations, corroborating the amorphous structure of the glassy matrix. Overall, this study successfully explored the glass formation of transparent ZIF-62 and its integration with a luminescent MOF, demonstrating the potential of these crystal–glass composites for advanced functional materials.

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Keywords: MOF composites, Luminescent lanthanide MOFs, ZIF62 glass formation, Solid state NMR

How phosphate or germanate glasses can provide solutions for integrated optics

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The integration of photonic components has become crucial in several areas such as sensing, data communication, biomedical, quantum technology and optical storage. Silica based glass composition is not always well adapted and can present limitations. Oxide glasses of exotic non-silicate composition such as phosphate, germanate or gallate glass matrices become then particularly interesting for photonic applications by offering original photosensitivity properties or extended transparency ranges in the infrared.

Reducing the size of components and photonic systems is challenging. Among the different approach, femtosecond (fs) Direct Laser Writing (DLW) has appeared well adapted for implementing high precise and localized multiscale three-dimensional modification in glass to design low scale photonic component. Indeed, Direct Laser Writing (DLW) has been an exponentially growing research field during the last two decades, by providing an efficient and robust way to directly address three dimensional (3D) structures in transparent materials such as glass using femtosecond laser pulses. Generally, DLW in glasses induces physical changes such as permanent local refractive index modifications that have been classified in silica under three distinct regime inducing refractive index modification, nanogratings and voids labelled Type I, Type II & Type III.

Adapting the glass composition to the DLW techniques allows generating novel optical components hardly accessible with silica based glass compositions. Indeed, among the different approach, the adaptation of the glass composition to DLW is becoming an emerging topic in material science. Femtosecond laser structuring applied to silver or bismuth-containing glass allows for instance developing a new regime of interaction based on photochemistry and redox. It allows creating a variety of photo-induced species or nanoparticles depending on the laser parameters but also the material glass composition leading to unique three-dimensional linear and nonlinear optical properties. Close relations have been established between the local structural modification, the initial glass composition and the optical response.

DLW associated to exotic glass composition can led to the development of various photonic components such as waveguides for integrated optics, imaging or sensors, custom phase plates, but

*Speaker

also more recently prototypes of “free” lenses, micro-optics or novel way to engineer integrated lasers. **Keywords:** phosphate, germanate, photosensitive, laser material interaction

Fs-laser induced nanostructures for high temperature optical sensing – challenging the limits of glass

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When ultrashort laser pulses are tightly focused inside transparent glass, they generate extremely high light intensities, on the order of tens of TW/cm^2. This leads to ultrafast heating of the exposed glass to thousands of degrees, along with multi-gigapascal pressure shockwaves, resulting in irreversible material transformations. These transformations, such as phase separation, crystallization, or cavitation, depend on both the laser parameters and the glass composition. These modifications can be used to functionalize glass-based devices, including optical fibers in the form of Fiber Bragg gratings (FBGs) for sensing applications. FBGs offer advantages like compactness, sensitivity, flexibility, and multiplexing capabilities for measuring temperature, pressure, or strain. However, in high-temperature environments (above 800 ∘C), such as turbine engines, combustors, or nuclear reactors, specific nanostructures like Types IIp and IIIp must be imprinted in the glass due to their good thermal stability. For instance, in standard Ge-doped silica core optical fibers, these nanostructures can withstand 900 ∘C for 1 year and 1100 ∘C for 30 minutes, respectively. While impressive, this limits their use in more extreme but requested conditions, such as 1000 ∘C for 1 year in aircraft or above 1500 ∘C for 30 minutes in alarm systems.

This presentation will review the key parameters / mechanisms driving the erasure of these nanostructures at elevated temperatures, which ultimately degrade the optical sensor response(s) (e.g., wavelength drift and reflectivity loss in FBGs). A theoretical framework based on the Rayleigh-Plesset equation, combined with optical and electron microscopy analyses, will help clarify the degradation kinetics. Lifetime predictions for these optical devices will also be discussed, supported by accelerated aging experiments.
Finally, we will explore potential strategies to enhance the thermal stability of such devices. These include using glass compositions with photo-imprinted crystalline phases (e.g., ZrO_2- or Al_2O_3-based) and developing novel glass compositions like oxycarbides to increase glass viscosity and improve thermal stability over silica-rich glasses. Both theoretical and preliminary experimental validations will be presented.

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Keywords: optical sensors, photo, structuring, nanoporous structures, high temperature

Controlling pump power and Er3+ doping concentration in zinc-germante-tellurite glasses for light-emitting devices

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This work investigates tunable color emission in Er3+ doped tellurite glasses with nominal composition (70 – x)TeO2–25ZnO–5GeO2–xEr2O3 (x = 0.25, 0.50, 0.75, 1.00 mol%). Tellurite hosts are attractive for color-controllable emitters owing to their high transparency from the visible to near-IR and strong nonlinear response that supports efficient upconversion (UC). By varying the 980 nm pump power and the Er3+ concentration, we quantify how the green/red UC intensity ratio changes-and thus how the perceived emission color can be tuned. Micro-photoluminescence measurements were performed on a system using a 980 nm diode laser and a 50x objective to ensure precise focusing on the glass surface. Chromaticity mapping was employed to track color coordinates as functions of excitation power and dopant level. The study elucidates the energy-transfer pathways underlying UC and demonstrates the suitability of the TZG glass matrix for color-controlled light-emitting applications. Complementary UV–Vis absorption spectroscopy was used to derive refractive indices from transmittance via the Nussbaumer method and to validate dispersion with Sellmeier fits. Optical band gaps and Urbach energies were obtained from Tauc analyses. A systematic increase in optical band gap with Er3+ content is observed, suggesting modifications of the local field and glass network around the activator ions. Together, these results provide design guidelines for optimizing rare-earth-doped glasses as tunable color light sources.

Keywords: Tellurite glasses, Rare, earth ions, Chromaticity, Luminescence

*Speaker

Innovative environmental multisensing for waterbody quality monitoring and remediation assessment

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Water pollution has reached critical and continuously increasing levels, driving a global need for advanced solutions to monitor environmental water quality. Real-time in situ monitoring systems enable faster responses and more efficient water treatment management (1). However,

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natural water bodies are highly heterogeneous and dynamic, making accurate in situ monitoring challenging with current technologies. There is a clear need for sensing devices with improved selectivity, higher sensitivity, and broader detection ranges.
Although several in situ monitoring solutions exist, many-primarily from non-EU suppliers-remain limited in scope, measuring only a few parameters and suffering from high costs, limited reliability, and significant energy consumption. To better meet end-user needs and enhance environmental monitoring, innovative sensing technologies are required.

The european project IBAIA addresses these challenges through the development of four complementary sensor modules based on photonic and electrochemical technologies, integrated with microfluidic and microelectronic systems:

- A Mid-IR sensor module combining a chalcogenide glass transducer, QCL chip array, and III-V detector for selective detection of organic micropollutants, supported by regenerable or biodegradable polymers and an optimized microfluidic system for reduced environmental impact.

- A VIS-NIR sensor module based on rare-earth-doped oxide glass for improved salinity measurements and microplastic detection.

- An optode sensor array for cost-effective monitoring of pH, O_2, and CO_2, including integrated temperature compensation.

- A regenerable electrochemical sensor using nanostructured gold or carbon microelectrodes for detecting trace metals (e.g., As, Cd) and nutrients (e.g., phosphates, nitrates).

These modules will be integrated into a single portable, cost-effective multi-sensor platform. Each module will be interchangeable, providing flexibility in both functionality and cost depending on user requirements. The IBAIA system will enable real-time, in situ monitoring of multiple pollutants and physicochemical parameters, supported by advanced remote data processing, including machine learning and data fusion.

The system is designed for deployment across diverse aquatic environments, such as rivers, lakes, estuarine, and coastal waters. It will be particularly valuable for rapid response to accidental pollution events and for monitoring wastewater treatment processes, including phytoremediation systems.

The project has received funding from the European Union's Horizon Europe Framework Programme under grant agreement No 101092723.
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Keywords: chalcogenide, thin films, waveguide, sensor, water pollutants monitoring

Infrared photonic sensors based on chalcogenide thin films for monitoring of water pollutants

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Detecting organic molecules in water is a major scientific and environmental challenge due to rising pollution and growing global demand for clean water. Conventional analytical techniques, though precise, are unsuitable for real-time or in situ monitoring. To address this, the development of portable optical sensors has become essential. Mid-infrared (MIR) spectroscopy offers powerful molecular identification through unique vibrational signatures but conventional instruments remain bulky and costly. Integrated photonic platforms based on waveguides and evanescent-field sensing provide a compact and efficient alternative, enabling real-time analyte detection directly in aqueous environments.
Chalcogenide glasses have emerged as promising materials for mid-infrared (MIR) photonics due to their unique optical and physical properties. Composed of elements such as sulfur, selenium,

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or tellurium combined with arsenic or germanium, they provide broad MIR transparency and high refractive indices that allow strong light confinement in waveguides. Their refractive index can be tuned through composition to balance confinement and evanescent field penetration, optimizing sensor sensitivity. Moreover, their amorphous structure permits thin-film deposition on diverse substrates using scalable techniques like RF sputtering, enabling the fabrication of integrated photonic components.

This study develops planar waveguide structures based on GeSe2 chalcogenide glasses for mid-infrared (MIR) sensing in water, avoiding arsenic compounds for environmental safety reasons. Thin films were deposited by RF sputtering and thoroughly characterized for morphology and optical properties. The films exhibited high uniformity, low surface roughness, and low optical losses. Waveguide geometry was optimized to enhance evanescent field penetration and improve interaction with target analytes.

An integrated fabrication and processing framework was developed to convert chalcogenide materials into scalable sensing platforms for water analysis. The waveguides were surface-functionalized with a hydrophobic polymer coating to improve chemical stability, analyte selectivity, and durability while maintaining MIR transparency. The resulting transducer is compatible with microfluidic systems and designed to be reconfigurable for various sensing scenarios. Its modular architecture supports the integration of quantum cascade laser arrays and MIR detectors, enabling compact, versatile, and portable in situ sensing solutions.
The financial supports of the European Union's Horizon Europe Framework Programme under grant agreement No 101092723 (IBAIA)

Keywords: chalcogenide, thin films, waveguide, sensor, water pollutants monitoring

Phosphor-in-glass (PiG) composites for white light emission and persistent luminescence

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The integration of luminescent particles into glass matrices has emerged as an alternative strategy for developing multifunctional materials with enhanced optical and luminescent performance, environmental compatibility, and thermal stability. The so-called Phosphor-in-Glass (PiG) systems can offer a robust alternative for solid state lighting, photochromism,

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and persistent luminescence (PersL) combining the advantages of inorganic phosphors with the processability and mechanical resilience of glasses. Recent works have demonstrated that the microstructure of the glass host – pore morphology, particle dispersion, and interface chemistry – plays a critical role in stabilizing the particles, tuning the properties, and securing long-term stability of these composites. At the Glass division at BAM, we have been working on this research topic through different approaches. Examples are lead-free double halide perovskites as $Cs_2Ag_{0.4}Na_{0.6}Bi_yIn_{1-y}Cl_6$ (CANBIC, $y = 0.01$–0.04) obtained by mechanochemistry and the silicates Sr_2SiO_4:Eu(II) and $BaMgAl_{10}O_{17}$:Eu(II) obtained by sol gel, which are dispersed in hybrid matrices. Besides, we have been studying the photochromic and PersL phosphors $Sr_2MgSi_2O_7$:Eu^{2+},Dy^{3+}, $LiNa_7Al_6Si_6O_{24}(Cl,S)_2$:$Ti^{3+}$ and $Na_8Al_6Si_6O_{24}(Cl,S)_2/(Br,S)_2$, sintered into borosilicate glasses. The composite materials are characterized from the structural, thermal, and photophysical viewpoints through DRX, DSC, Raman, UV-Vis, and PL. In this work we will present an overview of the results so far obtained and future perspectives.
Keywords: phosphor in glass, perovskites, persistent luminescence, glass composites

SiO2-Er3+:NaGdF4 upconversion coatings prepared by combining green hydrothermal and sol-gel methods

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This work reports the successful preparation of SiO2-Er3+:NaGdF4 upconversion (UC) coatings using a pre-crystallized nanoparticles sol-gel route. The synthesis combines the use of a green hydrothermal method for the controlled crystallization of β-NaGdF4 nanocrystals with a low-temperature sol-gel process to obtain homogeneous coatings. Dopamine was employed as a surface functionalizing agent, which provided excellent colloidal stability and prevented nanoparticle agglomeration during the incorporation into the SiO2 sol. Different amounts of Er3+dopant were explored and the best UC performance was observed for 6 mol% Er3+:NaGdF4. The resulting coatings also exhibited remarkable UC luminescence under near-infrared (NIR) excitation, attributed to the preservation of the crystalline phase and the uniform distribution of nanocrystals within the silica matrix. Structural and optical characterizations (XRD, FTIR, TEM, and photoluminescence spectroscopy) confirmed the successful integration of Er3+:NaGdF4 within the silica matrix. This study presents a promising approach for the fabrication of rare-earth based UC coatings for applications in photonics and optoelectronics.

Keywords: UC coatings, sol, gel, luminesce, SiO2, Er3+:NaGdF4

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Managing Efficient Second-Order Optical Nonlinearity in Optical glasses by micro-poling methods

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Numerous breakthroughs in photonics have been achieved by harnessing nonlinear optical properties, particularly in the field of information technologies. To fully exploit the nonlinear optical potential of glass, multidisciplinary research efforts have been essential, integrating optics, glass chemistry, materials science, and the development of advanced optical or electrical polarization processes. This presentation explores both the fundamental aspects of second-order optical properties in glasses and recent advances demonstrating that amorphous inorganic materials can now rival lithium niobate single crystals in performance. Through a thermo-electrical imprinting process, we show the ability to precisely control-at the micrometer scale-the geometry and spatial location of highly efficient second-order optical responses ($\chi(2) = 29$ pm/V at 1.06 μm) in amorphous niobate thin films. These results open up exciting opportunities for the future design of integrated nonlinear photonic circuits based on amorphous inorganic materials, leveraging the spatially selective and effective second-order optical susceptibility of these innovative materials.

*Speaker

Soft glasses: a powerful platform for the exploration of new concepts and applications

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Soft glasses offer a huge versatility in optical properties through tailoring of glass composition and doping with luminescent species (lanthanides, crystal particles). Their ability to be processed and shaped at relatively low temperature opens up unprecedented control of optical fibre cross-sectional structures and new avenues to incorporate crystal particles or to suppress their formation in glass. These features make soft glasses a powerful platform to explore new science and engineering concepts as well as new applications as illustrated by these examples:

- tellurite glass fibres doped with luminescent lanthanide ions for new avenues in temperature sensing and volumetric display (1,2,3)
- extrusion-based glass shaping techniques for fabricating optical fibre preforms with new structures (4,5,6)
- tellurite and lead-silicate glass fibres doped with luminescent diamond particles for quantum-based magnetic field sensing; design of doping technique to control size and spatial distribution of diamond particles in fibres (7,8,9)
- tellurite glass fibres doped with lanthanide-containing microcrystals for new concept of lasing at the limit of glass transparency (10)
- unprecedented control of the size and concentration of gold nanocrystals in tellurite glass for extraordinary tuning of plasmonic effects (11)
- glass-based tissue-mimicking phantom material with tailored absorption, luminescence and scattering for calibration of imaging systems (12)
- ZBLAN fluoride glass fibres drawn in microgravity for next-generation fibre optics cables for conventional and quantum communication (13)

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Influence of Rare Earth Concentration on the Structural Properties and Luminescence Thermometry Performance of Fluorophosphate Glasses and Glass-Ceramics

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Glass-ceramics combine the compositional versatility of glasses with the mechanical stability of ceramics, enabling advanced applications such as waveguides and sensors. Rare-earth ions (RE3+) are attractive for luminescence thermometry due to their narrow emission bands and high compatibility with host matrices, especially in glasses and glass-ceramics. This study investigates the influence of the material type on the temperature-dependent upconversion emission in fluorophosphate glasses and glass-ceramics containing different concentrations of ytterbium(III) (Yb3+) and erbium(III) (Er3+), while maintaining a constant ((PO3)–)/(F–) ratio. DSC thermograms revealed relatively low characteristic temperatures (glass transition, Tg, and onset crystallization, Tx, temperatures) for the glasses, which increased with the incorporation of RE3+. The increase in Tg suggests enhanced structural connectivity, likely due to network crosslinking by RE oxides, whereas the rise in Tx indicates a tendency toward crystallization inhibition by RE ions. The high thermal stability ($\Delta T = Tx - Tg$), above 100 ∘C, enabled the formation of glass-ceramics through controlled heat treatments. Raman spectra showed a decrease in Q2 units accompanied by an increase in Q1 and Q0 units, indicating phosphate network depolymerization with increasing RE3+ content, along with redshifts in the bands assigned to Q0 and Q2, associated with P–O bond weakening and increased local effective mass. 19F NMR analyses revealed four distinct fluorine sites, whose chemical shift variations suggest increased fluoride coordination with RE3+. Additionally, the paramagnetic nature of RE3+ induces changes in fluorine magnetic relaxation rates (shortening T2), leading to peak broadening as the RE3+ content increases. Overall, the DSC, Raman, and NMR 19F results provide evidence that RE3+ addition modifies the short-range order around fluoride ions and the overall structure of the glass network. Finally, under 980 nm excitation, the intensity ratio between the emissions from the thermally coupled levels 2H11/2 (525 nm) and 4S3/2 (546 nm) served as a thermometric parameter (Boltzmann distribution) and yielded relative (SR) and absolute (SA) thermal sensitivities of approximately 1.1% K–1 and 3.2×10–3 K–1, respectively, confirming the potential of these materials as primary optical thermometers.

*Speaker

Keywords: Lanthanides, luminescence thermometry, Raman, NMR

Green and NIR Emissions of Yb3+-doped CsPbBr3 Perovskite Nanocrystals Embedded in Borosilicate glass for Anti-counterfeiting Applications

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Abstract

Halide perovskite nanocrystals have demonstrated significant potential in optoelectronic applications such as solar cells, lasers and light-emitting diodes (LEDs). Notably, the CsPbX3 (X = Cl, Br, or I) perovskite nanocrystals (PNCs) exhibit a wide range of luminescence properties, including high photoluminescence quantum yield (PLQY), narrow emission linewidths, and tunable emission spectra across the entire visible range. Additionally, rare-earth-doped PNCs show remarkable optical and luminescence properties, as well as wide range of excitation and emission bands along with improved PLQY. This versatility has attracted considerable interest from researchers, leading to further exploration of inorganic-based perovskite nanocrystal embedded in glass (PNEG). Borosilicate glasses, known for their excellent thermal and chemical stability, are used to achieve high quantum efficiency in emissions and are considered for various applications.

In this study, Yb3+-doped CsPbBr3 PNCs embedded in boro-silicate glass were synthesized by melt quenching technique and subsequent heat-treatment process. The crystalline phases formed within the glass were confirmed via X-ray diffraction (XRD) analysis after heat-treatment at different conditions. The formation and microstructure PNCs were confirmed by transmission electron microscopy (TEM) analysis. Optical and photoluminescence spectra were measured, confirming the intense of green emission from CsPbBr3 PNCs and NIR emission of Yb3+ ions. PLQY improved above 75% for green emission (530 nm) by changing the Yb3+ ion concentration under UV light excitation. Time-resolved spectroscopic results were evaluated to estimate decay dynamics of PNCs. Thermal, photostability, and chemical stability were examined for practical applications. The results indicated that these materials can be used as phosphors for anti-counterfeiting applications which can be excited both under UV and IR (980 nm) excitation.

Keywords: CsPbBr3, Yb3+ ions, Quantum cutting, Green and NIR emission, Anticounterfeiting.

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Synthesis and Characterization of Glasses and Fibers for Ultra-Sensitive Magneto-Optical Sensors

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Abstract:
In view of the scientific progress and the high demand for innovation in the field of magneto-optical devices for applications in current and magnetic field sensors, there is ongoing research into glass compositions with high concentrations of paramagnetic ions, especially those based on Tb3+. The main challenge in this field is to find glass matrices that allow the incorporation of high content of rare earth elements presenting high thermal stability. Aiming the development of the next-generation of magneto-optical (MO) devices, we have systematically investigated the viability of boro-aluminate (BAG) glasses containing Tb4O7 for optical fiber fabrication. Thermal analysis (DSC) revealed excellent stability against devitrification (with Tx-Tg> 150 ∘C), while Tg ranges 693–704 ∘C and Tx are around 850–942 ∘C, depending on the glass composition. Furthermore, the glasses exhibited high transparency from _˜500 up to 1500 nm due to electronic absorptions of Tb3+. The magneto optical constant (Verdet, Vb) at 632 nm reached _˜109 radT-1m-1 for BAG containing 13 mol % of Tb4O7. Based on these properties, a study was conducted in order to obtain a MO fiber. Core-cladding preforms were successfully obtained by using the rod-in-tube technique. To obtain the tube, a new *lifting* methodology was developed and the experimental details will be presented. The resulting multi-mode fiber shows low attenuation, with _˜4 dB/m at 1120 nm, and can be used for applications in the O band, at 1310 nm optical window, consolidating this material platform as highly promising for advanced MO devices.
Acknowledgments: This work was supported by São Paulo Research Foundation -FAPESP (Project number 2025/10231-7) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

Keywords: Fiber Optics, Magneto Optical Sensors, Boro, aluminate Glass

*Speaker

Bright blue up-conversion in $Tm^{3+}/Nd^{3+}/Yb^{3+}$ triply-doped phosphate glass fibers for photonic applications

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Rare-earth (RE^{3+})-doped glasses exhibiting up-conversion (UC) luminescence have attracted significant attention for photonic applications. Among them, thulium (Tm^{3+})-containing materials stand out for their strong blue emission under near-infrared excitation, making them suitable for solid-state lasers and other light-emitting devices. Typically, Tm^{3+} ions are co-doped with other RE^{3+} ions to enhance UC efficiency; however, increasing dopant concentration can compromise solubility and hinder fiber fabrication. In this work, alkali–aluminum–phosphate glasses, a host matrix known for high RE^{3+} solubility and excellent fiber-drawing capability, were synthesized with varying concentrations of Tm^{3+}, Nd^{3+}, and Yb^{3+} ions. Corresponding tri-doped optical fibers were also fabricated. The glasses were excited at 808 nm and 980 nm to investigate the UC mechanisms, while the optical fibers exhibited bright blue luminescence when excited at 788 nm and 980 nm. The strong UC emission combined with low optical loss highlights the promising potential of these triply-doped phosphate fibers for next-generation fiber-based photonic devices. **Keywords:** blue up, conversion, rare, earth luminescence, aluminophosphate glasses,

optically active optical fibers, photonics.

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Transition-metal-modified gallate glass fibers for power-scalable mid-infrared supercontinuum generation

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Over the past decades, fiber-based supercontinuum (SC) sources covering the 1-5 μm spectral range have become key tools for spectroscopy, biomedical imaging, environmental sensing, and metrology. However, further power scaling and long-term stability remain limited by the trade-off between nonlinearity and thermomechanical robustness in existing mid-infrared (MIR) glass fibers. Addressing this challenge requires new glass compositions that simultaneously deliver high optical performance and mechanical reliability.
In this talk, we present the development of transition-metal-containing gallate glasses, incorporating oxides such as niobium and tantalum to achieve an exceptional balance between robustness and nonlinearity. By introducing up to 20 mol% of transition-metal oxide, we achieve a 25% increase in hardness and a two-order-of-magnitude improvement in water corrosion resistance compared to transition-metal-free gallate glass. At the same time, the nonlinear refractive index more than doubles, exceeding that of silica by over an order of magnitude. Remarkably, these enhancements can be achieved without significantly altering the thermal dilatometric behavior, thus preserving the glass processability required for fiber fabrication.

Leveraging these optimized compositions, we fabricated niobium-rich gallate step-index multimode fibers, which were successfully used to generate supercontinuum spectra spanning from 600 nm to 4.5 μm. Numerical modeling was employed to further optimize the fiber design under realistic pumping conditions near 2 μm, consistent with mature thulium-doped fiber laser technology.
Owing to their unique combination of thermomechanical resilience, chemical durability, and high optical nonlinearity, transition-metal-modified gallate fibers represent a powerful new platform for mid-infrared photonics. They open a path toward power-scalable, all-fiber supercontinuum

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sources capable of delivering average powers approaching 100 W across the 0.5-5 μm range, offering new opportunities for high-brightness, broadband light generation in demanding environments.

Keywords: Glass, Fiber, Mid, infrared, Supercontinuum, Gallate, Heavy, metal oxide

Multi-functional optical fibers based infrared spectroscopic bio sensing

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We have developed bio-functionalized chalcogenide (GeSbS) infrared optical glass fibers designed for mid-infrared evanescent wave spectroscopy. The tapered sensing zone of the fiber was surface-biotinylated by reacting a maleimidegroup with sulfhydryl sites on the glass surface. The interaction between biotin and streptavidin was then investigated using fiber evanescent wave spectroscopy. By comparing the kinetic responses of functionalized and non-functionalized fiber surfaces at various protein concentrations, we demonstrated the high bio-selectivity of the functionalized glass fibers. This surface functionalization significantly enhances protein enrichment, improving the protein detection limit by more than two orders of magnitude compared to non-functionalized reference fibers. In a second phase, we aimed to extend the mid-infrared transparency window for integrated fiber-based biosensors. To achieve this, we studied the effect of sulfur-to-selenium substitution on the efficiency of surface bio-functionalization. Using complementary techniques-including vibrational spectroscopy, surface characterization, and fluorescence-based protein detection-we correlated glass structure with bio-functionalization performance. Our findings show that maleimide reactivity on selenide glass surfaces is effective for bio-functionalization, greatly expanding the available spectroscopic window for highly sensitive infrared bio-detection.

Keywords: Chalcogenide glass fibers, biofunctionalization, evanescent wave spectroscopy, sulfur selenium substitution, protein detection, mid infrared sensing

*Speaker

Disclosing mechanism of the effect of short-range and medium-range structures on spectroscopic properties of active ions in silica-based glasses

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With the rapid development of artificial intelligence (AI) and sensing technologies, there is an increasing and urgent demand on broadband optical communication and new laser band. Silica-based glass serves as an excellent medium for the active ions such as rare-earth ions and bismuth ions to realize high power fiber laser and fiber amplification in various bands. In this talk, we will present our latest research progress in understanding how the local structure influences the luminescence behaviors of active ions such as neodymium and bismuth ions. The relationship among local structure, thermal history, and luminescent properties will be discussed. Our findings indicate that not only short-range but also medium-range structure significantly affects the luminescent behaviors of these active ions in glasses.

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Preparation, crystallization kinetics, and optical temperature sensing properties of Er^{3+} and Tm^{3+} doped oxyfluoride glass and glass-ceramics containing $KErF_4$, $KTmF_4$, and $KZnF_3$ crystals

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Accurate temperature measurement is vital in many different fields, such as industrial operations, biomedical diagnostics, and environmental monitoring. However, conventional temperature sensors such as thermocouples, resistance temperature detectors (RTDs), and infrared sensors, often encounter limitations in harsh environments due to electromagnetic interference, slow response times, and material degradation. These limitations underscore the need for advanced, non-contact temperature sensing systems that offer high sensitivity, stability, and reliability. In this work, singly doped Er^{3+} and Tm^{3+} oxyfluoride glasses (OxG) and glass-ceramics (OxGC) containing $KZnF_3$, $KErF_4$, and $KTmF_4$ nanocrystals were successfully fabricated via the melt-quenching method to explore their potential for optical thermometry applications. Crystallization kinetics revealed the formation of $KZnF_3$ as the primary nanocrystalline phase, while $KErF_4$ and $KTmF_4$ appeared as secondary phases, particularly at higher concentrations of Er^{3+} and Tm^{3+} ions, providing suitable lattice environments for rare-earth incorporation. Both, Er^{3+} and Tm^{3+} ions, were effectively embedded into their respective low-phonon-energy fluoride nanocrystals, reducing non-radiative losses and enhancing luminescence efficiency. Strong upconversion emissions corresponding to the Er^{3+} ($^2H_{11/2}$, $^4S_{3/2} \rightarrow {}^4I_{15/2}$) and Tm^{3+} ($^1D_2 \rightarrow {}^3F_4$) transitions were observed. Using the fluorescence intensity ratio (FIR) technique, temperature-dependent emissions from both Er^{3+} and Tm^{3+} ions demonstrated the capability for high-resolution optical thermometry in transparent glass and glass-ceramic matrices. Furthermore, the optical properties of the OxG and OxGC systems were examined under NIR excitation, emphasizing their upconversion behavior and temperature-dependent luminescence characteristics. By analyzing both thermally coupled and non-thermally coupled energy levels, the temperature sensing performance was optimized. These findings suggest that the developed materials possess strong potential for use in luminescent thermometry, laser systems, and advanced photonic technolo-

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gies. **Keywords:** Crystallization, Luminescence, Optical Thermometry, Up, conversion, Oxyfluoride, Fluorescence Intensity.

A fresh look to the correlation of nonlinear spatiotemporal light shaping and local structure of silica fibers

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Many photonic applications, such as fully fiber-based laser sources, require access to new wavelengths (visible, UV, mid-IR) via non-linear conversion. However, although nonlinear optical conversion has been extensively studied, from a structural point of view it remains relatively unknown.
The aim of this communication is therefore to evidence how the local structure in silica optical fibers impacts non-linear inscription.

Numerous studies in the literature show that the fictitious temperature (Tf), germanium content, distribution of large silica rings and the presence of impurities (phosphorus + OH content) influence the short- and medium-range order of silica glasses (2)(3)(4)(5). In order to study the structure of the fibers, we use vibrational techniques (Raman, FTIR, OPTIR) before and after non-linear writing in the fibers. Non-linear writing in fibers is possible thanks to an optical setup called optical poling which induces a local reorganization of the lattice. The effects of the fiber structure on the optical poling efficiency are then highlighted by multivariate analysis. The chemometric approach, specifically the principal component analysis, facilitates the decorrelation of parameters that modify the structure which is linked to the non-linear spatio-temporal formation of light. All of these results will ultimately enable the creation of a database for establishing a robust predictive model which will correlate poling efficiency to the fibers shaping.

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Keywords: Photonics / Optical properties / Fibers / Local structure / Silica

Vitrification-annealing enables white-light emission in zeolitic imidazolate frameworks

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Zeolitic imidazolate framework (ZIF) glasses, as a subset of metal-organic framework (MOF) glasses, are a newly emerged family of melt-quenched glasses. Recently, ZIF glasses have attracted attention from materials scientists owing to their fascinating properties, such as ultrahigh glass-forming ability, high structural porosity, processability and lack of grain boundaries, and multi-functionality (e.g., gas separation and energy storage). Zn-based ZIF glasses are the most promising MOF glass candidates for large-scale applications, However, their photonic functionality remains largely unexplored. In this study, we report the discovery of broadband white light emission in ZIF-62, achieved through a vitrification-pressurization-annealing strategy. In this strategy, visible (blue) light emission emerged after the vitrification of ZIF-62, which is subsequently enhanced and broadened upon pressurization of the ZIF-62 glass. Additionally, a sharp red shift (37 nm) of the emission peak occurred in pressurized ZIF-62 glass as the annealing temperature exceeded a critical annealing temperature ($1.07\,T$g). This implies that the photoluminescence behavior of ZIF-62 can be precisely tailored by this strategy. The photoluminescence quantum yield of ZIF-62 glass reached 12.2% after annealing at $1.13\,T$g for 30 min. The origin of the observed phenomena was revealed by conducting structure analyses. Based on the annealed ZIF-62 glass with the best performance, we fabricated a white light-emitting diode (LED) with a luminous efficacy of 4.2 lm/W and high operational stability, retaining 74.1% after 180 min of operation. This study demonstrated the feasibility of utilizing ZIF-62 glass in LED applications and a significant advancement in the development of one-component white LEDs.

Keywords: Zeolitic imidazolate framework glasses, Critical annealing temperature, Red shift, Electronic conjugation, White light emission

*Speaker

Pressure-Induced Energy Transfer Enhancement in SCS:Nd^(3+)/Yb^(3+) Glass Investigated By Luminescence Spectroscopy

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Near-infrared (NIR) quantum cutting (QC) via downconversion (DC) in Nd^3+/Yb^3+ co-doped sodium calcium silicate (SCS) glasses was investigated through luminescence spectroscopy under high-pressure conditions using a diamond anvil cell. Nd^3+/Yb^3+ co-doped glasses are promising for photonic applications due to their efficient energy transfer (ET) mechanisms. Rare-earth systems have attracted significant interest for spectral conversion processes, such as downconversion, which can help mitigate spectral mismatch losses in conventional silicon-based solar cells. Pressure is a key thermodynamic variable capable of modifying the ligand field, local structure, and energy levels. Understanding these effects is essential for the development of optical sensors under extreme conditions. In this work, the spectral evolution was analyzed from ambient pressure up to 18 GPa. Emission intensity variations and peak shifts were evaluated to investigate the energy gap evolution between Nd^3+ and Yb^3+ and to assess the downconversion process. The application of high pressure promotes energy level matching between Nd^3+ and Yb^3+, leading to enhanced energy transfer efficiency. After decompression, the samples exhibit permanent modifications in their electronic structure. These results highlight the potential of this system for optical pressure sensing and photonic energy conversion applications. **Keywords:** Downconversion, Sodium Calcium Silicate Glass, Luminescence Spectroscopy, High Pressure, Eletronic Structure

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Phase-separation modulated dual-band PL of CsPbBr3 perovskite nanocrystals in glasses

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Cesium lead halide (CsPbX3, X=Cl, Br, I) have emerged as important optoelectronic materials for their potentials towards light-emitting diodes, date storage, X-ray detection and imaging, etc. Incorporation of CsPbX3 perovskite nanocrystals into glasses can significantly improve their chemical and thermal stabilities, facilitating their potential applications. Tuning the band gap energies of glass-embedded CsPbX3 perovskite nanocrystals, i.e., the optical absorption and photoluminescence, can be achieved by adjusting the size and halide components of these nanocrystals, which is mainly based the composition of the glass and thermal treatment conditions. However, based on these two methods, only single band photoluminescence is realized, and dual-band photoluminescence from these CsPbX3 nanocrystals in glasses have not realized. In this work, a new strategy is proposed to control the growth of CsPbBr3 perovskite nanocrystals in glasses. Glasses with phase separation are designed in order to control the precipitation of CsPbBr3 perovskite nanocrystals. It is found that the CsPbBr3 perovskite nanocrystals can be formed in these phases separated glasses and size of the CsPbBr3 perovskite nanocrystals is determined by the phase separation, leading to the formation of CsPbBr3 perovskite nanocrystals with different size. Consequently, dual-band photoluminescence is realized with stable photoluminescence in the blue and green spectral region. Detailed mechanisms governing the size and photoluminescence of CsPbBr3 perovskite nanocrystals in glasses will be discussed. Results reported in this work are valuable for the development of optoelectronic devices based glass-embedded CsPbBr3 perovskite nanocrystals.

Keywords: Perovskite nanocrystals, Phase separation, Photoluminescence, CsPbX3

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Engineering the optical bandgap and structural correlations in tellurite glasses via GeO2 incorporation

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Tuning the optical bandgap is crucial for the development of integrated photonics device applications. Tellurite glasses are promising materials for photonics due to their remarkable properties, surpassing those of conventional glasses. This research presents a comprehensive exploration of the structural changes in tellurite glasses arising from the substitution of TeO2 by GeO2. The non-crystalline nature of the samples was corroborated by their broad X-ray diffraction patterns and by the presence of a glass transition temperature. The optical bandgap displays a linear dependence on the GeO2 content. Moreover, the Raman band intensity ratio between the TeO4 and TeO3/TeO3+1 structural units also demonstrates a linear correlation with GeO2 content. In addition, the glass transition temperature increases, while the density decreases, as GeO2 content increases. According to the Raman spectroscopy analysis, this behaviour is linked to the formation of interconnected GeO4 units, which form three, four and six-membered rings, and a higher bond dissociation energy of the Ge-O bonds compared to Te-O. These correlations are attributed to the successful isovalent substitution of Te4+ and Ge4+, achieved under controlled synthesis conditions. This strong, linear structure-property relationship offers a reliable route for designing novel tellurite glasses with targeted optical functionalities.

Keywords: Tellurite glasses, Optical bandgap, Raman spectroscopy

*Speaker

Photoluminescence in bioactive glasses

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Bioactive glasses are biocompatible materials that can form strong bonds with biological tissues. Among these, innovative luminescent bioactive glasses stand out by also exhibiting optical activity, primarily achieved through the incorporation of rare-earth (RE) ions such as europium, terbium, or neodymium. The typical matrix of these amorphous bioactive glasses mainly consists of silica, calcia, and phosphorous oxide, with occasional modifications involving other ions to further enhance their bioactivity.
The studies presented here focus on investigating the luminescent properties of bioactive glasses doped with rare-earth ions. Luminescence intensity proves to be highly sensitive to various factors, including thermal treatment, glass degradation, and biomineralization processes. Additionally, this luminescent behavior changes dynamically as drug molecules are gradually released from the glass matrix. Analysis of spectral profiles and emission lifetimes provides valuable insights into the material's structure and interactions. In particular, co-doping with pairs of ions, such as Tb3+/Yb3+ or Er3+/Yb3+, facilitates energy upconversion that allows for near-infrared excitation, a feature especially advantageous for biological applications. Moreover, the potential for encapsulating drugs within these luminescent bioactive glasses opens exciting new possibilities, especially in cancer treatment. These materials integrate biocompatibility, bioactivity, and optical functionality into a multifunctional platform, enabling advanced biomedical applications like real-time monitoring of drug delivery and tracking the degradation of implants, which ultimately promote bone regeneration and the healing of soft tissues.
Continued research focused on multifunctional doping strategies is essential to advance clinical applications. Further work will pave the way for the next generation of regenerative medicine, as well as innovative diagnostic and therapeutic platforms that combine sensing and treatment.

Keywords: bioglass, photoluminescence, melt quenching, sol gel, medical applications

*Speaker

Thermo-electrical polarization of an ionic silicate glass surface assisted by plasma: properties and application to liquid-crystals molecular alignment

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We report a plasma-assisted thermo-electrical polarization treatment of glassy surfaces and its application to tailor liquid-crystals molecular alignment. The functionalization process is performed in a simple wire-anode configuration used to generate a dielectric-barrier discharge (DBD) plasma at the glass surface, which promotes in-plane electrical polarization. We correlated structural (Raman) and compositional (EPMA) measurements with the electrical response of the polarized glass, measured via second-harmonic generation (SHG) microscopy. These results show that the in-plane electric field arises from a long-range gradient poling effect extending over several hundred micrometers, driven by surface plasma ignition at the glass–gas interface. The spatial distributions of SHG signal and near-electrode structural modifications are qualitatively explained by an electrostatic model and correlated with the plasma properties.
Subsequently, we demonstrate the potential of such in-plane polarized glass substrates for liquid-crystals alignment control. The electrically polarized surfaces in contact with nematic mesophases display strong versatility, allowing both single- and multi-domain structuring from micrometer to millimeter scale. Moreover, dynamic measurements of liquid-crystals motion via polarized-light microscopy suggest molecular anchoring at the interface similar to commercially available substrates.
These results demonstrate that plasma-assisted thermo-electrical polarization enables controlled spatial structuring and shaping of electrical polarization effects, with potential application to multi-scale tailoring of liquid-crystals mesophases. This work opens new perspectives for engineering surface electrical properties of ionic glassy compositions.

Keywords: polarization, raman, microscopy, spectroscopy, liquid crystals, plasma, surface, treatment, electrical, nonlinear

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Controlled microstructuring of glass optical responses by electrothermal poling

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The rapid progress of integrated photonics demands materials that go beyond traditional crystalline and semiconductor platforms. In this context, glass emerges as a versatile medium combining broad optical transparency with very low optical losses, outstanding structural stability, and tunable functional responses. From this perspective, controlled microstructuring in glass offers a powerful route to tailor light–matter interactions and to introduce active properties such as electro-optic or nonlinear behavior. In this work, sodium niobium germanate glasses were microstructured by electrothermal poling to induce localized linear and nonlinear optical functionalities. The printing process combines heating and the application of an electric field to modify the glass surface, creating a surface microlayer on the sample near the anodic electrode. This microlayer creates an induced static electric field that generates spatially modulated second harmonic generation (SHG) responses that follow the pattern of the anodic electrode used in the poling treatment. Correlative characterizations combining Raman spectroscopy, phase-contrast imaging, atomic force microscopy and SHG mapping revealed a strong spatial correlation between the glass network structural reorganization, refractive-index variations, and localized $\chi(2)$ responses. Microscale SHG imaging confirmed the electro-optical origin of the nonlinear response, localized at the electrode edges and governed by the micro-anode geometry. Linear and nonlinear diffraction experiments exhibited well-defined periodic responses, validating the long-range order of the imprinted structures. This work establishes electro-thermal poling as a powerful approach for imprinting stable, designable $\chi(2)$ microstructures in glass, opening new opportunities for compact and engineered nonlinear photonic devices.

Keywords: glass, electrothermal poling, surface structuring, linear and nonlinear optics

*Speaker

Physical and structural properties of La2O3–WO3–MoO3 glasses prepared by a levitation technique

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Glass formation was achieved at compositions of 20 and 25 mol% La2O3 in the La2O3–WO3–MoO3 ternary system using a levitation technique. All obtained glasses were transparent, with color gradually changing from colorless to brown as the MoO3 content increased. The composition dependence of thermal and structural properties was investigated. The glass transition temperature, Tg, and crystallization temperature, TX, decreased with increasing the MoO3 content, while the DSC signal for Tg became less distinct as the gap between Tg and TX gradually narrowed. The density decreased linearly with the substitution of MoO3 for WO3, and the packing density showed a similar but less pronounced trend. Raman scattering spectra and XAFS measurements revealed that the structure of of the glass with $x = 25$ closely resembles those of the crystalline phase of La2Mo3O12 and La2W3O12. The similarities and differences between the glass and the crystalline phases will be discussed.

Keywords: Optical transparency, Raman scattering, XAFS

*Speaker

Development of Radiation Hard Optical and Photonic Glasses

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The increasing deployment of optical and photonic technologies in high radiation environments such as space exploration and nuclear systems has amplified the demand for radiation hard glass materials. Glasses, by virtue of their amorphous structure, exhibit inherent resistance to the kinetic disruptions caused by particle radiation, yet they remain susceptible to radiation. The formation of electronic defect sites and alterations in network connectivity can degrade optical performance through increased attenuation and shifts in refractive index.
This talk will begin with a review of commercially available radiation hard optical materials, followed by insights from two lines of research conducted at Glass Technology Services into the development of advanced glass compositions tailored for photonic applications in phosphate and heavy metal oxide glass systems.

Work on ErYbCe phosphate glasses will be presented, including the methodology for enhancing radiation resistance and results from spectroscopic analyses performed before and after exposure to 0.6 MGy X-ray doses. These analyses demonstrate a marked improvement in radiation hardness compared to baseline compositions.

Research on vanadate heavy metal oxide glass systems, a family of oxide glasses with promising potential for mid-wave infrared (MWIR) applications, will also be discussed. These materials exhibit low-level electronic conductivity via polaronic transport across mixed valence states, offering potential for intrinsic radiation tolerance. Experimental outcomes from binary vanadate glasses subjected to 0.6 MGy X-ray irradiation will be shared, with FTIR data supporting robust radiation resilience, likely facilitated by defect recombination enabled by the materials' conductive properties.

These findings demonstrate the capability of glass materials to perform effectively in high radiation environments, supporting their use in advanced optical systems. However, further challenges remain in validating long-term performance and more demanding radiation sources.

*Speaker

Keywords: Radiation hard glass, photonic applications, optical materials, phosphate glass, vanadate glass, MWIR, MIR, X, ray irradiation, spectroscopy, FTIR, fluorescence, defects, radiation damage, conductivity

Multi-material optical components for infrared

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Abstract:

The growing demand for integrated photonic devices operating in the infrared range is driving the exploration of new, innovative fabrication processes capable of overcoming the limitations of conventional approaches. Traditional techniques remain largely confined to essentially two-dimensional or linear geometries and face difficulties when combining different materials within a single platform. Yet, achieving three-dimensional and multi-material integration is a key challenge for advancing miniaturization, performance, and functional diversification of photonic devices.

In this context, the present work investigates the innovative combination of advanced additive and subtractive processes, FLICE (Femtosecond Laser Irradiation assisted Chemical Etching) and PAMI (Pressure-Assisted Melt Impregnation) with the goal of developing three-dimensional, multi-material integrated optical components specifically tailored for applications in the near- and mid-infrared domains. The project focuses on three main axes: the design and structuring of high-Tg matrices such as Barium Germano-Gallate (BGG); the development of an infiltration setup for low-Tg infrared-transparent glasses (such as chalcogenide and tellurite glasses); and the characterization of the optical performance of the resulting structures.

Significant results have already been achieved. A custom-designed device enabled the successful infiltration of chalcogenide glasses into borosilicate capillaries with an internal diameter of 500 μm. In parallel, laser irradiation followed by chemical etching allowed the fabrication of buried microchannels located 300 to 500 μm below the glass surface and interconnected within Y_2O_3-doped BGG matrices. These channels, with lengths ranging from 1 mm to 2 mm and diameters between 100 μm and 400 μm, can be subsequently infiltrated to form three-dimensional, multi-material photonic platforms.

These results, combining technological innovation with the realization of three-dimensional, multi-material structures, represent an important step toward the development of next-generation integrated photonic devices, such as waveguides, micro-spectrometers, optical couplers, paving the way for compact and high-performance photonic platforms for infrared applications.

*Speaker

Keywords: infiltration, irradiation, FLICE, PAMI, chalcogenide and tellurite glasses, infrared

Fabrication of complex bismuth-doped silicate fiber using an all-vapor deposition method

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The current systems exploit only 11 THz of the 47 THz available in the low-loss region of SMF fibers, through the well-established erbium-doped fiber amplifiers (EDFAs). The utilization of the remaining spectral regions is being extensively studied as part of the ongoing effort to further increase data transmission capacity. Over two decades of research have established bismuth-doped silicate fibers as one of the most promising solutions, with commercial products already available in recent years. Bi:doped silicate can cover a wide range of emission and amplification window, while offering low noise-figures. The addition of co-dopant in the silicate matrixe (Ge, P, B...) can shift the net-gain window from the 1250 up to 1700 nm.
However, several technological challenges still surround the use and fabrication of Bi-doped fibers. Firstly, their low absorption typically limits the use of cladding-pumping configurations and requires in-band core pumping over lengths of several hundred meters to achieve gain levels exceeding 30 dB. Secondly, most fibers are fabricated using solution-doping techniques, which restricts the architecture to single-core designs.
The present study demonstrates the fabrication of Bi-doped silicate, germanosilicate, and phosphosilicate fibers using an all-vapor technique developed in-house. This approach offers significant advantages in terms of design flexibility, enabling the production of pedestal-doped fibers with precise control over both doping concentration and refractive index profile. We also present results on the amplification performance of these fibers.

Keywords: Silicates, bismuth, fibers, amplifiers, MCVD

*Speaker

Tb^{3+} doped phosphate glasses and glass-ceramics

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Phosphate glasses are attractive hosts for rare-earth ions due to their high solubility, low melting temperature, and excellent optical transparency. Doping with trivalent terbium (Tb^{3+}) ions produces intense green luminescence corresponding to the $^5D_4 \rightarrow {}^7F_5$ transition, which is significant for photonic and display applications (1,2). When doped with high concentration of Tb^{3+}, these glasses/glass-ceramics can find additional uses as Faraday rotators. Building on these studies, the controlled transformation of phosphate glass into glass-ceramics can further enhance luminescence by improving local symmetry and reducing non-radiative losses (3). For example, Hongisto et al. demonstrated that transparent Yb^{3+} doped phosphate glass-ceramics with enhanced spectroscopic properties can be obtained from the glass with the composition 10 Na_2O – 90 $NaPO_3$ (in mol%) (4).

In this presentation, we will explain how to prepare Tb^{3+}-doped glasses with the composition $(100 - x)(10\ Na_2O - 90\ NaPO_3) - x\ Tb_4O_7$ (x = 0, 1.5, 2.5, 3.5 mol%) using the conventional melt-quenching technique. A thermal treatment was performed at various temperatures to induce crystallization which was confirmed using XRD and SEM. The influence of Tb^{3+} concentration and heat-treatment temperature on the structural, thermal, and optical properties will be presented. The luminescence properties of the glasses and heat-treated glasses under 377 nm excitation will be discussed. We will demonstrate that Tb^{3+}-doped phosphate glass-ceramics are promising materials for solid-state lighting and photonic applications.

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Phosphate glass, ceramics, Terbium doping, Green emission, Photoluminescence spectroscopy, Photonic applications

Development of novel composites composed of glass matrix and phosphors via SPS technique

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Recently, composites made of rare-earth (RE) doped crystals and persistent luminescent (PeL) particles have been found to be promising materials as NIR rechargeable "optical battery". PeL refers to the type of emission which lasts for a long time (from seconds to hours) after the removal of the irradiation source. By combining the NaYF4: Yb, Tm upconversion materials with typical UV/blue upconversion emission (350/475 nm) and UV rechargeable SrAl2O4:Eu,Dy persistent luminescent particles, the green persistent luminescence at _˜ 520 nm could be activated by 980-nm NIR excitation due to the spectra overlapping between the upconversion emissions and absorption of persistent phosphors. This NIR conversion to visible light could be useful for solar cell application for example if it could be obtained from glass-based materials used as a substrate for the solar cell. These materials can be used to accumulate the solar energy during the day producing visible light to the solar cell for the production of the electric current during the night. The aim of this work is to develop new transparent composites composed of glass, Tm3+, Yb3+ codoped crystals and PeL phosphors using the Spark Plasma Sintering (SPS) technique. Composites have been prepared with optimized amounts of UC and PeL crystals. The SPS offers several advantages when compared to the traditional sintering processes, like a rapid processing, lower sintering temperature, better homogenity and others.

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Lead-Free Functional Glasses for Radiation Shielding: Advances in SiO_2-, B_2O_3- and TeO_2-Modified Glass Systems

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The development of lead-free oxide glasses represents a sustainable and technologically significant route toward functional materials that combine optical transparency, mechanical robustness, and high ionizing-radiation shielding capability. This study consolidates recent progress on SiO_2-, B_2O_3-, and TeO_2-based matrices modified with heavy-metal oxides such as BaO, Bi_2O_3, and related compounds, highlighting the correlation between structural configuration, density, and attenuation performance compared with conventional Pb-containing glasses. The combination of strong network formers (SiO_2, B_2O_3) and highly polarizable TeO_2 units enables the fabrication of dense yet optically clear matrices exhibiting linear attenuation coefficients (μ) in the range of 20–30 cm^{-1} at 59.5 keV, half-value layers (HVL) of approximately 0.23–0.26 cm, and radiation protection efficiencies exceeding 95% for diagnostic energies. These results are comparable to, or surpass, the performance of commercial RS-series glasses, for instance. SiO_2–BaO systems demonstrated an excellent balance between optical transmittance ($\geq$ 90%) and gamma-ray shielding, while B_2O_3-rich compositions enhanced charged-particle attenuation due to the presence of strong covalent B–O bonds. Meanwhile, TeO_2-based matrices provided the highest gamma- and neutron-shielding efficiencies, attributed to the elevated atomic number of Te ($Z = 52$), its electronic polarizability, and the structural compactness of Te–O networks. All investigated systems preserved broad optical transmittance (400–1500 nm) and tunable optical bandgaps ranging from 3.4 to 4.8 eV, coupled with mechanical hardness values around 3–5 GPa, exceeding those typically reported for commercial radiation-shielding glasses. Overall, these lead-free systems match or outperform conventional Pb-based counterparts while offering distinct advantages in terms of reduced weight, improved chemical durability, and environmental compatibility. The synergistic interaction among SiO_2, B_2O_3, and TeO_2 glass formers with heavy-metal oxides provides a compositional platform for tailoring density, transparency, and shielding strength simultaneously. Collectively, these findings establish a foundation for the next generation of sustainable, optically functional, and environmentally responsible radiation-shielding glasses, with potential applications in medical diagnostics, nuclear safety, and advanced photonic technologies. **Keywords:** Radiation shielding, Radiation protection, Medical glass, Gamma,

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ray attenuation

Chalcogenide and tellurite microspheres

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Microspheres are a class of morphology-dependent resonators in which light is confined by continuous total internal reflection near the cavity perimeter. The modes have therefore been named "whispering gallery modes". Such optical microcavity offers strong spatial light confinement due to small mode volumes as well as important temporal confinement described by the optical quality factor Q. Surface tension induced microspheres lead to high optical Q factor (1) and are of great interest for low threshold lasing and sensing (2). The small mode volume and the long photon storage time is also favorable to nonlinear optical effects generation such as Raman gain or frequency comb generation (3). Therefore, soft glasses that present high rare earth (RE) solubility, strong nonlinear optical properties and a wide transparency range from visible to mid infrared (MIR) have a huge potential for micro-resonator optics.

Chalcogenide and tellurite glasses present large third-order Kerr and Raman nonlinearities. We have previously demonstrated ultra-wideband MIR light conversion called supercontinuum in both tellurite and chalcogenide fibers through high purity synthesis and low loss fiber drawing (4).

In this presentation, we will describe the production of microspheres from chalcogenide and tellurite glass fibers fabricated in ICB lab. In both cases, we show that state of the art Q factors of 10^7 were obtained and is material absorption limited. As_2Se_3 spheres were used to conduct Raman emission studies. Raman lasing was observed from undoped tellurite microspheres. We also used the high RE solubility of tellurite glass to produce Tm^{3+}/Ho^{3+} co-doped tellurite microspheres and obtained lasing at 2 μm.

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Modification of the properties of dielectric nanoparticles contained in an optical fiber using a femtosecond laser

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Recently, new types of optical fibers containing dielectric nanoparticles have been developed. These unique fibers, whose scattering properties are significantly enhanced by the presence of nanoparticles in their core are being widely developed for distributed optical fiber sensor applications. The scattering performances strongly depend on the nanoparticles characteristics. Therefore, it is crucial to control and adjust their properties on demand. The nanoparticles contained in the core of these fibers are formed by phase separation during the preform preparation stage by doping silica glass with lanthanum ions. As the drawing parameters (temperature or drawing speed) are modified, the La-silicate nanoparticles can be altered as they can melt, grow, elongate and break up due to Rayleigh-Plateau instability. However, the nanoparticles have the same characteristics along the fiber, over at least several tens of meters. The current challenge is to modify and control the properties of the nanoparticles to modulate their characteristics on an arbitrary fiber length with micrometer precision. To this end, we propose an approach based on laser-induced local heating directly in the core of the fiber. When an intense femtosecond laser is tightly focused in a silica fiber, light is absorbed via multiphoton processes only at the microscale focal point, located in the core of the fiber. This absorption leads to a pseudo-plasma formation, a dense quasi-free electrons gas coexisting with the ionic lattice. The system then relaxes in few microseconds. The use of a high repetition rate laser (typically about MHz) leads to cumulative effects accompanied by a significant temperature increase thus enabling very localized heating and therefore controlled modification of the nanoparticle characteristics at the micrometer scale. Here, we show that by adjusting the laser parameters, via a beam-shaping technique, controlled structural modifications are laser-induced in the core of fibers containing nanoparticles. First, electronic and optical microscropy, micro-Raman spectroscopy and chemi-

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cal composition analysis revealed reorganization occurring in the laser-heated zone, particularly lanthanum migration. Then, to gain insight on the laser-induced temperature distribution, we also imaged the pseudo-plasma emission in real time. This study shows the great potential of using femtosecond lasers to engineer nanoparticles contained in optical fibers.

Keywords: optical fiber, nanoparticles, chemical migration, beam shaping, femtosecond laser induced plasma

Glass Crystallisation as a Route to New Metastable Oxides: Example of the Highly Non-Stoichiometric Garnets

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The development of new synthesis methods for metal oxides can play an important role in the discovery of highly original materials with new compositions and crystal structures. In this context, the crystallisation of glasses and undercooled melts is a relatively under-explored technique for the isolation of new metastable oxides, and when it is coupled to rapid melt-quenching methods it can be applied to a surprisingly wide range of compositions. Here I will present some recent examples where containerless processing (aerodynamic levitation with laser heating) is used to produce glassy reactive precursors with diverse compositions, which can then be crystallised under controlled heating conditions to yield new and surprising functional oxides. This includes new families of highly-nonstoichiometric aluminate garnets based on *RE*3Al5O12 – well known luminescence hosts that are typically considered as line phases – which can form with up to 20mol% excess of rare-earth cations according to *RE*3+xAl5-xO12 ($0 < x < 0.6$; *RE* = Eu3+, Gd3+, Tb3+, Y3+) when their melts are quenched from ˜2000∘C. The crystal structures of these garnets accommodate excess *RE*3+ by substitution of Al3+ at the octahedral sublattice: for example, up to 30% of these crystallographic sites are substituted in Gd3.6Al4.4O12, a radical increase upon the defect-level concentrations achievable by solid state reaction methods. The distribution of *RE3+* over two crystallographic sites has implications for the luminescence properties of these materials, because rare-earth activators are no longer confined to a single sublattice, and this has a strong impact on the chromaticity of up-conversion systems such as YAG:Yb3+/Er3+. This opens pathways to property tuning in garnets by control of host stoichiometry, and the prospect of improved performance or new applications for other garnet-type materials.

Keywords: crystallisation, garnet, luminescence, aerodynamic levitation

*Speaker

Optical thermometry based on the plasmon-enhanced fluorescence intensity in Er3+/Yb3+ co-doped tellurite glasses and gold nanoparticles

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Tellurite glasses doped with erbium ions (Er3+) have attracted considerable interest for the development of optoelectronic devices and temperature sensors because of their high midinfrared transmittance, low phonon energy, excellent optical properties, and stability in extreme environments without electromagnetic interference. In this work, the combined influence of Er3+ doping and gold nanoparticles (AuNPs) on the thermal sensitivity of tellurite glasses was investigated using the fluorescence intensity ratio technique based on the thermally coupled levels of the Er3+ ion.The samples were synthesized by the melt-quenching method with varying concentrations of Er3+, and subsequently subjected to annealing treatments of 0, 12, 24 and 36 hours at temperatures below the glass transition temperature. Structural and optical characterization was performed by X-ray diffraction (XRD), optical absorption spectroscopy, emission spectroscopy and temperature-dependent luminescence measurements. The results showed a notable increase in fluorescence intensity and in both absolute and relative thermal sensitivities for the co-doped samples containing Er3+ and Au NPs, which is attributable to the coupling between Er3+ ions and the localized plasmonic fields generated by the metallic nanoparticles. An improvement in radiative energy-transfer efficiency and in the thermal stability of the material was also observed. These findings demonstrate that the combination of Er3+ and Au NPs in tellurite glass is an effective strategy to optimize the performance of optical temperature sensors, with strong potential for high-precision thermal monitoring systems.

Keywords: Tellurite glasses, Optical thermometry, Fluorescence Intensity Ratio, Thermally coupled levels, Rare, earth ions

*Speaker

Tuning of broadband Near-Infrared emission in Bismuth-doped Tellurite glasses for optical amplifiers

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The growing demand for high-speed and large capacity data transmission has driven the search for active optical amplification materials exhibiting near-infrared (NIR) emission that covers the telecommunication bands (O, E, S, C) simultaneously. In this work, the structural and optical properties, particularly the NIR emission behavior of tellurite glasses doped with low concentrations of bismuth were systematically investigated under different heattreatment durations to understand their emission mechanisms as well as their potential for telecommunication applications. The samples were synthesized by the melt quenching technique and characterized through optical absorption spectroscopy, X-ray diffraction, refractive index measurements, and NIR emission spectroscopy. The results show that the incorporation of Bi2O3 at low concentrations preserves the amorphous nature of the glass matrix and suppresses the formation of bismuth clusters that limit optical amplifier efficiency. Furthermore, the NIR emission intensity and bandwidth increase with the bismuth content, reaching a broad spectrum from approximately 900 to 1600 nm, effectively covering the O–E–S–C telecommunication bands. The observed emission is attributed to Bismuth active centers (Bix+), where x+ are the possible oxidation states formed during melting and heat treatment, whose optical response is modulated by the glass structure and local environment. These findings highlight Bix+ doped tellurite glasses as promising candidates for optical amplifiers and integrated optoelectronic devices in high-speed telecommunication systems.

Keywords: Tellurite glasses, Bismuth near, infrared luminescence, Telecommunication bands, Optical amplifiers

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Real Time Radiation Induced Attenuation of Commercial Flat FD-7 RPL Irradiated with 2.5 MeV Electron Beam at High Doses

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FD-7 radiophotoluminescence (RPL) glass dosimeters commercially designed for clinical and personal applications, are also explored today for high dose applications in kGy-MGy range. Monitoring such high radiation levels using accurate dosimetry is accordingly necessary to prevent components' failure and maximize their lifetime. In this context, FD-7 RPL dosimeters need further characterization under irradiation conditions where their response is still not fully understood. This study presents the first investigation of flat (8.5 mm ×8.5 mm ×1.5 mm) FD-7 RPL dosimeters irradiated with 2.5 MeV electron beam at SIRIUS facility. The evolution of the transmission spectra was recorded during irradiation and the growth kinetics of Radiation Induced Attenuation (RIA) were deduced up to 1 MGy at different dose rates: 2.7 Gy/s, 30 Gy/s and 300 Gy/s. The kinetics of RIA as a function of dose exhibit strong consistency, with repeated measurements at varying dose points under the same dose rate showing nearly identical growth trends. This demonstrates excellent repeatability of online RIA measurements for FD-7 RPLs at the facility even at high dose rate of 300 Gy/s. Preliminary results show the RIA dose response depends on dose rate and operation wavelength. For example, the data set dispersion at 7 kGy varying the dose rate, corresponds to 70% at 550 nm and drops to 14% at 800 nm. Post-irradiation measurements taken up to 50 minutes, also reveals partial RIA recovery also depending on dose rate and considered wavelength. These responses align with the previous findings reported for rod-type FD-7 RPLs irradiated with X-rays. Recent experiments focusing on comparing the online RIA responses with 2.5 MeV electron beam and X-rays will be presented during the conference.

Keywords: dosimeters, glass, high, dose, radiation induced attenuation

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Effect of Some Oxidizing Agents on the Color of TiO2-Nucleated ZnO-Al2O3-SiO2 Glass-Ceramics

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The presence of unpaired electrons in the d-orbitals of transition metals, such as titanium (Ti), is recognized as a source of coloration in glasses and glass-ceramics (GCs). This is particularly true for compositions within the ZnO-Al2O3-SiO2 (ZAS) system, where TiO2 is commonly added as a nucleating agent. In this case, glasses and GCs acquire a characteristic yellowish to brownish color due to the presence of Ti3+ ions, limiting their use in applications requiring transparent and colorless materials. To address this undesired effect, different oxidizing agents-CeO2, Sb2O3, and As2O3-were individually added to a base ZAS composition containing TiO2 as the sole nucleating agent. The objective was to promote the oxidation of Ti3+ ions to Ti4+ during the glass melting process. The effectiveness of the selected oxidizing agents in eliminating the coloration of the resulting glasses and GCs was evaluated by comparing their light transmittance in the visible range and by conducting CIELAB colorimetric analysis. Additionally, Electron Paramagnetic Resonance measurements were implemented to determine the oxidation states of the coloring ions. Finally, Vickers hardness tests were carried out to investigate the impact of CeO2, Sb2O3, and As2O3 on the mechanical performance of the GCs. The results demonstrate that As2O3 and Sb2O3 are more effective than CeO2 in reducing coloration and enhancing the light transmittance in the visible range of the ZAS GCs containing TiO2 without affecting their hardness.

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Keywords: ZAS glass ceramics, nucleating agents, color, oxidizing agents, light transmittance, mechanical hardness

Fabrication of phosphate glass/metal fibers for photoelectrochemical sensing

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Sensors miniaturization is a source of strong research. This study aims to initiate research efforts to design a compact tool that may be employed for minimally-invasive photoelectrochemical sensing in small constrained environments. A key aspect of this concept is the development of a single tool enabling the coupling between illumination and electrochemical charge transfer at the liquid/solid interface. The approach proposed in this work is the realization of multifunctional fibers that combine several materials such as phosphate glasses and metals, compatible with assembling and drawing approaches to design and fabricate multi-material fibers. In this context, hybrid phosphate glass/metal fibers which have both shown, light transmission from 350 to 900 nm and electrical conduction in the metal over several tens of centimeters have been produced. Photocurrent generation in such hybrid fibers has been shown with an illumination of the semiconductor through the phosphate glass. In addition, glucose detection has been highlight as a first step to photoelectrochemical sensing.

Keywords: phosphate glasses, multimaterial fibers, photoelectrochemistry

*Speaker

Femtosecond laser writing of birefringent optical modifications in nanoporous glass versus fused silica

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Ultrashort laser pulses can induce a wide range of structural modifications within the bulk of glass materials, such as Type I, Type II, Type X, and Type III, based on the energy deposition and the resulting structural characteristics. Among these, Type II (nanogratings) and Type X (elliptical nanopores) have attracted particular attention due to their strong birefringence properties, with Type X additionally offering exceptional optical transparency (up to 99% in the visible spectrum). Both modification types have demonstrated promising applications in optical data storage, 3D geometric phase optics, and other optical elements, including optical sensors, geometric phase optics, polarization converters, and birefringent components. Fused silica remains the most widely studied material for these applications, and many laser-written nanograting based devices are already close to or partially in commercialization. However, scaling to industrial production is still hindered by significant challenges, such as limited processing speeds and residual stress formation. Recent studies have shown that the intrinsic free volume of glass plays a key role in nanograting formation, suggesting that nanoporous glasses (NPG) could provide a more favorable material for fs-laser modification and potentially facilitate industrialization of such applications. In this work, we present a comparative study of fs-laser-induced birefringent modifications in NPG and fused silica. Experiments were performed using a Satsuma (Amplitude Systèmes) laser source (1030 nm, 350-1000 fs, 100 kHz), with pulse energy varied between 0.5-4 μJ and scanning speed between 0.5-50 mm/s under 0.16 NA focusing. The resulting structures were evaluated through retardance and optical transmission measurements. Our results show that the large free volume of NPG (average size of pores is 8-12 nm) facilitates the formation of both Type II and Type X modifications. The formation of elongated nanopores (Type X) demonstrates the combination of moderate birefringence and high transparency. Importantly, NPG exhibits broader processing windows for both types and higher possible retardance than fused silica, with values up to 788 nm achieved at writing speeds as high as 50 mm/s (NA = 0.16). These findings highlight the potential of NPG for fast, low-loss inscription of birefringent structures and its advantages over fused silica for advanced photonic applications.

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Keywords: fs, lasers, silica glass, nanoporous glass

Low-loss chalcogenide glasses and fibers made by Additive Manufacturing

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In recent years, there has been growing interest in optical materials and fibers for the mid-infrared (mid-IR) region. This interest stems from societal needs in health and environmental monitoring, as well as from demands in defense applications. The mid-IR spectral region includes atmospheric transmission windows (3–5 μm and 8–12 μm), which are essential for thermal imaging in both military and civilian contexts.
The development of chalcogenide microstructured optical fibers (MOFs) enables the combination of chalcogenide glasses mid-IR transparency (up to 12 μm) with the unique optical properties of MOFs, thanks to the high degree of freedom in designing their geometrical structures. In this context, additive manufacturing of glass materials emerges as a promising technique to achieve complex designs that are difficult to realize using conventional methods such as stack-and-draw or molding.
Taking advantage of the specific physical properties of chalcogenide glasses-such as their low glass transition temperature and extrusion temperature-we have demonstrated that chalcogenide preforms can be rapidly fabricated by fused deposition modeling (FDM) using a customized RepRap-style 3D printer fed with chalcogenide glass rods. These as-printed preforms can subsequently be drawn into chalcogenide optical fibers. The optical quality of the printed glasses and the different fiber designs obtained during the drawing process will be presented and discussed.

Keywords: Chalcogenide fibers, 3D printing, Mid, Infrared

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Tailoring Multifunctional Properties through Controlled Synthesis of Gd- and Mn-Doped Zinc Tungstate Glass-Ceramics

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Zinc tungstate ($ZnWO_4$) has attracted considerable interest due to its remarkable chemical stability, monoclinic crystal structure, and suitability for a wide range of applications including photocatalysis, luminescence, and scintillation. Current research efforts increasingly focus on tailoring the functional performance of $ZnWO_4$ through controlled doping with transition-metal and rare-earth elements.[1] Among the most promising dopants, gadolinium (Gd) and manganese (Mn) offer distinctive advantages: Gd contributes strong luminescent behaviour and a high magnetic moment, while Mn introduces valuable electronic and magnetic functionalities. Moreover, previous studies have demonstrated that Gd and Mn doping can substantially alter the structural and functional response of $ZnWO_4$, improving dielectric behaviour, and modulating luminescent emission.[2] Yet, a systematic understanding of how each dopant—and their incorporation—affects the overall properties of $ZnWO_4$ nanocrystals remains incomplete.

This work addresses this gap by synthesizing Gd- and Mn-doped $ZnWO_4$ nanocrystals via a co-precipitation route and conducting a detailed characterization of their structural, morphological, functional, dielectric, and magnetic properties. The results reveal that the incorporation of Gd^{3+} and Mn^{2+} ions influence crystallization behaviour in distinct ways, primarily due to differences in ionic radii and local lattice distortions. Luminescence studies show efficient blue–yellowish emissions in the co-doped systems, opening opportunities for warm white-light generation when combined with suitable red-emitting ions. Furthermore, Mn-doped $ZnWO_4$ nanocrystals exhibit enhanced magnetic and electrical responses compared with the pristine material.

Finally, the influence of embedding these nanocrystals into an amorphous borate-based glass

*Speaker

matrix is examined, demonstrating how glass–nanocrystal interactions further modulate their optical and functional behaviour.

Overall, this study provides new insights into the role of Gd and Mn dopants in engineering $ZnWO_4$-based nanostructures for advanced optical, electronic, and multifunctional applications.

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This research was supported by project VEGA 1/0045/24 of the Grant Agency of the Slovak Republic. The authors also gratefully acknowledge Semnan University, Iran, National Textile University, Pakistan, and Parto Negar Shahab Company – Radonik Iran, for their invaluable support and collaboration. **Keywords:** Optical, Electric and Magnetic properties, Zinc tungstat,

Nanocrystals, Mn and Gd dopants

Rare Earth Titanate Glasses for Optical Devices

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Recent development of titanate network glasses provides a new host material for rare earth ions. The glasses contain ∼80 mole% titanium oxide with the balance rare earth oxide (1). The network is composed mainly of corner and edge shared octahedra. The glasses have relatively low phonon energy combined with a high solubility and uniform distribution for rare earth ions. Glasses have been formed into spheres and fibers directly from the supercooled liquid phase. Spheres have been post-processed to make disks, enabling optical property measurements including fluorescence lifetime and bandwidth for erbium and neodymium doped glasses. Measurements of gain in Yb-doped fibers and laser demonstration in Nd-doped disks will be presented (2,3). The results will be discussed in the context of developing new optical devices enabled by these materials.

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*Speaker

A new oxysulfide glass-ceramics embedded with ternary rare earth sulfide nanocrystals

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Ternary rare earth sulfides (ALnS2) exhibit wide bandgap, low phonon energy, and high transmittance in the infrared region, making them promising candidates for applications in anti-counterfeiting, light-emitting diodes, and X-ray detection and imaging. However, the practical application of ALnS2 is significantly hindered by their poor chemical stability, including oxidation and agglomeration. Improving the stability of ALnS2 remains a huge challenge. In this work, we propose a novel strategy for in-situ crystallization of ALnS2 nanocrystals in glass matrix. Stable glass can effectively isolate ALnS2 nanocrystals from the external environment, thus significantly enhancing their stability. The results show that a series of ALnS2 nanocrystals (NaScS2_˜NaLaS2) were successfully precipitated in glass. The nanocrystals structure of the prepared ALnS2 nanocrystals include rhombohedral and cubic phases, and they have low phonon energy (< 350 cm-1).

Keywords: Ternary rare earth sulfides, Oxysulfide glass, ceramics, Low phonon energy

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Chiral optical properties induced by elliptically polarized beam in silica via Femtosecond laser writing

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Femtosecond direct laser writing (FDLW), developed over decades as a mature photonic fabrication technique, has enabled applications in health (1,2), selective chemical etching (3), optical data storage (4-6), and photonic components (7-10). These advances are based on three main laser-induced modifications: refractive index changes (11), nanogratings (12), and voids (13). Asymmetric nanostructures have been achieved through strategies such as 'quill' writing (14), silica decomposition (15), and shear stress fields (16). More recently, multilayer writing has induced chiral optical properties via anisotropic nanogratings and stress (17-18), though this approach remains multistep.

Traditionally, asymmetric writing relies on linear polarized beams, where pulse front tilt, shear stress, or the torque from the combination play an important role. Structured beams have emerged as alternatives, which was proved with 3D polarization structured Bessel beams successfully imprinting chirality in silica (19). In this work, we demonstrated that elliptically polarized femtosecond laser beams can directly induce chiral optical properties in silica. SEM analysis reveals the morphology of distinct 3D nanostructures along the propagation direction, which evolves from nanoporous features into hybrid forms combining nanoporous and nanoplane domains and ends with nanoplane. Important chiral optical properties such as circular birefringence (CB) and circular dichroism (CD) were detected via Muller microscopy system. Increasing with pulse number and energy (below 100 kHz repetition rate), CB can reach up to 0.2 rad with 1,000 pulses at 1.5 μJ. Crucially, its sign reverses with the handedness of elliptically polarization, confirming that the induced chirality originates from polarization-dependence.

In summary, our results uncover the overlooked potential of elliptically polarized beams in FDLW for inducing chiral optical responses. Compared with conventional methods, this approach offers a simpler and more efficient route to fabricate chiral photonic elements, including isolators, waveguides, and encryption structures. Beyond its practical advantages, this work advances understanding of light–matter interactions and opens new perspectives for laser-based manufacturing of chiral optical components.

Keywords: fs laser writing, chiral optical property

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Thermal Mirror Spectroscopy: a new approach to obtain emission quantum efficiency of luminescent glasses

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The characterization of the optical properties of rare-earth-doped glasses is fundamental for the development of new photonic devices. A key parameter governing the performance of these materials is the luminescence quantum efficiency, which is often limited by concentration-dependent non-radiative processes. In this work, a investigation of the concentration quenching mechanisms was carried out on a series of glasses of the low-silica CaO-Al2O3-SiO2-MgO (LSCAS) system doped with different concentrations of Neodymium ions. The employed approach consisted of using two independent methodologies for the determination of luminescence quantum efficiency. First, the Judd-Ofelt theory was applied to the absorption spectroscopic data to calculate the theoretical radiative properties, which, in conjunction with the fluorescence lifetime measurements, allowed for a first determination of the quantum efficiency. Second, the new approach, the Thermal Mirror Spectroscopy was used as an independent photothermal method, based on the relationship between heat generation and the excitation wavelength. The central objective of this work is, therefore, to perform a comparative analysis of the results obtained by these two distinct methodological routes. This approach allows not only for the robust determination of the quantum efficiency but also for the cross-validation of the methods for investigating the concentration quenching mechanisms in the studied glass system.

Keywords: Neodymium, Photothermal techniques, Judd, Ofelt

*Speaker

Impact of Ion Exchange (IOX) alteration layer properties on glass surface contact electrification

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A specialized methodology has been developed to measure tribocharging behavior on glass surfaces at the micro- and nano-scale, utilizing side band Kelvin Probe Force Microscopy (KPFM) on ultra-thin glass substrates ranging from approximately 20 to 150 μm in thickness. Initial experiments, conducted to validate this method, revealed significant variability depending on whether the glass substrate had undergone chemical strengthening through ion exchange (IOX) or remained in its parent-glass form. Chemically strengthened IOX glasses showed a pronounced dependence of charge accumulation on glass thickness, with a substantial magnitude of positive charge (+ΔVtip-surface). In contrast, non-ion-exchanged (NIOX) glasses exhibited no thickness dependence and accumulated a much smaller magnitude of charge, but with the opposite polarity. To better understand the factors influencing contact charging, further experiments were undertaken to deliberately engineer the properties of the IOX alteration layer, allowing for the deconvolution of the various contributions to tribocharging observed on glass surfaces. Complementing these experimental findings, a theoretical framework was established using Finite Element Modeling (FEM) and Density Functional Theory (DFT) calculations, providing a solid foundation for interpreting results and elucidating the mechanisms governing tribocharging behavior in ion-exchanged glass systems.

Keywords: IOX, surface, contact, charging, glass

*Speaker

Multiscale modeling of heterogeneous etching

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Glass dissolution is a complex multi-scale phenomenon, where variations in the etch rate at the atomistic scale can reveal emerging topographical features at larger length scales. This presentation details a new multiscale etching and dissolution model for glassy materials. The primary advancement is the development of an upscaled semi-Markovian algorithm which can simulate surface topography as a function of etch depth at the mesoscale. Unlike deterministic etch models, our mesoscale stochastic model uses probability distributions of etch rates as input, providing the origin of local variability and ultimately to surface roughness. Etch rate distributions can be derived from atomistic simulations (e.g., kinetic Monte Carlo or molecular dynamics) or measured experimentally. Finally, the power of this new tool will be demonstrated by showing how it can be used to solve and understand different problems in glass surface science.

Keywords: etching, modeling

*Speaker

Regeneration of Combustion-Degraded Quartz Optical Windows via Chemical and Mechanical Treatment

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View ports, i.e. sight glasses to observe thermal processes are made of quartz glass, vitreous silica. The degradation and contamination under high-temperature combustion remains a critical obstacle to stable optical diagnostics. While degradation mechanisms are well studied, restoration of flame-exposed quartz glass has been scarcely explored. The presented work experimentally establishes a combined chemical and mechanical-cleaning strategy that regenerates UV transmittance while maintaining surface integrity. Systematic tests were carried out in combination with spectroscopic and microscopic analyses conducted with UV-VIS-NIR spectroscopy, Raman spectroscopy and confocal light microscopy.

Keywords: Combustion, exposed glass, UV–Vis, NIR transmittance, Raman spectroscopy, surface degradation, Chemical cleaning

*Speaker

Invisible Damage on Glass Surfaces: Assessment of Surface/Subsurface Modification and Durability

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Invisible damage describes subtle surface or subsurface modifications in glass that evade standard inspection yet may manifest during downstream processing or reliability evaluations. This work explores the reproducibility and characterization of such damage under sub-threshold blunt contact conditions. Controlled loading experiments were combined with surface techniques on multicomponent silicate glasses, including surface topography mapping, compositional and spectroscopic analysis, and molecular-level simulations. Results show that topographical changes range from undetectable to shallow features, while chemical and structural alterations occur within the contact zone-even when physical changes are absent. Post-processing steps, such as etching, revealed these modified regions, confirming their latent nature. Despite clear evidence of structural and chemical modifications, mechanical strength testing did not demonstrate measurable degradation, leaving the threshold for reliability impact unresolved. These insights advance understanding of hidden damage mechanisms and underscore their relevance to product durability and cosmetic quality.

Keywords: Glass surfaces, Surface/subsurface modifications, Contact, induced changes, Chemical durability, Mechanical durability, Topography mapping, Spectroscopic analysis, Molecular dynamics modeling, Sub, threshold contact

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Experimental Investigation of Combined Chemical Strengthening and Flame Treatment for Post-Processing of Soda Lime Glass

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While chemical strengthening has long been established in the float glass and display glass industry, its sustainable implementation in the container glass industry remains a challenge (1). Despite the successful application of surface ion exchange using potassium nitrate for strengthening container glasses during the 1980-1990s in the former German Democratic Republic, this technique is seldom utilized on an industrial scale today (2). The main obstacle for transferring this technology to this sector lies in the incompatible nature of batch processing in chemical strengthening, limiting its application to the vast volumes necessary for continuous container glass production (elevating manufacturing costs and unit prices).
To overcome this issue, efforts were made to build up an accelerated ion exchange process for high-throughput production to shorten overall process times and increase economic attractiveness. Our development aims to combinate the immersion of glasses in the potassium nitrate salt bath and a subsequent flame treatment of the glass surfaces. This raises several questions, starting with the implementation of such a combination and ending with the examination of whether the desired strengthening effect can be accelerated. Since the sodium-potassium ion exchange is a diffusion-driven process, it is time and temperature dependent (3,4).

A subsequent flame treatment should make it possible to overheat the glass surface in a relatively short time and thus accelerate the diffusion of the potassium ions into the glass (Fig. 1). The question of whether the stresses generated by such short-term overheating persist, or dissolve through relaxation processes, will be discussed. This study compares float glass samples that have been chemically tempered with samples that have undergone combined conditioning. In addition, the focus is placed on the amount of potassium in the first few micrometers of the glass surface and how that may change the glass itself.

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Keywords: chemical strengthening, strength enhancement, flame treatment, ion exchange

Comparative aging of colored opal glass from the late 19th and early 20th centuries

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Opal glass offers an aesthetic alternative to clear glass. Used in decorative objects and tableware from XIXe century, opal glass keeps or improves the major properties of glass as mechanical resistance or chemical durability. Depending on the microstructure and chemical composition, opal glass shows an opalescent and slightly tinted appearance. In this study, two types of opal glass were studied. The oldest one was produced at the end of the 19th century in the glassworks of Vierzon (France) for decorative objects such as vases. The more recent opal glass was developed at the *Duralex* glassworks (La Chapelle-Saint-Mesmin, France) between 1964 and 1966 for tableware such as plates and cups. These opal glasses are colored in the mass, in white, blue, Emerald green or cream. Opalescence was obtained from the crystallization of calcium fluoride or complex phosphate oxides. In this study, both types of opal were examined and their chemical durability was compared, when submitted to accelerated ageing at 80∘C in atmospheric conditions and aggressive solution in acidic and alkaline environment. Chemical, structural and microstructural analyses have been carried out thanks to SEM-EDS, XRD, Raman spectroscopy, ToF-SIMS, ICP-AES and solid NMR. The glass matrix ability to retain the metallic coloring agents was explored.

Keywords: Opal glass, Chemical durability, Structure, Aging

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PMMA-Silica Nanoparticle Composite Coatings for Increased Strength of Soda Lime Silicate Glass

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Poly(methyl methacrylate) (PMMA) silica nanoparticle composite coatings are applied to glass for improved strength. The coatings are applied to glass slides via the dip coating method, and the strength is evaluated using 4-point bend flexural tests. The improvement in strength from these coatings is due to the flaw filling mechanism. Flaw filling is shown by scanning electron microscopy and focused ion beam (SEM and FIB), to cross section a Vickers indent on the glass surface that was coated over, displaying the depth and amount to which the coating filled the indent. Additionally, the nanoparticles incorporated into the coating provide the PMMA matrix with a reinforcement effect that enhances the overall strength improvement of the coating. Five different coatings are tested with different weight percentages of nanoparticles ranging from 0-2wt%. Three different groups of samples are tested for strength. Group one consists of coating unaltered glass slides, group two samples have controlled defects (CD) on the glass surface made using a Vickers indenter, and group three samples have controlled defects on the coating surface (CDOC) also created via Vickers indenter. All the coatings maintain high optical transparency across the visible spectrum and have thickness values ranging from 1-3 μm. While there is evidence of other coatings providing strengthening to glass, this effect has never been shown with PMMA-silica nanoparticle composite coatings. These coatings are beneficial due to the biocompatibility of PMMA and the favorable mechanical properties of silica nanoparticles. In addition, these coatings can be processed via solution mixing in a one pot method without the need for any additives.

Keywords: Strength, Coating, Polymer Nanoparticle Composite Coating

*Speaker

Study of Point Scatterers in Highly Reflective Coatings for Gravitational Wave Interferometer Mirrors.

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Gravitational wave detectors such as Advanced Virgo and Advanced LIGO require mirrors with exceptional optical properties to enable the detection of infinitesimal spacetime distortions. The performance of highly reflective optical coatings, made up of amorphous silica and tantala layers, is limited by light scattering caused by micrometer-size surface defects and deposition imperfections, which directly affects the circulating laser power and the sensitivity of the detectors.
This work focuses on the study of tantala monolayers deposited on a fused silica substrate by Ion Beam Sputtering (IBS) at Laboratoire des Matériaux Avancés (LMA). Advanced characterization techniques, including Optical Microscopy, Environmental Scanning Electron Microscopy (ESEM), Atomic Force Microscopy (AFM), and Focused Ion Beam (FIB) were performed at MATEIS Laboratory (Matériaux : Ingénierie et Sciences). The analysis focuses on understanding the nature of these defects, their formation and the underlying mechanisms. The main objective is to understand how deposition parameters influence the defect density and the optical properties in order to optimize the deposition process for a reduction of the defect density by a factor of two.
The results contribute to improving fabrication processes and material selection for the next-generation gravitational wave detectors, ensuring mirrors with outstanding optical properties, while advancing precision optical glass coatings.

Keywords: multilayer optical coatings, optical properties, light scattering, Ion Beam Sputtering, gravitational wave detectors.

*Speaker

Effects of encapsulation glass erosion by sandblasting and temperature variation on solar panels efficiency

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Solar is the most promising energy source and most powerful among renewable energies especially in the several regions of the Arabic country (Saharan regions), particularly in Algeria. The protective glasses and encapsulations of photovoltaic cells (PV) are subjected to various conditions of environment and particularly the wind of sand.
In this work, we simulated the sand storms by the sandblasting test and its effect on glass surface. We examine the effect of the sandblasted encapsulation glass of the panels on the optical transmission and the relative efficiency. The thermographs of solar panel are obtained by infra-red camera to examine the distribution of temperature according to irradiance of the sun.
Finally, we introduced a damage function of the panel's relative efficiency in function of the sandblasted glass. The efficiency of panels depends strongly of the glass surfaces behaviour when they are subjected to impacts of particles.

Keywords: Photovoltaic cells, solar, energy, Encapsulation Glass, Erosion, Impact, Sandblasting

*Speaker

Mechanical properties and local structure evolution in the sol-gel thin-films during high temperature heat treatment

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To provide thermal comfort and reduce carbon footprint, many functions are provided to glazing by coating, for applications related to buildings, transport or decoration. In some cases, these glass products must undergo thermal tempering to give the glass better mechanical strength. The development of functional coatings resistant to high temperatures ($> 600\circ$C) is thus a major challenge that sol-gel coatings can contribute to address. Indeed, the inorganic nature of the precursors is compatible with temperature resistance and allows good covalent adhesion to glass substrate. However, one of the limitations of these materials is the cracks generated in the layers due to the high tensile stresses that occurs during the condensation of the network and the evaporation of solvents. In addition, two known phenomena occur during tempering: the diffusion of alkali ions from the substrate to the layer and the passage of the melting temperature of the glass, which complicates the mechanics of the problem. This leads to a serious limitation in the achievable thicknesses of coatings and reduces the field of possible applications for the design of new products. The objective of this work is to better understand the relationships between the glass substrate, the structure, and the mechanical properties of the silica-based sol-gel layers during this complex tempering process. To reach this goal, we have developed an original strategy based on the combination of several ex- and in-situ techniques that allow us to follow the evolution of the microstructure of the layer (Raman spectroscopy), the mechanical properties (Nano-indentation) and the stress (curvature measurement) during the tempering coupled with the alkali ions migration from the glass substrate.

*Speaker

Keywords: silica sol gel, alkaline diffusion, glass thin coating, Raman spectroscopy, stress measurement, condensation, structural evolution, fracture

Feasibility of Albite and Sanidine as Environmental Barrier Coatings for CMAS Corrosion Prevention

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Calcia-Magnesia-Alumina-Silicate (CMAS) is a molten silicate deposit that forms on gas turbine engine blades made of nickel-based superalloys at elevated temperatures (> 1200 °C). Its infiltration into thermal barrier coatings (TBCs) significantly accelerates degradation, ultimately leading to mechanical failure of the engine. This study investigates the potential of Albite ($NaAlSi_3O_8$) and Sanidine ($KAlSi_3O_8$) as environmental barrier coatings (EBCs) to mitigate CMAS attack and extend blade lifetime. Two experimental approaches were designed to study the interaction between simulated CMAS glass and the EBCs at 1300 °C: (1) coating EBC pellets with CMAS glass powder to investigate interfacial reactions, and (2) preparing mixed pellets by combining EBC and CMAS in varying proportions to examine the microstructural evolution of reaction products. The heat-treated samples were characterized using SEM-EDS and XRD. The findings from these experiments will be presented in this paper. **Keywords:**

Environmental barrier coatings, coatings, CMAS, CMAS corrosion, Albite, Sanidine

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Glass and amorphous dielectrics at the heart of Gravitational Waves detection.

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It may not be widely known, but glass, and in particular fused silica, was at the heart of the technological revolution that enabled the first detection of GW signals more than 10 years ago and has since enabled the detection of around 300 signals. The challenges facing glass, and amorphous dielectrics in general, are now even greater than before. The limit to the detection of gravitational waves stems from the materials used to reflect light from the test masses: these materials form so-called Bragg mirrors and must have low thermal noise and ultra-low optical absorption. In order to support upgrades to existing detectors (LIGO, Virgo, and KAGRA) and the advent of third-generation detectors (Einstein Telescope and Cosmic Explorer), it is necessary to develop new materials with significant improvements over current ones. After a general introduction to the problems of materials in gravitational wave detection, the presentation will focus on understanding thermal noise and optical absorption in amorphous optical materials and will illustrate the lines of research pursued by the groups involved in the Virgo collaboration.

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Improving the luminescent emissions of oxyfluoride and oxide tellurite glass thin films deposited by pulsed laser deposition through annealing in an oxygen atmosphere

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Er3+ doped tellurite and oxyfluoro-tellurite glasses combine high refractive index, broad infrared transparency, and low phonon energy, making them attractive hosts for active photonics. Translating these materials to thin films via pulsed laser deposition (PLD) enables planar integration but typically yields as-deposited films with depressed photoluminescence due to stress, defect-assisted non-radiative pathways, and OH- absorption. We systematically assess how post-deposition annealing at 315 ^{o}C in O2 recovers and enhances emission in PLD films. Compared with unannealed controls, the 1.53 um luminescence under 980 nm excitation increases markedly with annealing time, reaching a maximum at 6 h before declining at longer durations. The early-time enhancement is attributed to defect passivation, OH- removal, and structural relaxation, whereas the late-time decrease is consistent with Er3+ migration/clustering and cross-relaxation. These results establish post-annealing as a critical step to restore and optimize Er3+ emission in PLD tellurite and oxyfluoro-tellurite thin films for integrated photonic devices.

Keywords: Tellurite glasses, Oxyfluoride glasses, Rare, earth ions, Pulsed laser deposition, Thin films

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In-situ observation of macrodeformation of sheet glass induced by ion exchange

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Chemical strengthening of sheet glass becomes more substantial and more popular compared to its physical strengthening via thermal tempering. It is understandable that imbalance of residual stresses between two faces of sheet glass tends to cause unintentional macrodeformation in the form of warpage or bending. For instance, the mismatch in kinetics of Na - K ion exchange originating from the anisotropy between air- and tin-side needs to be taken into consideration to avoid the nonzero curvature when float glass undergoes ion exchange. In addition, ultra-thin glass with thickness tantamount to _˜50 um for use as cover window in foldable smartphones is more vulnerable to the unwanted macrodeformation, so it requires extra care to perform ion exchange. In this study, curvatures of 100-um-thick ultra-thin glass caused by ion exchange were in-situ observed and then numerically formulated as a function of time and temperature. The classical Stoney formula was successfully modified to quantitatively interpret time- and temperature-dependent evolutions of curvature due to elastic deformation. Moreover, contribution of plastic deformation stemming from the stress-induced structural relaxation was introduced as in the form of curvature in our numerical modeling. A special attention is paid to other ion exchange conditions such as Na - Li and Na - (Li, K) to address their significance and potential applications.

Keywords: ion exchange, chemical strengthening, sheet glass, warpage

*Speaker

INDUSTRIAL EXAMPLES OF GLASS ANALYSES BY ToF-SIMS AND XPS

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SERMA TECHNOLOGIES, a wholly owned subsidiary of SERMA GROUP, proposes activities of technology expertise, analysis, control, test, consulting and training, on semiconductors, materials, active and passive components, boards, systems, batteries, hydrogen and solar panels for signal and power electronics. SERMA TECHNOLOGIES supports its customers by advising them at R&D, Engineering, Manufacturing and Sustaining phases.

Within SERMA TECHNOLOGIES, the Science et Surface laboratory is a materials analysis and expertise laboratory that groups together all the usual physico-chemical surface analysis techniques (XPS, SSIMS, DSIMS, GD-OES, FTIR, FIB, SEM, TEM, AFM, etc.). We assist our customers in development assistance (materials and processes), quality control and defect analysis expertise.

Through examples, we will demonstrate the interest of ToF-SIMS and XPS techniques to study glass alteration, glass treatments and glass defects. **Keywords:** ToF, SIMS, XPS, glass alteration,

glass treatments, glass defects

*Speaker

Laser welding of glass as a key technology for safe and cost-effective storage solutions

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In recent years, the glass industry has made significant advances in processing technology, particularly through the use of laser welding (1, 2, 3). This process allows for selective heating and bonding of glass components without the creation of critical thermal stress. It has enabled both thin-walled and thick-walled glass products, such as borosilicate tubes, to be successfully joined (4, 5, 6). The technology opens up new possibilities to manufacture sealed glass containers with defined wall thicknesses from semi-finished products.

Laser welded, large hollowware could be suitable for a safe and long-term stable storage of hazardous waste materials in underground landfills. In this presentation we will demonstrate the welding process and show the strength and residual stress profiles of the resulting glass containers. The major focus of the presentation will be set to aging tests of the welded glass against the environmental conditions of the underground waste disposal sites on one hand side and various different type of waste materials on the other hand. The general potential for storing critical waste materials in hollow glass bodies joined with the laser welding technology is explored and the relevancy for different wastes identified.

(1) https://doi.org/10.1007/s00170-016-9314-9
(2) https://doi.org/10.1016/j.procir.2022.08.068
(3) https://doi.org/10.2351/7.0001120
(4) https://doi.org/10.2351/1.5061063
(5) https://doi.org/10.1364/AO.47.006524
(6) LIA Paper zu LasGlaReLa eingereicht aber noch nicht veröffentlicht

Keywords: Laser Welding, Corrosion, sealed glass containers, critical waste materials

*Speaker

Three-Dimensional Structural Characterization of Hierarchical Nanoporous Layers Formed by Corrosion

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Glass surfaces exposed to corrosive environments can develop various textures and microstructures through chemical alteration processes. Among these corrosion-induced surface modifications, we have focused on a unique hierarchical nanoporous layer characterized by a gradual decrease in pore diameter from the surface toward the interior of the glass. This depth-dependent pore structure creates a continuous gradient in refractive index, enabling functional properties while maintaining optical transparency. In our previous studies, we demonstrated that the hierarchical nanoporous layer (HNL) glass exhibits anti-reflective properties and super-hydrophilicity without compromising transparency, making it promising for optical and surface-functional applications. However, structural characterization had been limited primarily to surface and cross-sectional observations using conventional scanning electron microscopy (SEM), for example, which provided only two-dimensional information about the complex three-dimensional porous network.
In this study, we employed focused ion beam scanning electron microscopy (FIB-SEM) tomography to precisely measure the three-dimensional structure of the hierarchical nanoporous layers. The FIB-SEM technique enables sequential milling and imaging at nanometer-scale resolution, allowing reconstruction of the complete porous architecture throughout the depth profile. This approach reveals critical structural information, including pore connectivity, tortuosity, spatial distribution, and the nature of the gradient in pore size from the surface to the bulk glass.

Furthermore, we compare the three-dimensional structural data obtained from FIB-SEM tomography with pore size distribution measurements from nitrogen adsorption analysis. The nitrogen adsorption method provides complementary information about pore volume, specific surface area, and statistical pore size distributions based on the Brunauer-Emmett-Teller (BET) theory and Barrett-Joyner-Halenda (BJH) analysis. By correlating these different characterization techniques, we discuss the structural features of the hierarchical nanoporous layers, including the relationship between three-dimensional pore morphology and functional surface properties. This comprehensive structural analysis advances our understanding of corrosion-induced nanoporous glass formation and provides insights for controlled fabrication of functional glass surfaces with tailored optical and wetting properties.

*Speaker

Keywords: porous structure, 3D tomography

Non-Bridging Oxygen in Leached and Electron-Irradiated Barium Glass

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The interaction between alkali–silicate glass and water, as well as with electron irradiation, was studied to understand the behaviour of non-bridging oxygens (NBOs) under different dealkalisation conditions. When alkali–silicate glass is immersed in water, water molecules and their dissociation products penetrate the network due to a chemical potential gradient. Hydrogen, water, and hydronium ions readily diffuse into the glass, while alkali ions migrate towards the surface and dissolve into the aqueous phase. Consequently, the near-surface region becomes dealkalised and enriched in hydrogen, which substitutes for alkali ions at NBO sites.
In contrast, irradiation with electrons of moderate energy induces alkali migration out of the irradiated volume, again forming a dealkalised region but without available hydrogen for substitution. In such cases, NBOs cannot be stabilised by hydrogen, leading instead to structural relaxation and the formation of defect oxygens (DOs).

To investigate these mechanisms, a commercial barium–alkali–silicate glass was studied using X-ray photoelectron spectroscopy (XPS). Four samples were prepared to represent various corrosion and relaxation conditions: (i) the original untreated surface (S), (ii) the same glass annealed under vacuum (ST), (iii) glass leached in demineralised water (W), and (iv) leached glass subsequently annealed (WT). After treatment, samples were analysed by XPS on the surface and after sputtering to a depth of 20 nm. For comparison, two additional specimens were irradiated with electrons at doses below and above the incubation threshold.

Decomposition of the O 1s spectra revealed the distribution of bridging oxygens (BOs) and NBOs, enabling the identification of structural and chemical changes. In water-treated glass, the oxygen-to-network-former ratio remained constant, confirming the stability of the silicate subnetwork. However, oxygen atoms could dynamically exchange between NBO, DO, and hydrogen-bonded (HO) states depending on the treatment. Not all NBO–M (M = alkali) bonds were replaced by NBO–H, leaving some defect-type oxygens with similar binding energies.
Electron-irradiated samples exhibited analogous relaxation behaviour. Low-dose irradiation induced partial sodium migration without significant structural change, while high-dose exposure produced complete surface dealkalisation and polymerisation of the glass network via conversion of DOs into BOs, accompanied by oxygen release and enhanced structural ordering.

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Keywords: silicate glass, surface, electron irradiation, leaching, nonbridging oxygen

Decoding glass durability: new insights into the role of composition

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To some extent, glass composition can be tailored to achieve a desired chemical durability. However, this requires a detailed understanding of how composition influences the mechanisms of glass alteration. These mechanisms govern the alteration rate, which in turn strongly depends on environmental conditions such as temperature, pH, and fluid composition-factors that are closely linked to the intended application of the glass.
We first show that combining structural descriptors of the glass allows for accurate predictions of its initial dissolution rate under fixed pH and temperature conditions. The proposed model distinguishes between glasses exhibiting congruent and incongruent dissolution behaviors.

Under conditions favorable to gel formation, this alteration layer may become passivating through densification and precipitation. In such cases, the alteration rate decreases by several orders of magnitude compared to the initial rate. We present recent findings highlighting the role of network-forming elements such as Si, B, and Al in these passivation mechanisms.
We also introduce the latest models developed to link gel properties to residual alteration rates. These include stochastic (Monte Carlo) models as well as continuum models that describe the spatial and temporal evolution of the gel's physical and chemical properties. While currently explanatory in nature, these models are progressively evolving toward predictive capabilities.

Keywords: alteration, corrosion, nuclear glass, kinetics

*Speaker

Network Polymerization, Aluminum Coordination, and the Shifting Mechanisms of Glass Dissolution

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Adding Al2O3 is traditionally known to enhance the chemical durability of silicate glasses. This improvement arises from the tetrahedral coordination of Al3+ ions within the glass network, which requires charge compensation by alkali or alkaline-earth cations. As a result, the concentration of non-bridging oxygens decreases, leading to a more connected and hydrolysis-resistant network. Interestingly, most functional glasses are **peralkaline**, meaning their alkali/alkaline-earth oxide–to–Al2O3 ratio exceeds one. This raises important questions: What happens when the glass structure becomes fully polymerized, or when Al3+ adopts a coordination number greater than four? Does Al3+ still enhance chemical durability under such conditions? And does the underlying mechanism of corrosion remain the same?
The present study addresses these questions by investigating the dissolution kinetics and mechanisms of MgO–Al2O3–B2O3–SiO2 glasses designed along the peralkaline–to–metaluminous–to–peraluminous compositional join. Dissolution experiments were conducted in aqueous HCl solution at pH = 1. A comprehensive suite of bulk and surface-sensitive spectroscopic and electron microscopy techniques, complemented by molecular dynamics simulations, was employed to elucidate the chemo-structural factors controlling glass dissolution.
The results reveal a transition from **incongruent** to **congruent** dissolution as the glass composition shifts from peralkaline to peraluminous. Moreover, the initial dissolution rates of Mg, Al, and B decrease, while that of Si increases across the same compositional trend. These behaviors are interpreted in terms of systematic modifications in the short- to medium-range structure of the glass network with changing composition.

Keywords: glass, chemical durability, aluminum, structure

*Speaker

Tellurite glasses and optical fibers coated with lanthanide coordination polymers: a new composite material for chemical sensing

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Coordination polymers (CPs) have gained significant attention as chemical sensors due to their highly tunable porous structures, enabling selective interactions with target analytes. Lanthanide-based coordination polymers (Ln-CPs) have been extensively utilized in optical sensing owing to their photoluminescent properties. However, these applications typically require deposition on stable substrates with appropriate chemical and physical characteristics. This study introduces simple and rapid *in situ* synthesis and coating process for Ln-CPs on oxide glass bulks and optical fibers. Eu3+-based CPs were successfully coated onto tellurite and phosphate glasses using polycarboxylic acids as ligands. Although slight deviations from previously reported crystalline structures were observed, the luminescent coatings were effectively formed and demonstrated good adhesion to the tellurite glass substrates. These materials exhibited potential selectivity toward carbonyl compounds, showing an enhanced luminescent response at low concentrations. The successful integration of Ln-CPs onto TZN-based optical fibers underscores their potential for real-time remote sensing, offering promising applications in environmental monitoring, industrial safety, and biomedical diagnostics.

Keywords: luminescent coatings, lanthanide, coordination polymers, tellurite glasses, optical fibers, chemical sensing.

*Speaker

Investigation of 2.5 MeV Electron Radiation–Induced Modifications in Silica Thin Films

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Silica thin films are widely used as protective layers in microelectronics, optics, and biomedical applications due to their excellent thermal, chemical, and mechanical stability. Their structure and properties, however, depend strongly on their growth technique and conditions (1). Variations in network polymerization, porosity, and hydroxyl content distinguish thermally grown oxides from deposited ones. Certain deposited silica films, especially those produced by plasma-enhanced-chemical-vapor-deposition (PECVD) or by magnetron sputtering, exhibit structural characteristics comparable to an irradiation-densified silica known as the metamict phase (2,3) as evidenced by their intense D_2 Raman band, typical of metamict phase. Nevertheless, some can be even denser (2.35 g·cm^{-3} vs 2.26 g·cm^{-3}), suggesting distinct atomic-scale associated with the growing process.

The objectif of this study is first to compare the structure and properties of different silica films according to the preparation mode (thermally grown oxides, structurally resembling fused bulk silica, PECVD-films and High-Power-Impulse-Magnetron-Sputtering (HiPIMS) films exhibiting denser network), Second, to characterize the evolution of these films under electron irradiation and to follow their relaxation compared to that of bulk silica.

Electron irradiations were conducted using a 2.5 MeV beam at the Sirius accelerator (LSI-EMIRA). Nano-FTIR (SMIS-beamline-SOLEIL), Raman spectroscopy and ellipsometry (for refractive index) were performed. First results indicate a remarkable electron-radiation resistance of thermal oxides compared to PECVD-deposited films. The latter showed a 26 cm^{-1} shift toward higher wavenumbers and narrowing of the 1119 cm^{-1} Si–O–Si as-stretching band in the nano-FTIR spectrum, indicating a more homogeneous network with reduced Si–O–Si bond-angle dispersion. Raman and ellipsometry analyses (ongoing) will refine this interpretation. Irradiation at 600 K (1 GGy) caused hydrogen loss confirmed by ERDA, consistent with network compaction via dehydration–condensation. Notably, regardless of their initial composition, all irradiated PECVD-films evolved, after a 600 K irradiation, towards a structure and composition resembling that of wet thermal oxides, with comparable thickness. Furthermore, unlike thermal annealing, irradiation induces deeper structural and compositional transformations—an effect relevant for silica direct-bonding applications where controlled modification of OH content and distribution is critical.

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Electron irradiation, NanoFTIR, PECVD, Thermal oxidation, HiPIMS

The Formation and Characterization of Gel Layers on Modified Aluminoborate Glasses during Aqueous Corrosion

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The nature of gel formation on borate glasses during dissolution remains relatively unexplored, despite relevance to bioactive glass applications. In this work, we investigate gel layer formation on sodium- and potassium- modified aluminoborate glasses after dissolution in deionized water. Analysis of bulk monoliths provided insights into the evolution of gel layers formed on borate glass surfaces as a result of aqueous corrosion. The dissolution of the monoliths occurred at the bulk scale with all glass components degrading as opposed to the selective ion leaching observed in many silicate glass systems. Powder X-ray diffraction revealed primarily amorphous gels after exposure except for one composition which formed the mineral santite due to stoichiometric similarity with the base glass. The resulting gel did not inhibit ion release from the glass into solution as shown by ICP-AES analysis of both the gel and solution. Data suggests good tunability of ion release by altering the bulk glass composition which greatly impacts the structural durability of the network. This work provides conclusive observations of macroscopic gel formation on fast dissolving borate glass surfaces.

Keywords: Corrosion, Borate, Dissolution

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Texturing glass surfaces for enhancing tactile experience

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In today's world, much of our interaction with information displays occurs through touch screens, where tactile feedback plays a significant role in the user experience. One promising approach to improve this experience is through the texturing of glass surfaces. This talk will discuss the results of human perception experiments conducted on textured glass samples, highlighting the types of textures participants favored. Furthermore, it will cover different techniques for texturing glass and provide an overview of their potential uses and advantages.

Keywords: surface texturing, etching, tactility, haptics

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Factors Governing Staining of Float Glass Exposed to an Acid Cleaning Product

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Staining of architectural float glass facades is a recurrent and costly issue in urban environments, particularly under exposure to acid rain and aggressive post-construction cleaning procedures. This study investigates the causes of staining observed in laminated float glass panels from four commercial manufacturers after exposure to an acidic cleaning product. Six glass samples were examined, including unused samples and samples previously installed in building facades. Three hypotheses were tested: (i) the influence of surface tin contamination originating from the float bath, (ii) the role of bulk chemical composition and chemical durability, and (iii) the influence of surface condition, particularly roughness and micro-scratches. A multiscale characterization approach was employed, combining refractive index measurements, nanoindentation, EDS, XPS, XRF, chemical solubility tests, and laser scanning microscopy. Although tin was detected at the outer surface, reaching up to 3.6 at% in one sample, no correlation was found between tin concentration, oxidation state (Sn^{2+}/Sn^{4+}), and staining susceptibility. One unused glass with a higher network modifier-to-former ratio exhibited lower chemical durability and stained readily upon acid exposure. For previously used glasses, staining was strongly associated with surface condition. Well-polished surfaces showed only minor roughness changes after acid contact, whereas pre-damaged surfaces exhibited rapid roughness amplification and pronounced visible staining. These results demonstrate that staining susceptibility in float glass is primarily governed by intrinsic chemical durability and surface condition, rather than by surface tin contamination. **Keywords:** Chemical durability, float glass, staining, surface roughness, tin contamination

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Pharmaceutical glass BS50: Chemical alteration phenomena in aqueous and atmospheric medium.

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Type I glasses, commonly referred to as "neutral glass" (1), used for medical solutions, are low-alkali aluminoborosilicate glasses, of which composition has been designed to favor high polymerization degree and homogeneity of the glass network. These structural properties are probably related to their excellent chemical durability. Within this composition domain, we will focus solely on BS50 aluminoborosilicate glass, named after its thermal expansion coefficient of $50{\cdot}10^{-7}$ K^{-1} (1).

The chemical durability of aluminoborosilicate glasses has been extensively studied because of their use as nuclear wasteforms. However, polymerized compositions such as BS50 have been less explored and the details of their chemical alteration by water are not described in the literature (2). Despite these compositions are tailored to be highly durable, their surface composition, structure and microstructure are inevitably modified by water attack, which is of importance to control the surface properties of the pharmaceutical glass.

The purpose of this study is to establish behavioral laws describing the alteration mechanisms governing the BS50 glass surface, in submerged and atmospheric environments. We therefore monitored alteration of monolith and powdered BS50 glass samples in the laboratory, by varying several parameters such as temperature, pH, and time. The microstructure of the monolith samples surfaces was observed using an optical microscope, a SEM and an AFM. The chemical modifications of the surface and sub-surface were characterized using ToF-SIMS and XPS. The hydration rate was determined by measuring the thickness of the hydrated layer (TOF-SIMS) and by thermogravimetric analysis (TGA) of glass powders. For alterations in submerged environment, the congruent versus incongruent behaviour, as well as the kinetics of glass dissolution were measured by ICP-AES of the leachates.

The poster will put together and summarize the main results concerning the alteration of BS50-type aluminoborosilicate glass in submerged and atmospheric environments.

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Keywords: Glass surface, alteration, aluminoborosilicate glass, pharmaceutical glass, BS50

Ultrashort laser-treated PVD ZrCuAg-based thin film metallic glasses, towards bactericid advanced surfaces

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Due to the lack of metallurgical crystalline defects, bulk metallic glasses (BMG) have displayed attractive physical and chemical properties. They have been intensively studied, but BMGs development was however limited to relatively small sizes linked to required fast quench rates. Recently, thin film metallic glasses (TFMGs) have emerged as alternative syrface materials for many advanced applications. Physical vapor deposition (PVD) processes, like sputtering, make now possible synthesis of TFMG in an extended range of compositions. It has been demonstrated that binary Zr-Cu films (13-85 at.%Cu), presenting a glassy-like microstructure, can be obtained using pure Cu and Zr targets (1).
The biomedical field constitutes probably one of the most promising field, where TFMGs could be really interesting candidates. Their chemistry can be indeed easily controlled, giving rise for instance to bactericide or bacteriostatic surfaces, depending on the film silver content (2).

In the current study, we propose a further degree of freedom to functionalize the surface, linked to the control, at a sub-micrometer scale, of its topography. Considering the fineness of targeted textures on the hand, and the preservation of the amorphous nature of the film surface on the other hand, ultrashort lasers were used (3).

In the present work, laser-treatments were applied to Zr-Cu-Ag TFMGs, synthesized by magnetron sputtering. These films are amorphous, smooth, display high hardness. Modifying the operating laser parameters (wavelength, frequency, pulse number and duration, fluency...), specific sub-micrometric LIPSS designs (Laser-Induced Periodic Surface Structures) were achieved

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(4). Behaviour of the fs laser-treated surface, in terms of hydro-phily/phoby, was then measured at different scales: macroscopic (contact angle measurement) as well as microscopic, using an environmental SEM under the humid *in situ* mode. The bactericid character of surfaces is then discussed in light of both the films chemical composition and its surface texture.

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Keywords: Thin film metallic glasses, PVD process, laser texturing, Environmental SEM, biological active surfaces, wetting

The effectiveness of Liquid treatment for the Dealkalization of pharmaceutical glass containers

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In the pharmaceutical industry, the stability of glass containers is paramount, especially regarding 'Specific release,' which refers to the leaching of elements, mainly Alkali and Alkaline earth, from glass into solutions
This study focuses on Soda Lime Silicate Glass, the most susceptible to such release, and explores innovative approaches to mitigate this issue.

The most used approach in the glass industry involves the use of a sulfur-based gas treatment to dealkalize the internal surface of glass containers. Unfortunately, it presents some drawbacks related to the used reactants.

We present here the results obtained by applying liquid treatment, based on non-toxic compounds and on a different application process. In detail, different parameters have been studied to optimize the application of the solution, such as Vial Temperature Application (250-600∘C), Nozzle Aperture Time, and Post Deposition Annealing Cycle. In addition, studies on the setup of application effectiveness have been conducted.

The quantification of the specific release follows pharmacopoeia regulations that set the limits for the titration but do not account for all the elements released in solutions. To gain insight into this phenomenon, we used Inductively Coupled Plasma – Optical Emission Spectroscopy and Inductively Coupled Plasma – Mass Spectrometry for the quantification of elements.

For a morphological analysis, Scanning Electron Microscopy and Atomic Force Microscopy were used for the characterization of the vials surface. Finally, Ion Beam Analysis was used for the characterization of the elemental depth profile variation of treated samples before and after re-

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lease experiment.

Morphologically, the gas-treated vials 'surface presents a homogeneous pitting that varies by area, due to the contact of the glass with sulfuric acid. A morphology that liquid-treated vials do not present.

Our results indicated that increasing the vials temperature of application leads, in the first nanometers, to a decrease in the Na profile and a slight increase in H, a correlation reflective of the underlying mechanism of the treatment.
Following parameter optimization, the liquid treatment demonstrated a reduction of at least 90% in elements released, such as Na, Ca and Si, thereby affirming its efficacy in enhancing the chemical durability of the vials.

Keywords: dealkalization, glass surface, pharmaceutical glass packaging, leachable

Thermal annealing of GeO2-based coatings: glass transition and implications for coatings in high-performance Bragg mirrors

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Amorphous GeO2-based optical coatings have recently been proposed as building blocks in the next-generation high-performance Bragg mirrors for Gravitational Wave Detectors(1-4). Like for every amorphous material so far considered for this role, also in the case of GeO2-based coatings a post-deposition thermal annealing is necessary to relax the coating structure while avoiding crystallization(5-7). However, unlike more commonly used coating materials such as SiO2, TiO2 and Ta2O5, several properties of GeO2-based coatings show non-monotonous trends during the thermal annealing(8). In particular, the thickness of amorphous mixed Ti:GeO2 coatings increases when the coating is heated up to 600 ∘C, but then it starts decreasing rapidly when the coating is held at that constant temperature(8), as determined with in situ spectroscopic ellipsometry. This peculiar trend, and other remarkable temperature-dependent behaviors of GeO2-based coatings, are interpreted by considering the strong glass-forming properties of GeO2.

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Keywords: Germanium oxide, ellipsometry, in situ, thermal annealing

Processing & thermal behavior of alkali silicate solutions, xerogels & coatings

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Aqueous alkali silicates, also known as waterglass or soluble silicates, are industrially relevant systems with applications in fireproof products, paints and cardboards etc. Their foaming/intumescent behavior has been of particular interest whereby fire-resistance is exhibited due to insulating property and barrier role of a rigid foam. The foaming behavior of waterglass systems is due to the release of proton-related species (network silanols, solvating water and free water molecules) from the silicate network. Upon thermal treatment, xerogels result at temperatures approaching 150 °C due to removal of all the free water in the system. Further increase in temperature to 250 °C and beyond causes the release of solvating water molecules and silanols resulting in macroscopic volumetric expansion of the silicate network that acts as a rigid thermal foam. Sodium silicate solutions exhibit extensive volumetric expansion, lithium silicates do not expand due to crystallization and phase separation while potassium silicates show a behavior in-between sodium and lithium silicates. The thermal behavior of these silicate systems has been comprehensively elaborated on a fundamental scale using a combination of tools including liquid and solid-state NMR spectroscopy, Raman spectroscopy, TGA/DSC & XRD. This analysis helps in understanding the underlying microscopic structural changes responsible for the observed macroscopic foaming phenomenon exhibited by alkali silicate systems upon thermal treatment. Furthermore, thick, homogeneous and high-quality coatings have also been elaborated from these waterglass systems with potential in various applications such as thermal management, optically tunable systems, illuminating road markings, composite coatings for electronic applications, porous filters, corrosion resistant and hydrophobic coatings. The thermal behavior of these coatings conforms to that observed for solutions and xerogels, however, the properties are thickness-dependent and have been evaluated with the help of Raman spectroscopy, SEM and XRD. Lastly, laser processing of these thick silicate coatings has allowed to control the foaming behavior by producing varying degree of porosities throughout the volume that may find use in several applications. **Keywords:** Silicates, Foam, Structure, Coating, Crystallization

*Speaker

Strategies for mitigating the diffusion of deleterious species within Low E stacks to ensure the preservation of the electrical conductivity of Ag

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To reduce the carbon footprint, low emissivity glazing developed by glass makers contributes to tackle the thermal losses through the windows of the buildings. In these products, the radiative part of the heat loss – particularly in the far-infrared range - is minimized by applying a thin layer of silver at the surface of one glass panel. This Ag layer is embedded between other nanometric layers such as nitrides (SiNx), oxides (ZnO, SiOx...) and sub-nanometric metallic layers (Ti, NiCr), all deposited using magnetron sputtering. These layers are designed to optimize the transmission in the visible range while primarily enhancing and maintaining the conductivity of the Ag. Indeed, according to the Hagen-Rubens law, the reflection of the infrared is directly correlated to the layer's electrical conductivity. It is therefore essential to maximize the silver layer's conductivity by limiting the migration of any species that could degrade it during the deposition step, the post treatment such as tempering and throughout the whole glazing's service life. The present work first examines the different species – such as oxygen-based ones, alkalis- identified as degrading the conductivity of the silver, providing some insights into the underlying mechanisms. It then outlines the different strategies implemented to control the flux of deleterious species, ranging from adding a sub-nanometric layer at the silver interfaces, to the optimizing the thicker barrier layers (SiO2, SiNx). Finally, the impact of these solutions during the deposition step and during thermal post-treatment is discussed.

Keywords: diffusion, coating, silver, annealing, conductivity

*Speaker

Design of chemical etch processes for multicomponent commercial glasses

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The design of wet chemical processes to etch, thin, polish, or texture glass for producing parts with the desired surface characteristics is integral to manufacturing many glasses for technological applications. In this pursuit, fluoride- and non-fluoride based aqueous solutions (such as HF, HCl, NaOH, etc.) are both typically used to produce the surface properties, strength, and cosmetics required for the product, where the resulting characteristics require direct insights into the fundamental mechanisms controlling reactions between the glass surface and the aqueous solution. This investigation will specifically focus on the impact of aqueous species like HF, H3O+, and OH- on the dissolution kinetics and surface evolution of multicomponent glasses relevant to chemical processing. Surface features like morphology, cosmetics, chemistry, and contact damage will be examined in detail as a function of the extent of dissolution and identity of the chemical etchant and process utilized.

Keywords: etching, dissolution, surfaces, aqueous chemistry

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Water-Based Organosilane Coatings for Low-Friction and Scratch-Resistant Pharmaceutical Glass Vials: From Dipping to Automated Spray Deposition

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Glass is still the preferred material for pharmaceutical packaging due to its excellent chemical resistance and inertness. However, it is prone to surface damage, scratch sensitivity, and limited handling strength. Conventional hot-end and cold-end coatings rely on multi-step processes and environmentally problematic precursors, motivating the development of greener and more scalable alternatives. This work investigates water-based organosilane coatings designed to improve sustainability and maintain mechanical performance of the external surface of glass vials, with the goal of making them scalable for industrial processing.
Different coating strategies based on water-borne organosilanes combined with lubricant were explored, involving formulations with distinct functional groups to enhance surface adhesion, scratch and frictional performance. The study investigates formulation and process development, progressing from dipping to manual airbrush spraying and ultimately to automated spray deposition suitable for high-throughput manufacturing.

In the dip and airbrush study, soda-lime-silicate glass substrates were subjected to surface activation to increase hydroxyl density and improve silanization efficiency. Automated spray deposition performed on heated substrates (80–120 ∘C) enabled rapid solvent evaporation and silane condensation without pre-activation, confirming the compatibility of water-based coatings with industrial constraints.

Experimental characterization included contact angle (CA) measurements to assess surface wettability, atomic force microscopy (AFM) to study coating morphology, and X-ray photoelectron

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spectroscopy (XPS) to confirm the presence of the coating through nitrogen and carbon signals and to study molecular orientation under different deposition parameters.

Mechanical performance was evaluated through scratch and friction measurements. Coated samples consistently showed higher critical loads (Lc), indicating delayed transitions from Hertzian cracking to fracture and confirming the protective effect of the new surface coating formulations. Tribological analysis revealed a significant reduction in the coefficient of friction (COF), demonstrating greater lubrication compared to uncoated surfaces.
The combination of eco-friendly chemistry, surface protection and scalable processing highlights the potential of these coatings to replace traditional treatments and support the transition toward greener manufacturing practices in the pharmaceutical glass industry.

Keywords: Water, based coatings, Organosilanes, coated glass, Low, friction surfaces, Scratch resistant, coatings, Glass vials, Spray deposition, Sustainable manufacturing.

Effect of Hydrothermal Treatment on Surface Chemistry, Tribology, and Crack Resistance of Alkali Boroaluminosilicate Glasses

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It is well-known that water can lead to stress corrosion in glasses, but certain glass compositions can show an improvement in crack initiation resistance upon hydrothermal treatment, e.g., upon treatment of various multicomponent silicate glasses with water vapor at elevated temperature. Here, we study the effect of such hydrothermal treatment on the surface chemistry of two series of alkali-boroaluminosilicate and alkali-aluminosilicate glasses. Through indentation, friction/wear, NMR, XPS and infrared to ultraviolet spectroscopic ellipsometry measurements, we determine the changes in mechanical properties, surface structure and surface chemistry. These insights contribute to a deeper understanding of the mechanism behind the water vapor induced strengthening in complex glass systems. By elucidating the interplay between surface chemistry and mechanical performance, our study lays the groundwork for tailoring hydrothermal treatments to enhance glass mechanics.

Keywords: Hydrothermal treatment, Tribology, Friction, Wear, Ellipsometry, Crack resistance

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Development of low-carbon glass frits for glass enameling applications

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Les émaux sont des revêtements minéraux principalement composés de fritte de verre, obtenue par fusion d'oxydes tels que le bismuth, le bore, le zinc et le silicium, ainsi que de pigments inorganiques dispersés dans un milieu organique. Appliqué sur du verre plat par sérigraphie ou impression numérique, l'émail est séché puis cuit, ce qui permet à la fritte de fondre partiellement et d'adhérer au support, formant une couche vitreuse partiellement céramis ée qui encapsule les pigments. Dans le vitrage automobile, les émaux sont utilisés sur les bords des éléments vitrés (pare-brise, toit, lunette arrière) pour remplir des fonctions essentielles : masquer les zones de collage et les composants électroniques, garantir l'opacité, la brillance et la couleur (généralement noire), et protéger les adhésifs des rayons UV. La fritte, qui représente environ 80 % de la masse de l'émail, est essentielle à la compatibilité de mise en œuvre et aux performances finales. Sa fusibilité, liée à sa température de transition vitreuse (Tg) et à sa viscosité, doit être compatible avec les cycles de vitrification (450–550 °C), et son coefficient de dilatation thermique (CTE $\approx 90 \times 10^{-7}$ K^{-1}) doit correspondre à celui du substrat. Les frittes actuelles, principalement à base de silice, nécessitent des températures de fusion supérieures à 1400 °C. Mes recherches visent à développer des frittes hautes performances à faible empreinte carbone, en tenant compte du coût, de la disponibilité des matières premières et des aspects sanitaires. Nous étudions des formulations alternatives prometteuses, offrant des températures de fusion plus basses et des profils environnementaux améliorés, tout en présentant des propriétés intéressantes pour nos applications. Pour ce faire, je combine synthèse expérimentale et modélisation thermodynamique. Les verres sont préparés par trempe à l'état fondu et caractérisés à l'aide de DTA-TGA, TMA, HSM, SEM, XRD et FTIR, etc. En parallèle, la modélisation basée sur CALPHAD permet la construction de diagrammes de phase quasi-ternaires et de projections de liquidus, orientant les compositions vers des températures de traitement plus basses et améliorant la compréhension du comportement de l'émail pendant

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la cuisson. **Keywords:** enamel, low melting glass, frit, glass coating, thermodynamic modeling

Diffusion coefficients of H and Na in aluminosilicate and soda-lime silicate glasses

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The behavior of Na and H at the glass surface often differs from that in the bulk, posing a major challenge in the commercial use of glass. In particular, the movement of Na+ and H+ at the surface affects glass properties, optical characteristics, and electrical properties, making it necessary to understand and control these movements. In this report, we investigated the H diffusion coefficients in soda-lime silicate and aluminosilicate glasses. There are many reports on the Na diffusion coefficient in aluminosilicate glasses, which is higher than that in soda-lime glass with a similar Na content. This is attributed to the fact that Na+ coordinated with (AlO4)- is more mobile than Na+ coordinated with SiO-, which also explains why chemical strengthening of aluminosilicate glass by ion exchange (Na+ ⇔ K+ ion exchange) progresses more easily. On the other hand, there are few studies discussing the H diffusion coefficient. In this study, the H diffusion coefficients of aluminosilicate and soda-lime glasses were calculated from the H dehydration profiles obtained by D-SIMS from each glass after thermal dehydration. Previous reports have shown that the tens-of-micrometer H dehydration profiles observed when thermally dehydrating near Tg are not due to H2O or H3O+, but represent H+ deficiency profiles caused by H+ ⇔ Na+ exchange. The H diffusion coefficient calculated for aluminosilicate glass this time is one order of magnitude smaller than that of soda-lime glass analyzed using the same method. This indicates that Na ⇔ H exchange diffusion is less likely to occur in aluminosilicate glass, suggesting that in the glassy state, H+ does not easily coordinate with (AlO4)-Na+, making Na+ ⇔ H+ ion exchange difficult to progress. In the presentation, we will provide a detailed discussion on why H+ ⇔ Na+ exchange in aluminosilicate is reluctant to occur and introduce phenomena caused by the rate-limiting nature of the H+ ⇔ Na+ exchange reaction by (AlO4)-Na+, which exhibits a trend opposite to chemical strengthening.

Keywords: Hydrogen diffusion, Ion exchange, Aluminosilicate glass, Surface durability, Soda, lime glass

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Glass surface and etching considerations for use in advanced semiconductor packaging

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Glass is an increasingly critical material in the semiconductor industry, offering unique advantages across a wide range of applications such as glass carrier wafers, substrates for advanced packaging, or optical glass components for augmented reality or co-packaged optical systems. The exceptional properties achievable in glassy systems-such as chemical stability, mechanical stiffness, optical clarity, and tunable thermal/dielectric properties-offer significant value to semiconductor manufacturing and packaging processes. However, challenges remain for understanding the compatibility of various glasses within device fabrication processes. In this presentation, I will highlight a selection of aspects and observations related to glass surfaces that can manifest when leveraging glass in advanced semiconductor applications, such as considerations for surface cleanliness and contamination, factors impacting film adhesion, and nuances of glass etching useful for creating through-glass vias. These surface-related factors can significantly influence device reliability, making their understanding essential for continued successful integration of glass in emerging technologies.

Keywords: glass, surface, etch, corrosion, semiconductor, packaging, thin films

*Speaker

Plasma-Activation of Silica-Glass Surfaces Evidenced by XPS analysis: A Promising Route for Low Temperature Molecular Bonding

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Efficient optical glass assembly requires high optical quality interfaces without any additional intermediate layer. Molecular bonding relies on covalent bonds formation between the two surfaces put in contact.
Surfaces' plasma-activation has been proposed as a relevant approach for enhancing covalent bonds generation and the resulting bonding energy. It is widely reported for semi-conductor materials (1-2-3), but not common for glass (4-5).

We report on high resolution X-ray Photoelectron Spectroscopy measurements of silica glass surfaces activated by plasma. Plasma chemistries such as O2, O2+SF6, N2, Ozone have been measured, for several plasma operating conditions including RIE-CCP or RIE-ICP.

Dangling bonds generated in each plasma condition are identified and their atomic percentages measured. The main relevant dangling bonds are: O bond in SiO2, O bond in OH, F bond in SiOF, N bond in SiON, and O bond in H2O. Silanol -OH bonds formation is enhanced by CCP O2 plasma and Ozone, as already identified on Silicon (2). N2 plasma generates specific -SiON bonds with Si1O0.7N0.9. stoichiometry. Adding a very small percentage of SF6 to an O2 plasma generates -SiOF bonds. Dangling bonds exist at the surface and within the sub-surface _˜4nm-thick scanned by the XPS beam.

We propose to analyze mechanisms involved in dangling bonds generation and covalent bonds reconstruction during bonding considering an ab-initio molecular dynamics simulation approach (6-7). The fracture model developed in (7) has evidenced that siloxane bonds' stereo- configuration plays a key role in explaining the evolution of siloxane bonds fracture or their formation under dihydroxylation mechanism. Considering that plasma activation could induce strain at glass surface, this bond stereo-configuration is proposed for explaining both XPS-measured dangling bonds generation and siloxane bonds formation during assembly of plasma-activated

*Speaker

surfaces.

The Renatech network is acknowledged.

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Keywords: Molecular bonding, Optical Glass, Plasma activation, Surface analysis, X, ray photoelectron spectroscopy, Bonding mechanisms

Impact of complex irradiation scenarios on the structure and the properties of the SON68 glass

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The long-term safety of nuclear waste glasses in geological disposal requires understanding their behavior under self-irradiation. This study investigated the effects of external irradiation on SON68 nuclear glass to evaluate the validity of simplified glass compositions as surrogates and assess the representativeness of mono-beam irradiations compared to self-irradiation. SON68 glass samples were subjected to 2.5 MeV electron irradiation (simulating β/γ effects), 7 MeV Au ion irradiation (simulating α-recoil nuclei), and sequential electron-Au irradiation (simulating the sequential radiation scenario). Structural modifications were characterized using Raman spectroscopy, solid-state NMR, and XANES, while macroscopic properties were evaluated through density, hardness, and calorimetric measurements. Results demonstrate the dominance of nuclear damage over electronic damage, with Au irradiation inducing significant structural changes (network depolymerization, increased BO_3 units) and substantial property variations (swelling: +2.2 to 2.4%, hardness: -36 to -41%), while electron irradiation caused limited structural modifications despite notable hardness reduction (-12%). No synergistic effects were observed between sequential irradiations, confirming nuclear interaction dominance. Comparison with self-irradiated glasses showed that mono-beam irradiations provide conservative estimates suitable for safety assessment but overestimate certain properties (swelling by factor 4 to 5) due to α particle-induced recovery effects absent in single-beam approaches. These findings validate nuclear collision simulations as conservative upper-bound scenarios while highlighting the importance of understanding α particle-induced recovery processes for accurate long-term predictions.

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Keywords: nuclear glass, irradiation, mechanical properties, structural modification, long, term safety

Chemical replacement zones in ion exchange - from concentration depth profiles to hardness

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Chemical replacement zones in solid state materials have relevance in many fields of material science. The most powerful approach for generating such replacement zones is the electric field assisted ion exchange (EFAIE) which induces uni-directional transport in solids and allows to manipulate the physical properties of solid electrolytes, especially near the sample surface (1). Native alkali cations such as Na+ can, e.g., be exchanged by foreign cations introduced with, e.g., sputtered/molten electrodes (1, 2). The ion exchange can lead to, among other things, chemical hardening, improvement of antimicrobial properties or the formation of waveguides structures.
In this contribution we demonstrate the formation of pronounced replacement zones, and the quantification of the replacement zones by three different techniques. The alkali deuteron substitution (ADS) is a special form of the EFAIE, where Deuterium is converted to D+ ions at a thin platinum electrode. An electric field applied drives the D+ ions into the sample and induce replacement of the native (and mobile) alkali ions. This technique is an adaptation of the alkali proton substitution technique firstly introduced by Omata (3). We have implemented a modified version of this in our group recently (4).

In this contribution, we present the results of an ADS experiment on an ion conducting D263T borosilicate glass, for which the native properties have been established before in a CAIT experiment (5). As a result of the ADS experiment, the native Na+ and K+ are replaced by D+ ions up to a depth of 2 micrometer from the surface. The replacement zones are quantified by means of ToF-SIMS, nanoindentation and Nuclear Reaction Analysis (NRA). Ultimately, all three techniques arrive at the same properties of the replacement zone, however, with complementary information content.

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Effect of environment temperature on mechanochemical wear of soda lime silicate glass surface

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Abstract: Previous investigations indicated that the mechanochemical wear of soda lime silicate (SLS) glass in humid air at room temperature, but the wear of SLS glass at high temperature conditions remains elusive. In this study, the wear behaviors of SLS glass were investigated upon a Pyrex glass ball at a temperature range from 20 to 300 ℃. The results show that the mechanochemical wear of SLS glass surface decreases as the temperature increases. Even though the Vickers hardness of SLS glass decreases within the same temperature range, the wear of SLS glass is a mechanochemical wear driven process, not just a purely mechanic wear driven process. Sub-Tg annealing treatment shows that the subsurface densification underneath the mechanochemical wear track of SLS glass increases with the environment temperature, aligning with the increased interfacial friction force at sliding interfaces. Further analyses reveal that the suppressed hydrous species at glass surface as well as the sodium ion concentration in the glass surface plays important roles in mechanochemical wear of SLS glass in high environment temperature conditions. The findings of this study can complement the insights into the mechanochemical damage mechanism of silicate glass in high temperature conditions.

Keywords: Soda lime silicate (SLS) glass, Temperature, Mechanochemical wear

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Sol-gel derived anti-reflective coating on photovoltaic glass synergistical photocatalysis and photoelectric conversion enhancement

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The transmittance and surface condition of photovoltaic cover glass determine the energy conversion efficiency of specific solar cells modulus. In this study, composite films of TiO2-SiO2 and Ga-doped ZnO were fabricated on PV glass using sol-gel method and the transmittance, self-cleaning, and environmental tolerance performances were investigated. The TiO2-SiO2 morphologies and elements distribution of thin film proves the formation of SiO2/TiO2 core-shell like structure in thin film. The transmittance of coated photovoltaic glass in visible range is improved from 91.60% to 93.94%, with optimized TiO2/SiO2 ratio. Accordingly, the monocrystalline silicon solar cell conversion efficiency increases from 16.35% to 16.68%. In addition, the thin film shows excellent photocatalyst behaviour from 95.40% methylene blue dye degradation rate under Xeon lamp irradiation, and super hydrophilic property from 0∘ contact angle, which confirms the excellent self-cleaning performance. To further enhance the surface transmittance of photovoltaic glass, optimizing the doping content of Ga in ZnO thin film, the transmittance of coated photovoltaic glass in the visible range increase from 91.60% to 94.11%, and accordingly, the photoelectric conversion efficiency of monocrystalline silicon solar cells increases from 15.58% to 15.98%. After 75 minutes of xenon lamp irradiation, the methylene blue degradation rate reached as high as 99.67%. In addition, the film transmittance and photoelectric conversion efficiency remain stable with increasing time and also has a certain degree of resistance to low-temperature freezing and high-temperature heat resistance. However, the temperature rise during operation of photovoltaic devices leads to a decline in power generation efficiency. By embedding SiO_2 nanoparticles into PDMS, a novel film was developed that exhibits high transmittance in the visible light spectrum while also providing passive radiative cooling, thereby achieving simultaneous improvements in both photovoltaic conversion efficiency and operational lifespan.

Keywords: Sol, gel, photovoltaic glass, photocatalysis, photoelectric conversion efficiency, radiative

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cooling

Effect of electrolyte cations mechanochemical wear of soda lime silicate glass in aqueous solution

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It is well-known that the surface flaws and defects of glass are known to be sensitive to the environment to which the glass surface is exposed. Previous investigations indicated that the mechanochemical wear of soda lime silicate (SLS) glass in humid air is associated with the presence of sodium ion leaching and interactions with adsorbed water, but the wear of SLS glass in aqueous solutions remains elusive. In this study, the wear of SLS glass was investigated in aqueous solutions with the presence of various electrolyte cation sizes and valences. The results show that the mechanochemical wear of SLS glass decreases as the concentration of sodium ions in the aqueous solution increases. However, the mechanochemical wear of the SLS glass surface increases with the ion size for solutions with monovalent cations, but significantly decreases with the di- and trivalent cations in aqueous solutions. Further analyzes indicate that the sodium ion migration to the glass surface plays important roles in mechanochemical wear of SLS glass in aqueous solutions, in addition to the ion-exchange and hydrolysis of Si–O–Si network. The findings of this study provide further insights into the mechanochemical damage mechanism of silicate glass in aqueous environments.

Keywords: Mechanochemical wear, Electrolyte cations, Ion exchange, Network hydrolysis

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Improved B_2O_3 bearing nepheline glass-ceramics for dental applications: Synthesis and Characterisation

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Glass-ceramics based on crystallisations of nepheline have been the subject of several studies due to their attractive properties for dental applications. However, the high melting and processing temperatures remain a challenge in the aluminosilicate glass system. The aim of the study is to investigate the effect of introducing B_2O_3 to the starting nepheline glass compositions on melting, crystallisation and sintering temperatures. A series of five glass compositions were synthesised via the melt quench method, with one composition lacking B_2O_3, and the remaining compositions varying in the quantity of B_2O_3 added, from 1% to 4%. The starting glasses and glass-ceramics prepared from these compositions underwent analysis using a range of techniques, including DSC, XRD, Raman, Density and Dilatometry measurements. Results indicate a consistent decrease in the melting and crystallisation temperatures of the investigated glass system which will be further discussed in this presentation. **Keywords:** Nepheline, Dental

Glass, Ceramics, B_2O_3

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An effective shape factor of glass particles from the heterogeneous crystallization kinetics characterized by DSC

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Powder technology emerges as a promising alternative for unconventional glass compositions, enabling the production of glass or glass-ceramics from poor glass-forming compositions or those with high melting points or high viscosities in the molten state. In these cases, modern manufacturing techniques such as 3D printing and tape casting enable the production of intricate geometries at room temperature. Furthermore, few compositions, stoichiometric or not, exhibit homogeneous nucleation, and finding nucleating agents is a challenging task. On the other hand, heterogeneous nucleation always occurs on the surface of glass. Diopside (CaO.MgO.2SiO2) is an example of a glass composition with potential practical applications, lacking known efficient nucleating agents, whose crystalline phase is of interest due to its relatively high hardness, low dielectric constant, and lack of alkalis, making it suitable for use in substrates for electrical circuits. The Clusters model effectively describes the sintering process of glasses with concurrent crystallization. However, to date, a shape factor has been considered approximately constant for a given manufacturing process and treated as a correction factor obtained by adjusting the Clusters model to experimental data. To refine the Cluster model, verify its validity, and propose improvements, it is essential to define a shape factor that is experimentally measurable in the context of glass sintering and crystallization, independently of the model. In this work, we defined a particle shape factor that is independent of the Clusters model and developed a technique for estimating it from the crystallization kinetics of glass particles characterized by differential scanning calorimetry (DSC). We demonstrate that the shape of the particles significantly influences the crystallization kinetics of glass powder and must be considered in sinter-crystallization models of glass particles and in the analysis of experimental crystallization kinetics data. We demonstrate that diopside's DSC crystallization peaks, calculated using the improved Reis-Zanotto model, are in close agreement with DSC experimental results, allowing for the verification of the effects of particle shape, particle size distribution, and concentration of surface nucleation sites on its crystallization kinetics.

Keywords: diopside, glass, crystallization kinetics, sintering, particle, shape factor, DSC

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Sodium ion conducting glass ceramics

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Glass ceramics provide an innovative platform to combine key advantages of distinct material forms, i.e. glass and ceramics. While the glassy part lends homogeneity and impressive robustness, the polycrystalline part generally is responsible for the integrated functionality. The processing parameters are of utmost importance as they are not only decisive for the desired properties of the glass ceramic but also for overall manufacturability and upscaling. In addition to long-term expertise in development of glass-ceramics for home applications, ongoing R&D have broadened the scope of glass ceramics and extended its advantages to areas such as energy storage and power electronics. The diversity of these applications is a testimony to the versatility of glass ceramics while being commercially viable. This talk will focus on recent activities at Schott R&D towards the development of oxide electrolytes for sodium ion batteries. Sodium ion battery technologies are seen as potential alternative/supplement to current lithium ion technologies owing to inherent benefits such as low raw material costs, fast charging/discharging and low temperature performance. The solid electrolyte material is a key component in both liquid and solid-state Na-ion batteries demanding high ionic conductivities while being mechanically and chemically stable. Our glass ceramic approach allows us to achieve these objectives and promises low-cost and scalable production to address future demands. The resultant glass ceramic shows an attractive room temperature ionic conductivity of more than 2 mS/cm, comparable to the state of the art, and is stable against Na-metal anodes. Low electronic conductivity ensures the overall performance and activation of energies of around 0.3 eV ensures decent conductivity also at low temperatures down to −40 °C. **Keywords:** sodium ion, conductivity, glass ceramic, solid state electrolyte

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Influence of crystallization on stress corrosion cracking properties: Part I micro-structured lithium disilicate glass-ceramics

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Controlled crystallization has been used for decades to form glass-ceramics, which consist of crystals embedded in a residual glass. This type of material takes advantage of the beneficial properties of glass and crystal. Lithium disilicate is one of the most studied glass-ceramics (1). It is widely used for dental applications due to its elevated mechanical properties, translucency and similar hardness as natural teeth. For example, depending on the crystalized volume fraction and the crystal size, its fracture toughness is up to 5 times higher than its parent glass (2, 3, 4). The precipitation of lath shaped crystals producing an increasingly complex structure is considered to be at the origin of the improved property. On the other hand, stress corrosion cracking (SCC), which is one of the major causes of failure, has been scarcely studied. SCC is defined as crack propagation assisted by environmental conditions (temperature and relative humidity) and is known to depend on the presence of secondary phases (5). This study aims to investigate the link between SCC properties and the crystallization induced microstructure in lithium disilicate glass-ceramics. To this end, lithium disilicate glass-ceramics and its parent glass were tested in a dedicated setup for SCC measurement in controlled environmental conditions (Temperature = 23 ∘C, Relative humidity = 40 %). The effect of crystals on the crack path was examined by Atomic Force Microscopy (AFM). Also, structural and mineralogical analysis (XRD, NMR) were carried out to characterize the glass-ceramics microstructures. All

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these data are integrated in a holistic viewpoint to unravel the role played by the crystals on the SCC properties.

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Keywords: Lithium disilicate, Glass ceramic, Fracture, Stress corrosion cracking

All-Solid-State Sodium-Ion Secondary Batteries Fabricated Glass-Ceramics

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In this study, we developed an all-solid-state sodium-ion battery (Na-ASSB) that employs glass-ceramics for both the electrode active material and the solid electrolyte. This Na-ASSB is characterized by its high safety and wide operating temperature range.

Conventional lithium-ion batteries use organic liquid electrolytes, which pose risks of ignition and raise concerns about future resource shortages due to limited lithium supply. In contrast, Na-ASSBs fabricated nonflammable oxide-based solid electrolytes and sodium—an abundant natural resource—offer a safe and sustainable alternative without resource constraints. These batteries eliminate the risk of fire and the generation of toxic substances during operation, making them highly suitable for practical applications. The battery operates through the migration of carrier ions (Na^+) across the interface between the solid electrolyte and the active material. However, oxide-based solid electrolytes exhibit poor formability, making it difficult to integrate them with active materials and create favorable interfaces. This limitation decreases transport and makes battery operation challenging.

To address this problem, we developed an all-solid-state battery that employs glass-ceramics for both the electrode active material and the solid electrolyte. This approach takes advantage of the softening and flow properties of glass-ceramics within the glass transition region. By heating the glass-ceramic precursor, it softens and integrates the electrode active material with the oxide-based solid electrolyte, forming a well-connected interface and an effective ionic conduction pathway. Furthermore, heat treatment induces crystallization of phases that function as electrode active materials and ionic conductors, resulting in excellent battery performance.

As a result, the Na-ASSB demonstrated stable operation not only at room temperature but also across a wide temperature range from −20 °C to 200 °C. Because both the electrode active material and the solid electrolyte are composed entirely of oxide-based materials, the Na-ASSB achieves high safety, wide operating temperature range, and outstanding battery performance. These features make it a promising candidate for practical applications in various fields requiring high reliability and wide temperature adaptability. **Keywords:** glass, ceramics, sodium, ion battery, SIB, NIB

*Speaker

Lithium Aluminosilicate Glass-Ceramics With Near Zero Thermal Expansion Nucleated by Rare-Earth Orthoniobates

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Multifunctional luminescent transparent and opaque glass-ceramics with near zero thermal expansion coefficients have been prepared by conventional melt-quenching of lithium aluminosilicate glasses containing rare-earth (RE) (Y, Eu, Tm, Ho, Er, Yb, or Tb) oxides, and Nb2O5 and heat-treatments in the temperature range of 700 – 1350 ∘C.
The structure of glasses and its transformation upon heat-treatments were characterized by small angle X-ray scattering, differential thermal analysis, X-ray diffraction analysis (XRD), Raman spectroscopy, and transmission and scanning electron microscopy. Their properties were estimated by absorption and luminescence spectroscopy. Depending on the composition, glasses either are phase-separated and X-ray amorphous or contain traces of RENbO4 nanocrystals. RENbO4 nanocrystals with orthorhombic structure formed by heat-treatments at 700–900 ∘C promote crystallization of β-quartz solid solutions. Glass-ceramics obtained by heat-treatments at 1000 ∘C and above, contain β-spodumene solid solutions and tetragonal RE orthoniobates with traces of monoclinic phase or monoclinic RE orthoniobates.

In situ high-temperature XRD analysis clarifies the mechanism of monoclinic RENbO4 formation, which occurs not upon heating above 900 ∘C but at cooling the glass-ceramics after such heat-treatments, when RENbO4 nanocrystals with the ordered tetragonal structure exhibit the second-order transformation at ~550 ∘C. The spectral-luminescent properties of glass-ceramics reflect all the structural transformations of RE orthoniobate nanocrystals. Luminescent transparent glass-ceramics with near zero thermal expansion coefficients look promising for development of up- and down-conversion phosphors.
The work was supported by the Russian Science Foundation (Grant № 25-23-20131).

*Speaker

Keywords: glass, ceramics, rare, earth orthoniobates, Raman spectra, absorption, luminescence

Morphology, structure and properties of lithium gallium silicate glass-ceramics doped with FeO

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Saturable absorbers for eye-safe mid-infrared lasers are of great interest because they allow controlling emission parameters without the use of complex active Q-switches. ZnS and ZnS crystals doped with Fe2+ ions in tetrahedral sites can be used as saturable absorbers of lasers emitting at 2.7–2.95 μm. However, they have disadvantages of expensive and hazardous manufacturing and low hardness and laser damage threshold. Transparent glass-ceramics based on Fe2+-doped spinel nanocrystals are promising alternatives to such materials.
We report development and study of morphology, structure and spectral properties of transparent lithium gallium silicate glass-ceramics (GCs) doped with Fe2+ ions, and the first results of the application of GCs containing nanocrystals of γ-Ga2O3 with spinel structure doped with Fe2+ ions for passive Q-switching of near-IR lasers (1.54 and 1.94 μm).

Transparent and opaque GCs were prepared by glass melting and subsequent heat-treatments. According to XRD analysis and SEM data, the parent glasses are X-ray amorphous and phase separated. Their absorption spectra have a broad asymmetric band with a maximum at _˜1070 nm, caused by absorption of Fe2+ ions in octahedral sites.

Transparent GCs based on nanocrystals with spinel structure ranging in size from _˜2 to 16 nm are obtained by heat-treatments at temperatures of 650 - 800 ∘C. Their unit cell parameter a gradually decreases from 8.216 to 8.195 Å, indicating a change in the spinel composition from γ-Ga2O3 to LiGa5O8. The appearance and increase in the intensity of the broad absorption band with a maximum at 2140 nm indicates that Fe2+ ions from the initial glass enter the tetrahedral sites in spinel nanocrystals. In opaque GCs obtained by heat-treatments from 850 to 1180 ∘C, in addition to LiGa5O8, crystals of gallospodumene, LiGaSi2O6, are formed. GCs obtained by heat-treatments at 1100–1180 ∘C, also contain crystals of the monoclinic stable phase, β-Ga2O3.The crystallization mechanisms are revealed using the combination of DSC and XRD analysis.
Passive Q-switching was demonstrates for the first time using transparent GCs based on gallium-

*Speaker

containing spinels doped with Fe2+ ions as saturable absorbers of diode-pumped lasers emitting in the near-infrared spectral range.

Keywords: glassceramic, spinel, Ga2O3, FeO, saturable absorber, absorption

Influence of crystallization on stress corrosion cracking properties: Part II - nano-structured ZAS glass-ceramics

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Glass-ceramics have been increasingly used in a wide variety of applications over the past decades. In particular, gahnite glass-ceramics are a possible candidate for components of display panels and photovoltaic substrates (1). These glass-ceramics are obtained by crystallization of zinc aluminosilicate glasses.
Literature evidences numerous glass-ceramics properties (e.g. structure, Young's modulus, fracture toughness, etc.); however, the stress corrosion cracking (SCC) behavior of glass-ceramics is rarely considered. SCC concerns the subcritical crack growth of flaws/defects when the stress intensity factor (K) is less than the fracture toughness (2). Wiederhorn (3) evidenced three regions, plus environmental limit, of how the crack front velocity (v) depends on K along with environmental parameters (e.g. temperature, relative humidity, etc.). Herein, the study concentrates on region I where the crack front velocity is less than 1 μm/s. In this region the crack velocity increases exponentially with the stress intensity factor as the reaction between the stress bonds at the crack tip and water kinetically controls crack propagation.

The structure of the glass-ceramics plays on the SCC behavior. This presentation concerns the SCC properties of nanometric cuboidal gahnite structures, which will ultimately be contrasted with the nano-/micro-structured lithium disilicate glass-ceramics presented in Part I. These tests were conducted on double cleavage drilled compression (DCDC) samples in a well-controlled environment (Temperature = 19 ∘C, Relative humidity = 40 %). SCC characteristic curves were obtained for region I. Fracture surfaces studied after SCC experiments using Atomic

*Speaker

Force Microscopy (AFM) evidenced that crystals modified the crack path in the case of glass-ceramics. X-Ray Diffraction (XRD), Raman spectroscopy and Nuclear Magnetic Resonance (NMR) spectroscopy provided compositional and structural features of the materials. This will make it possible to link the structure changes induced by crystallization to the evolution in the SCC behavior.

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Keywords: Gahnite, ZAS, Glass ceramic, Fracture, Stress corrosion cracking, Glass

Demixed rare earth silicate glasses as surfactants for controlling the growth of epsilon-Fe2O3 nanocrystals in silica

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Glass ceramics can be prepared from phase-separated glasses by the crystallization of the matrix or demixed droplets. It is less common to exploit demixing to control the surface energy of the crystals growing in an amorphous matrix. We have developed a new methodology (1) to control the size and shape of epsilon-Fe2O3 nanoparticles stabilized within silica gels. This method relies on the metastable binodal decomposition of thermally treated silica gels containing rare-earth elements. Acting as a surfactant, the rare earth silicate droplets selectively coated specific surfaces of the epsilon-Fe2O3 crystals with a high density of oxygen atoms, and allowed the formation of rod-shaped crystals that were significantly larger than the roughly spherical crystals obtained when epsilon-Fe2O3 was formed within a pure silica glass. Because the surface energies of the different crystal facets depend on whether or not they are coated by the rare earth silicate glass, their growth rates by Ostwald ripening are also different, and this promotes anisotropic crystal shapes This finding and the study of the metastable demixing of glassy systems prepared by soft-chemistry methods can inspire new methodologies in the field of glass-ceramics. (1) Rare-Earth Silicates as High-Temperature Surfactants for the Controlled Synthesis of ϵ-Fe2O3 Nanoparticles, N. Khanam, Z. Ma, S. Ortiz Ropero, N. Dix, A. Vila Costa, J. Oró-Solé, J. L. García-Muñoz, J. Faraudo , M. Gich, Journal of the American Chemical Society, 147 (2025) 33403-33412

Keywords: demixed glasses, Ostwald ripening, surfactants, sol, gel, glass, ceramics

*Speaker

Crystal chemistry of stuffed derivatives of quartz with low thermal expansion

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A series of glass compositions in the (Li2O, MgO, ZnO)-Al2O3-SiO2 system were synthesized and crystallized to investigate how composition influences the crystal structure of metastable stuffed derivatives of quartz. Crystallization products were characterized using X-ray diffraction and, for the first time, Raman spectroscopy, revealing novel insights into the structural evolution of these solid solutions. These findings advance the understanding of the crystal chemistry of stuffed quartz derivatives and establish a method for determining crystal chemistry directly from crystal structure. The method is particularly valuable for nanosized crystals in glass-ceramics, which are inaccessible to conventional chemical probes and play a crucial role in the development of low-thermal expansion materials.

Keywords: crystal, chemistry, structure, stuffed, quartz, solid solution, X, ray, diffraction, Raman, spectroscopy, XRD, crystallography

*Speaker

Optical fiber thermometers based on Yb/Er codoped oxyfluoride glass-ceramics

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This study presents a dual-wavelength approach for Er^{3+}-based optical fiber thermometry, combining visible and infrared (IR) ratiometric photoluminescence (PL) to extend the sensing range by over 150 K toward higher temperatures. Yb^{3+}/Er^{3+} co-doped oxyfluoride glass-ceramic (GC) optical fibers containing LaF_3 or $NaLuF_4$ nanocrystals are used. The conventional green upconversion (UC) emission ($^2H_{11/2}$ vs $^4S_{3/2} \rightarrow {}^4I_{15/2}$) limits reliable sensing to below 650 K due to PL quenching. However, IR emission based on the redistribution within the $^4I_{13/2}$ multiplet shifts this limit above 800 K, offering much lower optical losses and PL yields up to four orders of magnitude higher. While GCs enhance the UC intensity compared to precursor glasses, no significant differences are observed for the IR emission or thermometric performance after crystallization. The LaF_3-GC shows a maximum absolute sensitivity (S_A) of 102 $\times$ 10^{-4} K^{-1} at 602 K in glass and 71 $\times$ 10^{-4} K^{-1} at 591 K in GC. The $NaLuF_4$-GC reaches 90 $\times$ 10^{-4} K^{-1} at 698 K. The IR channel, based on intensity ratios at 1498 and 1538/1610 nm, exhibits an S_A of $\sim$10 $\times$ 10^{-4} K^{-1} from 650–800 K and achieves temperature resolutions of 1.5–3 K (UC) and 4.8–6.4 K (IR).

Acknowledgements: Project PID2024-157258NB-C21, funded by MICIU/AEI/10.13039/501100011033/FEDER UE. **Keywords:** oxyfluoride glassceramics, LaF3, NaLuF4, luminescence, optical fiber, thermometers

*Speaker

Synthesis of compositionally-complex BaREGa3O7 melilites with small rare-earths (RE = Eu-Dy) by glass crystallization method

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Glass crystallization (GC) method is being developed as route to new metastable metal oxides. Gallate melilites with general formula (RE,AE)2Ga3O7 are layered oxides that have been well studied for luminescence and anionic conduction properties, which are readily tuned owing to the flexible ionic size combinations between A-site cation and GaO4 tetrahedra. The tetragonal parent melilite structure (e.g. of SrLaGa3O7) can be distorted by size misfit between cations, which is associated with two types of structural ordering: the stable 5D modulated structures in CaREGa3O7 (RE=La and Nd)1,2 and also the metastable 3 x 1 x 1 superstructures of SrREGa3O7 (RE=Dy-Lu and Y)3. These Sr melilites were successfully prepared through GC method in our previous work, but BaREGa3O7 series is far less extensive, with only the range La – Sm reported to form parent melilite by solid-state reactions4. Complex structural phenomena might be observed if small RE could be incorporated into Ba melilites. Considering even Ba2+ cation, by adding multiple RE cations (2-5) at A-site to introduce additional configurational entropy, it's promising to stabilize BaRE1/nGa3O7 at smaller (average) RE radius.

In this work, BaRE1/nGa3O7 containing up to 5 small REs (n = 1-5; RE = La - Dy) were prepared through GC method, systematic studies of their crystal structures and thermal stabilities were carried out. The results show for single-RE members, the melilite structure can extended as far as Gd. Furthermore, large size mismatch of Ba/RE driven BaREGa3O7 (RE = Sm, Eu, Gd) to form orthorhombic structure with a 3-fold cell expansion, verified by TEM and theoretical calculations, showing orthorhombic phases are energetically preferred among smaller RE cations. For multiple RE compositions, the RE average size (RA), rather than configurational entropy, plays a dominant role in stabilizing melilite structure. The results indicate orthorhombic structure prone to exist among BaRE1/nGa3O7 (n = 2-5) members that RA ranging from Sm to Gd. All of the as-made samples with RA $\leq$ Sm were shown to be metastable. BaRE1/nGa3O7 samples containing Eu3+ cation show orange luminescence under UV-Vis lights, among them, BaEuGa3O7 shows strongest orange emission and longer decay

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curve.

Keywords: glass crystallization, melilite, configurational entropy

Thermal expansion of Cu-stuffed SiO2-polymorphs prepared by sol-gel spray-drying

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To gain insight into the structure-property relationship of stuffed SiO2-polymorphs, CuAlO2-SiO2 nano-powders with 66, 85, 90, 95 and 97 mol% SiO2 were prepared by sol-gel spray-drying. Depending on thermal treatment, Cu-stuffed quartz or cristobalite solid solutions were crystallized and thermal expansion as well as phase transition were measured by high-temperature X-ray diffraction. For the investigated compositions both polymorphs show a positive thermal expansion even in the high-temperature modification.

Keywords: quartz, cristobalite, solid solutions, solgel, HTXRD, thermal expansion, copper

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Influence of Rare Earth Oxides on the Structure and Properties of Li2O-Al2O3-SiO2-MgO glass ceramics

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The properties of Li2O-Al2O3-SiO2-MgO (LASM) glass-ceramics, including the glass transition temperature, thermal expansion coefficient, and crystalline phase composition, can be tuned over a wide range by compositional adjustments. This tunability consequently affects their thermal, mechanical, and electrical properties, endowing them with broad application potential. In this study, rare-earth ion oxides were introduced into the glass composition. The effects of Y2O3 content on the microstructure and thermal properties of LASM glass-ceramics were investigated using differential scanning calorimetry (DSC), Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM). The results indicate that when the Y2O3 content is below 0.5 mol%, Y3+ ions incorporate into the network as intermediates, leading to an increased glass transition temperature and a reduced thermal expansion coefficient. When the Y2O3 content exceeds 1 %, the Q3 structures depolymerize into less-polymerized Q2 island structures, leading to the disruption of the network structure. Consequently, the glass transition temperature decreases, and the thermal expansion coefficient increases. An increase in Y2O3 content and a rise in heat-treatment temperature significantly promote the crystallization capability of the glass. Simultaneously, the introduction of Y2O3 also alters the primary crystalline phase of the glass-ceramics, exerting a considerable influence on their mechanical properties.This research provides a valuable reference for developing novel high-performance LASM glass-ceramic systems.

Keywords: Rare earth oxides, Li2O, Al2O3, SiO2, MgO Glass ceramics, Sintering temperature, Thermal expansion, Crystallization behavior

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Crystallization of Li2O-Al2O3-SiO2 glass-ceramics

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Li2O-Al2O3-SiO2 glass-ceramics are used in the manufacture of consumer goods ranging from electrical cooktops to hearths, fire rated glazings, taking advantage of their exceptional properties such as thermal shock resistance, IR and visible transparency and mechanical resistance. We report here the experimental process to design the thermal treatment that will transform the green glass into beta-quartz glass-ceramic by controlled crystallization. Beta-quartz is the main crystalline phase in the glass-ceramic microstructure but minor phases such as Srilankite and beta-spodumene are also present. We describe a simple process to control the beta-spodumene minor phase content which influences the ageing behaviour of the glass-ceramic.

Keywords: LAS, glass, ceramic, crystallization, thermal treatment

*Speaker

From Glass to Glass-Ceramic: ZnO-Modified Phosphate Glasses and Glass-Ceramics for Optical Applications

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Phosphate glasses have been extensively studied for their distinctive characteristics, including low melting point, excellent thermal stability, and high transparency compared to silicate and borate glasses. The addition of transition metal oxides, particularly zinc oxide (ZnO), enhances chemical and thermal stability, preventing structural degradation over time. Moreover, ZnO can act as a nucleating agent, facilitating controlled crystallization while preserving the transparency of the resulting glass-ceramics. This research investigates the effect of replacing P_2O_5 with ZnO in phosphate glasses of the system $(70–x)P_2O_5–(x)$ZnO–30SrO, where $x = 0$, 5, 10, 20, and 30 mol%. The glass samples were prepared using the conventional melt-quenching technique. Two series of glass-ceramic samples were produced by controlled crystallization using the composition with 30 mol% ZnO. The first series was prepared as a function of temperature (470 °C, 500 °C, 530 °C, 560 °C, and 590 °C for 4 h), and the second as a function of time (1, 2, 4, and 8 h at 530 °C). The structural, thermal, and optical properties of both glasses and transparent glass-ceramics were analyzed. Differential thermal analysis (DTA) showed that increasing ZnO content affects the glass transition temperature (T_g) and crystallization temperature (T_x). X-ray diffraction (XRD) confirmed the amorphous nature of the glasses and revealed the formation of crystalline phases after heat treatment. The degree of crystallization and crystallite size increased with both time and temperature of the heat treatment. FTIR spectroscopy, combined with deconvolution analysis, showed shifts in vibrational modes associated with phosphate groups, indicating changes in network connectivity as ZnO concentration increased. UV–Vis–NIR spectroscopy revealed high transparency in both glass and glass-ceramic samples, and transmittance measurements confirmed that this transparency was preserved following crystallization. Overall, the incorporation of ZnO enhances thermal stability, promotes nucleation, and preserves optical transparency. These materials show strong potential for applications in optical components, such as lenses and other photonic devices. **Keywords:** Phosphate glasses, ZnO, Controlled crystallization, Glass, ceramics, Optical properties.

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Effect of Al2O3 on the crystallization behavior and thermophysical properties of BaO-Al2O3-SiO2 system glass-ceramic

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The development of sealing materials for Solid Oxide Fuel Cell (SOFC) has emerged as a critical challenge affecting their applications. Sealing materials are required to endure high temperatures, complex chemical environments, and other adverse conditions. Glass-ceramics, as one type of sealing materials for SOFC, their composition exerts a significant influence on key parameters such as microstructure and coefficient of thermal expansion (CTE). In this work, BaO-Al2O3-SiO2-based glass-ceramics with different Al2O3 contents were prepared, and relevant tests were conducted on the glasses. Test results demonstrate that Al2O3 mainly exists in the form of (AlO4) tetrahedra in the glass network. With the increase in Al2O3 content, the glass network structure is strengthened, and the glass transition temperature (Tg) of the glass increases from 684 to 754 ∘C. Owing to the variation in glass composition and modification of the glass network structure, the peak crystallization temperature (Tp) of the samples first decreases and then increases with increasing Al2O3 content. Since the CTE of Ba5(Si8O21) is higher than that of BaAl2Si2O8, and Al2O3 reinforces the glass network structure, the CTE of the glass at 800 ∘C decreases from 12.48×10-6 to 9.78×10-6 ∘C-1 with increasing Al2O3 content.

Keywords: sealing glass, ceramic, thermal properties, network structure, crystallization behavior, CTE

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Microsized Rare-Earth Iron garnets (REIG) Single Crystals Obtained by Glass Crystallization: A New Route Toward Magneto-Optical Sensing Materials

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Rare-earth (RE) garnets, specifically Rare-Earth Iron Garnets (REIG, RE3Fe5O12), are highly relevant materials for magneto-optical (MO) applications due to their large Verdet constant. Traditionally, high-quality garnet single crystals are synthesized using conventional melt-growth techniques like Czochralski or Bridgman, which yield large crystals (mm to cm scale) and involving high costs and complex processing steps. However, the development of miniaturized photonic devices and high-sensitivity sensors creates a demand for high-quality, micrometer-sized single crystals, which are difficult to produce using these methods. This work presents a novel methodology for fabricating high-quality, micron-scale (10-80 μm) garnet single crystals through the controlled crystallization of a precursor glass matrix. The resulting glass-ceramic materials contain microsized single crystals embedded in a glassy matrix. Subsequently, selective chemical etching with acidic solutions was employed to dissolve the glassy phase, enabling the extraction and isolation of hundreds to thousands of REIG single crystals. Their morphology and size distribution were characterized using Scanning Electron Microscopy (SEM). The crystalline structure and phase purity were confirmed by Single Crystal X-ray diffraction (SCXRD), verifying the formation of the desired garnet structure. Furthermore, we evaluated the functional properties of the synthesized micro-crystals. This study demonstrates an efficient glass-ceramic method for producing garnet micro-crystals and validates their potential for integration into sensitive devices, such as those required for the detection of weak biomagnetic fields.
This work was supported by a grant from the São Paulo Research Foundation (FAPESP) (grant number: 2025/05131-3).

Keywords: Garnets, Magnetic properties, Sensors

*Speaker

Effect of initial glass density on surface crystallization behavior

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Surface crystallization is a critical issue in large-scale glass production, as it can compromise transparency and mechanical reliability. Although crystallization typically occurs at glass surfaces rather than in the bulk, the fundamental mechanisms remain poorly understood. Conventionally, evaluations often involve polished surfaces or impurity effects from outside, which complicate the representation of the pristine state of glass. Computational studies using molecular dynamics simulations have suggested that surface regions exhibit structural characteristics closer to crystalline phases compared to the bulk, implying that surface composition and molecular arrangement play an important role in nucleation. However, the experimental approach to these phenomena has been limited.

In this study, we experimentally investigated crystallization behavior at fresh glass surfaces by using the pulsed laser deposition (PLD) method to fabricate amorphous thin films under controlled conditions. By changing the oxygen partial pressure during deposition, we produced amorphous films with different densities to examine the relationship between initial amorphous density and crystallization tendency by using X-ray diffraction analyses. As a result, it revealed that crystalline phases with densities similar to the amorphous state preferentially precipitate. Transmission electron microscopy (TEM) provided direct evidence of nucleation and crystallization.

Initially, for research, it was investigated TiO2 , which was constructed as simple elements, after that, it was expanded to a soda lime aluminosilicate glass. Fabricated amorphous films confirm these elements by using XPS. We hope to discuss not only density but also the effects of compositions compared to previous works. This study bridges computational predictions with experimental observations, providing new insights into surface-driven crystallization.

Keywords: crystallization, nucleation, surface

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Effect of SnO_2 and CeO_2 doping on the crystallisation kinetics of a lithium aluminosilicate glass

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The use of refining agents in the industrial production of lithium aluminosilicate (LAS) glass-ceramics is essential. As the industry increasingly switches from refining oxides hazardous to health such as Sb_2O_3 and As_2O_3 towards ecological alternatives, the effect of the eco-friendly refining agents SnO_2 and CeO_2 in crystallisation and the associated formation of a residual glass melt must be clarified. In this context, a multi-analysis study was conducted using ICP-OES, DSC, viscometry, HT-XRD and HTOM to investigate the solubility, precipitation behaviour and possible role as a nucleating agent of CeO_2 and SnO_2 for quartz solid solutions (Qz-ss) in a LAS model glass composition. Particular attention was paid to the crystallisation kinetics of Qz-ss in a residual melt enriched with tin and cerium.

Keywords: Glass-ceramic, Lithium Aluminosilicates, Eco-friendly Refining Agents, Crystallisation, Nucleation, Residual Glass Melt Viscosity

*Speaker

Glass-Ceramic Synthesis of Na3V2(PO4)3 for Use in Sodium-Ion Batteries

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Sodium superionic conductor (NASICON)-type Na3V2(PO4)3 (NVP) is a promising cathode material for high-performance sodium-ion batteries (SIBs) due to its high reversible storage capacity, low cost, good thermal stability, excellent structural stability, and robust 3D framework. However, synthesizing the pure NASICON-type NVP requires complicated preparation methods, expensive equipment, long processing times; and its electrochemical performance strongly depends on synthesis conditions and vanadium redox control. In the present study, Na3V2(PO4)3 were synthesized by the glass-ceramic route. Two glasses with the composition of 37.5Na2O–25V2O5–37.5P2O5 (mol%) with/without 10 wt% sugar were prepared by a conventional melt-quenching method under redox conditions using a double-crucible design. The precursor powders were thoroughly mixed and placed in a small alumina inner crucible, which was then put into a larger outer crucible containing sacrificial carbon black surrounding to maintain a reducing atmosphere. During heat treatment, the sacrificial carbon consumes oxygen, establishing a locally buffered low oxygen partial pressure environment that is expected to promote the stabilization of vanadium in the V3+ oxidation state. A two-step crystallization profile comprising a nucleation step and a subsequent crystal growth step were performed in air also using a double-crucible approach. This approach is expected to suppress the formation of secondary phase impurities, promoting the formation of phase-pure NASICON-type Na3V2(PO4)3. Impedance spectroscopy results showed that the glass prepared with sugar exhibited an Na-ionic conductivity of _˜10-10 S.cm-1 (Ea0.72 eV) compared with _˜10-9 S.cm-1 (Ea0.59 eV) for the glass prepared without sugar, indicating better ionic conducting properties. Moreover, the XRD patterns after crystallization have shown NVP phase with some secondary phase impurities. These impurities can be mitigated through careful optimization of the synthesis conditions, particularly those governing the reduction of V2O5. In this study, we conclude that NASICON-type Na3V2(PO4)3 can be achieved in air without the need for costly external reducing atmospheres, such as H2-based gas, through the combination of a carbon-buffered double-crucible configuration, careful controlled low-temperature crystallization, and limited dwell times, which permits kinetic stabilization of V3+ within the NASICON framework.

Keywords: Na3V2(PO4)3, Glass, ceramic, Carbon, reducing atmosphere, NASICON, Sodium, ion batteries

*Speaker

Multi-functional single-crystal rare earth garnets prepared by the supersaturated methodology

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In this paper we will present an innovative methodology to produce multifunctional aluminum and gallium micro-scale single crystal garnets. $RE_3Ga_5O_{12}$ and $RE_3Al_5O_{12}$ single crystals (where RE are rare earth oxides, including Y and Sc) were obtained using rare earths supersaturated glass compositions. The mother glass is based on the system PbO (or BaO)–GeO_2–Bi_2O_3–Al_2O_3 (or Ga_2O_3)–RE_2O_3. To obtain the single crystals, the content of rare earths must ranges from 1 to 3 mol%, while lower concentrations lead to glass formation and higher induces uncontrolled crystallization. The cooling rate also plays a very important role in the crystallization. After melting the compositions at 1250 °C in a Pt crucible, typical 10 °C/min cooling rates were employed until the sample reaches 900 °C. After this step, the crucible is withdrawn from the furnace and cooled fast to room temperature. The single crystals can be separated from the glassy phase using a lixiviation process with HCl. This methodology allows the synthesis of a single or multi-rare earth elements in the same garnet. As examples of materials containing single rare earths we highlight the crystals of $Tb_3Ga_5O_{12}$, $Er_3Ga_5O_{12}$, $Dy_3Ga_5O_{12}$, $Tb_3Al_5O_{12}$, $Gd_3Al_5O_{12}$, among others while for multi-elements, the following examples of garnets were obtained: $Tb_{3-x}Eu_xGa_5O_{12}$, $Y_{3-x-y}Tm_xEr_yGa_5O_{12}$, $Nd_xY_{3-x}Al_5O_{12}$. The range of applications for such materials includes magneto-optics, luminescence, scintillators, lasers, thermometry, white light generation for micro LEDs, etc. The synthesis details and the main characterization of some systems will be presented.

Acknowledgments: The authors would like to thank São Paulo Research Foundation (FAPESP, grants number 2025/04339-0) and INCT-INFO – National Institute of Photonics for financial support. **Keywords:** Glasses, single crystals, rare earths, garnets

*Speaker

Dependence of thermal conductivity on crystalline features in silicate glass-ceramics

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As we face a future with more frequent and severe weather and temperature changes, the need for materials with controlled thermal properties is increasing. In particular, further understanding the thermal conductivity of glass and glass-ceramics can be essential for improving thermal insulation performances in, e.g., buildings.Recent investigations, specifically into the thermal conductivity of glass-ceramics' dependence on crystallinity, found an anomaly. Here, an initial decrease in thermal conductivity with increasing relative crystallinity up to 11.5%, and an increasing thermal conductivity from 18.5% and above, was found. Optimising and understanding the crystalline features of glass-ceramics, thus, present a promising pathway for enhancing its performance for further use, such as insulation materials. In this study, the impact of different crystalline features, e.g. degrees of crystallinity, crystal size, and crystal phase, on the thermal conductivity of glass-ceramics is investigated. Two glass compositions in the soda-lime-silica and lithium-aluminosilicate series are prepared, both series doped with different amounts of TiO2 and/or ZrO2 as nucleating agents. The crystallisation of each glass is performed isothermally based on the onset crystallisation temperature (Tc) for varying durations, to introduce different degrees of crystallinity and to control the crystal growth in order to obtain crystals of specific sizes. The crystallisation of the glasses will be examined both *in situ* and *ex situ*, using X-ray diffraction to determine the crystal phases, crystallisation kinetics, crystal sizes, and overall crystallinity.The thermal conductivity of the glass-ceramics with varying crystallinity and different crystalline features will be calculated from measurement of density (Archimedes' principle or He-pycnometry), specific heat capacity (Differential Scanning Calorimetry), and thermal diffusivity (LaserFlash analysis) at 25 ∘C. These results provide a deeper insight into the thermal conductivity of glass-ceramic silicates and explain which crystal features play a crucial role in the development of thermally insulating glass-ceramics.

Keywords: Glass, ceramics, crystallisation, crystallization, thermal conductivity

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Characterizations and optical properties of new highly transparent glass-ceramics elaborated in the TeO2-La2O3-In2O3 ternary system

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Tellurite glasses and glass-ceramics offer real prospects for optical applications in the near- and mid-infrared spectral range. Here, we focus on the 85.714 TeO2 – 14.286 La2O3 chemical composition, for which the anti-glass defined compound La2Te6O15 is known. The latter has the peculiarity of presenting an oxygen deficient fluorite-type crystal structure which combines a strong local disorder of the anionic sublattice, with a long-distance order of the cationic sublattice (La3+/Te4+ ions statistically occupy the same Wyckoff position).
The driving idea of this work is to crystallize the La2Te6O15 anti-glass phase from the parent glass. However, the extent of the glassy domain in the TeO2 – La2O3 binary system is quite limited, rendering impossible the synthesis of a bulk parent glass of the desired composition. Thus, by introducing indium oxide (In2O3) in partial substitution of La2O3, we show how it is possible to significantly enlarge the glassy domain and to easily synthesize a homogeneous bulk glass with the specific 85.714 TeO2 – 4.512 In2O3 – 9.774 La2O3 composition.

Adapted heat treatments make it then possible to elaborate highly transparent glass-ceramics for which the crystalline anti-glass phase (La,In)2Te6O15 (LITO) is observed. These glass-ceramics are characterized by the presence of crystalline spherulites dispersed within a glass matrix, and whose concentration and size increase with the duration of the heat treatment. The chemical composition of the spherulites, determined by Energy Dispersive Spectroscopy, is found perfectly identical to that of the glass matrix, and the acquired Raman spectroscopy data confirm the inherent structural disorder of this LITO phase. Furthermore, partial substitution of La3+ by Er3+ is demonstrated, and the conferred luminescent properties are measured for the corresponding parent glass and glass-ceramics.
Finally, Differential Scanning Calorimetry measurements combined with variable temperature

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powder X-Ray Diffraction experiments allow evidencing a phase transition, which occurs at higher temperatures. The latter is characterized by some cationic ordering and the transformation of the first disordered anti-glass polymorph into a second more ordered polymorph. Surprisingly, the formation of such final more ordered structure is only observed for undoped samples, suggesting that the partial substitution of La3+ by Er3+ somehow prevents its appearance.

Keywords: glasses, glass, ceramics, tellurites, spherulites, anti, glass

Stuffed derivatives of cristobalite crystallized from spray-dried glass powders: structure, phase transition and thermal expansion

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Functional crystals are a basic component of glass-ceramic development. In this context, stuffing of the cristobalite structure (Crs-ss) was explored as a route to modulate its properties. In particular, the incorporation of different cations (Ca^{2+}, Na^{+}, Cu^{2+}, Sr^{2+}, and K^{+}) into Crs-ss was analyzed in aluminosilicate spray-dried glass powders with SiO_2 contents of 97, 95, and 90 mol

Keywords: cristobalite, glass-ceramic, spray-drying, thermal expansion

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From Glasses to Glass-Ceramics / Composites: Designing Photonic Materials with Tailored Optical Properties

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Recent advancements in photonic materials have highlighted the potential of glasses with embedded crystalline phases to achieve multifunctionality. Glass-ceramics are typically fabricated through controlled crystallization of glass matrices, enabling the integration of nanocrystalline structures that enhance spectroscopic properties while retaining optical transparency. However, the crystallization process is inherently challenging to regulate-surface versus bulk crystallization, unpredictable precipitation of crystals, and difficulties in achieving targeted doping concentrations and crystalline phases. To overcome these limitations, the direct doping method presents a more robust alternative. This approach is based on incorporation of functional ions directly into the glass matrix. In this contribution, we will present a comprehensive overview of the development of glass-ceramics and composite materials, with a focus on the strategic integration of crystalline domains to enhance photonic performance. Rare-earth-doped phosphate and tellurite glasses are examined as model systems, wherein post-synthesis thermal treatments induce partial crystallization. Controlled nucleation and growth of nanocrystalline phases result in improved emission efficiency, lower phonon energy environments, and superior thermal stability-traits essential for solid-state lasers, optical amplifiers, and nonlinear photonic devices. Furthermore, we report on novel glass composites, especially those incorporating phosphor materials, which exhibit persistent luminescence. These composites demonstrate long-lasting afterglow and show promise in applications such as bioimaging and energy-efficient illumination. Overall, we will show that embedding crystals in glass matrices opens promising avenues for designing next-generation, sustainable photonic materials that merge high performance with fabrication versatility.

Keywords: glass, glass, ceramics, composites, luminescence

*Speaker

Vibrational anharmonicity as a probe of temperature-induced structural transformations of PbO.SiO2 silicate glasses, super cooled liquids, crystals and liquids: Raman scattering and molecular dynamic simulations

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In-situ Raman spectroscopy and Molecular Dynamics Simulation were used to explore in detail the temperature effects on PbO.SiO2 across its four phases: glass, supercooled liquid, crystalline phases, and liquid. From the Raman data, the changes in the Qn distribution were determined up to 1153 K, and also the changes in the wavenumber temperature coefficients. Meanwhile, from Molecular Dynamics, the structural transformation was observed through changes in the Qn population distribution up to 2400 K. The quantitative spectral analysis of the high-wavenumber spectral region ('Qn envelope', between 790 and 1200 cm-1) was performed alternatively by determining the one-parameter barycenter position and by curve fitting multiple functions. The results showed that configurational transformations occur only in the higher temperature range of supercooled liquid near the crystallization temperature, mainly in the liquid state, in which the increase of Q0 and Q1 population takes place at the expense of Q3 and Q4. In the glass and crystalline phases, only vibrational anharmonicity was observed.(1)

Keywords: temperature, structural transformations, metasilicate glasses, vibrational anharmonicity, Raman scattering, molecular dynamics

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Transparent keatite glass-ceramic for chemical strengthening

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Lithium aluminosilicate (LAS) glass-ceramics have long been used in applications requiring low thermal expansion, high transparency, and excellent thermal stability, such as cooktops, telescope mirror blanks, and high-temperature-resistant windows. Traditionally, transparent LAS glass-ceramics feature a high-quartz solid solution as the primary crystalline phase. In contrast, LAS glass-ceramics containing a keatite solid solution are typically translucent or opaque. However, keatite glass-ceramics are recognized for their superior mechanical properties, which can be further enhanced through chemical strengthening. In this work, we present a novel keatite glass-ceramic that achieves high transparency (visible light transmission, tau_vis, exceeding 85% at 0.7 mm thickness), low haze, and a neutral color tone, while remaining compatible with standard chemical strengthening processes. This high transparency was realized by carefully optimizing both the composition and the ceramization process to minimize the refractive index difference between the crystalline and residual amorphous phases. Conventional nucleation agents for LAS glass-ceramics, such as TiO_2, often impart a yellowish tint. Removing TiO_2 typically requires increased amounts of alternative nucleation agents to achieve sufficient nucleation and small crystal sizes, which can lead to devitrification and production challenges. Our approach involved optimizing the nucleation system to promote the formation of fine crystallites, thereby minimizing light scattering and maintaining color neutrality.

Keywords: LAS Glass, ceramic, Transparent keatite, Chemical strengthening

*Speaker

Synthesis of highly non-stoichiometric europium aluminate garnets by glass crystallisation

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Recent studies have emphasized that crystallisation of glass synthesised by containerless aerodynamic levitation (ADL) is a powerful method to stabilise new highly non-stoichiometric oxides (ns), specifically rare-earth aluminates garnets (RE3Al5O12) as highly ns-YAG (Y3+xAl5-xO12 with $x \leq 0.4$) (1), or highly ns-GAG (Gd3+xAl5-xO12 with $x \leq 0.6$) (2). While rare-earth aluminate garnets are well established as excellent hosts for luminescent dopant species, here, the principal interest lies in the structural modification achieved via a significant degree of substitutional disorder (excess of RE3+ substitutes on AlO6 sites). Specifically, the dopant is distributed between AO8 and BO6 sublattices, permitting a fine-tuning of the luminescence colour through chemical composition modulation. The sharing of the same site by atoms presenting such a large radii size mismatch (RE3+/Al3+) is unusual in crystal chemistry. The limit of this mismatch arise an open question which is the basis of this project: how much can the garnet structure be extended using larger rare earth (as Eu or Sm), that do not form thermodynamically stable garnet phases?
Yet, only stoichiometric europium alumina garnets (Eu3Al5O12/EAG) have been obtained by sol-gel process (3). It is described as a metastable phase requiring a high-energy consumptive process for its synthesis.

Due to the high metastability of stoichiometric and ns-EAG (Eu3+xAl5-xO12), the synthesis of glassy precursors by ADL went through a careful optimisation study. After glass crystallisation, XRD results show the existence of the solid solution up to $x = 0.6$ (Figure 1), which is equivalent to the GAG system. Due to a competition between garnet and nanostructured phase made of perovskite and alumina, the stoichiometric EAG is difficult to obtain. Micro-luminescence and micro-Raman analyses were performed on several samples, to improve our understanding of this phenomenon.
Additional experiments with samarium show the non-feasibility of pure SAG (Sm3Al5O12). EAG is therefore the limit of the rare-earth series, which implies that highly non-stoichiometric

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garnets should be synthesisable from Lu,Y to Eu. In light of the findings generated on EAG, these materials are highly promising to present optical characteristics, warranting further crystallographic and spectroscopic characterisation.

Keywords: Glass crystallisation, structure determination, ceramics, new oxide materials

Bi2S3 Q-Dot silicate glass for thermal Energy Harvesting

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Borosilicate glass (BSG), composed of SiO2 and B2O3, is technologically important due to its unique properties, such as a lower thermal expansion coefficient (3.4 × 10–6 ∘C–1), excellent chemical resistance, high dielectric strength, and a high softening temperature (800∘C). In our study, we synthesized a Bi2S3 quantum dot glass composite using a high temperature melt quenching method. The glass composition was carefully designed with 52% SiO2, 10% Na2O, 6% MgO, 6% B2O3, 12% K2O, 10% ZnO, and 4% TiO2. Bi2S3, in varying amounts (0.5–1 wt%), was introduced directly into the glass as the source of Bi2S3 quantum dots for the nanocomposite. The homogeneous mixture was melted in an alumina crucible at 1250∘C using an electrical muffle furnace. The glass was then annealed at 500∘C in another programmable furnace and slowly cooled to room temperature to relieve stress. The synthesized samples were characterized using X-ray diffraction (XRD) and UV-visible spectroscopy. The glass was then used to fabricate QD glass/MoS2 heterostructures via pulsed laser deposition for thermal management applications. A thick layer of QD glass, (a few micrometre) thick, was deposited onto a silicon substrate, followed by the sequential deposition of few nanometre of graphene and MoS2 layers. The QD glass served as a heat sink, capturing waste heat from ICT devices, while the MoS2 layer generated charge carriers in response to thermal energy. The process converts waste heat into useful power, offering an innovative solution for thermal management.

Keywords: structure, thermal property, amorphous

*Speaker

Precipitation kinetics of nucleating agents in LAS glass-ceramics by high temperature Raman spectroscopy

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The precipitation kinetics of nucleating agents in technical lithium aluminosilicate (LAS) glass-ceramics is difficult to determine due to the low content of 3 wt.

Keywords: Nucleation agents, LAS glass-ceramics, Precipitation kinetics, TiO_2, Raman spectroscopy

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Silicate glass-ceramics toward photonic application: From precursor design to fiber-type device

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Glass has a disordered structure without transition symmetry, resulting in optical isotropy and excellent formability. However, the structural isotropy leads the glass to forbid macroscopic polarization. Therefore, the ordering of polar structure based on crystallization in precursor glass, i.e., glass-ceramic (GC) technique, is regarded as an effective way to achieve permanent optical nonlinearity. To fabricate the GC material, nano-sizing of crystalline phases has been employed as a strategy for material's optical transparency so far.
A unique crystal growth based on heterogeneous nucleation has been found in silicate glass system (Fig. 1): Fresnoite-type phases, e.g., Sr2TiSi2O8, grow from glass surface, and eventually their growth fronts impinge on each other (1,2). The resulting transparent GCs show the single crystal-like domain and its highly-oriented texture, which are essential for lightwave control. The authors' group has been devoted to investigation of the GCs for application to photonic devices. In this talk, a series of our studies are introduced: Material design of precursor glass (2), optical modulation in the GCs based on Pockels effect (3), and fabrication of the GC fiber (4-6).

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*Speaker

Keywords: Silicate, Fresnoite, Surface crystallization, Optical nonlinearity, Pockels effect, Fiber

Crystallization of β-cristobalite in CaO-Al2O3-SiO2 glasses

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The crystallization of fused silica leads to the precipitation of cristobalite, which undergoes a transition from the low-temperature phase (α-cristobalite) to the high-temperature phase (β-cristobalite). This phase transition is associated with a steep increase in volume, resulting in material failure and rendering materials with high cristobalite concentrations nearly useless. However, β-cristobalite exhibits advantageous properties, such as low thermal expansion at high temperatures, making these materials suitable for applications as thermal shock-resistant refractories. To exploit the properties of β-cristobalite, this phase must be stabilized down to room temperature, preventing the occurrence of the phase transition. The stabilization of this high-temperature phase is feasible within the CaO-Al2O3-SiO2 system.
This paper investigates the mechanisms that enable the stabilization of β-cristobalite down to room temperature through micro- and nanostructural analyses using high resolution scanning transmission electron microscopic analyses including energy dispersive X-ray spectroscopy. The results are compared with those obtained using X-ray diffraction and dilatometry. Experiments investigating the effects of the Ca/Al ratio and crystallization conditions on the stabilization mechanism of the β-cristobalite phase are showcased. Moreover, the effect of the nucleating agents ZrO2 or TiO2 on the crystallization behaviour isstudied. The composition of the initial glass as well as the heat treatment conditions, especially the maximum temperature applied, significantly affect the stability of β-cristobalite. Volume crystallization can be achieved by the crystallization of mullite.
These findings enhance the understanding of cristobalite crystallization and provide valuable insights for the future development of thermal shock resistant refractories with elevated SiO2 concentrations.

Keywords: Glass ceramic, crystallization, cristobalite

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Crystal Growth and Melting Observed by High-Temperature Optical Microscopy – Evolution of Crystal Morphology and Thermodynamic Modeling

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Crystal growth plays an important role in the manufacturing of glass, where devitrification must be avoided, as well as in glass-ceramics, where crystallization must be controlled. The theoretical and experimental analysis of crystallization mechanisms and thermodynamics is therefore essential for combating undesirable devitrification processes (1). Especially, precise knowledge of the growth and melting kinetics near the liquidus temperature (TL) is important for the manufacturing process. However, the experimental accessibility using standard furnaces is limited, and thus even for the most intensively studied glass compositions the growth and melting behavior close to TL is not well understood.
In this study, we use high-temperature optical microscopy (HTOM) as a versatile method, which allows a precise time – temperature protocol with fast heating (max. _˜1800 K/min.) and cooling rates (max. _˜500 K/min.), to explore the region in the vicinity of TL. As a model case, the growth and melting behavior of Na4CaSi3O9 crystals from their isostoichiometric melt is presented. Although Na4CaSi3O9 is a potential devitrification product in the compositional range of many commercial glasses, its temperature-dependent crystal growth rate has, to the best of our knowledge, only been reported for deeply undercooled melt (_˜ 550 K below TL) (2). Combining conventional furnace and HTOM methods the temperature-dependency of the crystal growth rate, as well as the evolution of crystal morphology, over a wide temperature range from _˜ 550 K below TL towards close vicinity of TL (2 K) will be discussed. Melting rates have also been measured. The experimental results will finally be interpreted in the framework of crystal growth theory using thermodynamic modeling (3).

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Keywords: Crystal Growth, Thermodynamic modeling, Soda, Lime, Silicate

Crystal growth behavior and mechanical properties of glass-ceramics with the sequential crystallization of ZnAl2O4 and Zn2SiO4

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Glass-ceramics (GCs) exhibit excellent mechanical properties, however, their brittleness needs to be further reduced to meet various application requirements. In this work, multiphase GCs containing ZnAl2O4 and Zn2SiO4 crystals were prepared, and the influence of ZnAl2O4 preferential precipitation on the growth of Zn2SiO4 was investigated. ZnAl2O4 preferentially precipitated at relatively low temperatures, while Zn2SiO4 formed as the heat-treatment temperature increased. At higher temperatures, LiAlSiO4 also crystallized. When heat-treated at lower temperatures, short durations led to ZnAl2O4 formation, whereas prolonged durations promoted Zn2SiO4 precipitation. Crystal clusters were observed in the Zn2SiO4 phase, with larger crystals composed of numerous smaller grains. However, the preferential precipitation of ZnAl2O4 nanocrystals suppressed the growth of Zn2SiO4 crystals. The co-precipitation of ZnAl2O4 and Zn2SiO4 simultaneously enhanced the Vickers hardness and fracture toughness of the GCs, while significantly reducing brittleness. These findings provide valuable insights for designing GCs with superior mechanical properties.

Keywords: Glass, ceramics, ZnAl2O4, Zn2SiO4, Microstructure, Mechanical properties

*Speaker

Assessing glass forming ability from experimental, theoretical, MD and ML perspectives

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The fundamental principle that any liquid can be vitrified by sufficiently rapid cooling (exceeding the critical cooling rate, *Rc*) is well established. However, as George Morey noted in his classic book, *"Devitrification is the chief factor which limits the composition range of practical glasses; it is an ever-present danger in all glass manufacturing and working."* This underscores the persistent challenge of identifying the controlling crystallization parameters, which are needed to develop novel, good glass-forming compositions with tailored property combinations. This talk examines the contrast between the intrinsic ability to crystallize-governed by homogeneous crystal nucleation and growth-and the extrinsic (practical) scenario, dominated by heterogeneous nucleation induced by solid impurities or interfaces, which ultimately determine *R*c and the glass-forming ability (GFA). We present a comparative analysis of good and reluctant inorganic glass formers using experiments, theoretical calculations, and molecular dynamics (MD) simulations, and identify the main factors that control devitrification. Finally, we employ the Jezica parameter ($(\eta(\text{Tliq})/\text{Tliq}^2)$, where η = viscosity and Tliq = liquidus temperature) to guide machine learning (ML) training. The results identify oxide glass compositions that combine low viscosity at the liquidus temperature with a low liquidus itself-compositions absent from the original dataset-thus confirming the predictive power of ML for discovering novel good glass-forming formulations.

Keywords: crystallization, nucleation and growth, glass forming ability, critical cooling rates for glass formation

*Speaker

MXene–Bioglass Nanocomposites as Next-Generation Bioactive Platforms for Accelerated Bone Regeneration

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The incorporation of two-dimensional (2D) MXene nanomaterials into bioactive glass (BG) introduces a new class of multifunctional, electroactive biomaterials for next-generation bone tissue engineering. In this study, MXene–bioglass (MXene–BG) nanocomposites were synthesized via a modified sol–gel route to synergize the osteogenic ion-release capability of BG with the exceptional electrical conductivity and mechanical reinforcement of MXene. Structural and morphological analyses using XRD, FTIR, FESEM, and BET confirmed uniform MXene dispersion within the BG matrix, along with the retention of characteristic Si–O–Si and P–O–Si linkages essential for bioactivity. In vitro bioactivity testing in simulated body fluid (SBF) revealed rapid and dense hydroxyapatite (HAp) layer formation, suggesting enhanced ionic exchange and surface reactivity. Cytocompatibility and proliferation studies using MG-63 osteoblast-like cells demonstrated significantly higher cell viability, spreading, and attachment compared to pristine BG, indicating that the inclusion of MXene promotes improved cell–material interactions. Mechanistically, MXene nanosheets act as localized charge mediators, facilitating electrical stimulation and enhancing Ca^{2+}/PO_4^{3-} ion nucleation sites for faster mineralization. The combined chemo-electroactive response of MXene–BG provides a tunable microenvironment that can regulate cellular behavior and osteogenic differentiation. These findings highlight the potential of MXene–bioglass nanocomposites as smart, conductive biointerfaces for electrically assisted bone regeneration. Future studies will explore their angiogenic potential and in vivo bone healing efficacy, advancing their application toward bioelectronic implants and smart regenerative devices.

Keywords: MXene, Bioactive glass, Nanocomposite, Electroactive biomaterials, Hydroxyapatite formation

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Towards Infrared-transmitting maneuverable hybrid fibers combining chalcogenide glasses and shape-memory polymers

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Fibers are compact and small-scale structures initially developed for information transfer but have since greatly diversified owing to the invention of microstructured and multimaterial fibers. They are used to fabricate various devices such as light sources and mid-infrared waveguides for molecular detection. Among the emerging scientific directions, maneuverable fibers capable of being oriented in three dimensions show great potential for applications in various fields, such as biomedical, robotics or for sensing in general. Integrating materials with complementary properties within a single fiber enables both optical and mechanical control. This work aims to couple shape-memory functionality with infrared transmission by combining polymers and glasses compatible with the fiber drawing process. Fiber drawing consists in stretching a macroscopic preform into a microscopic fiber while maintaining structural homothety. Achieving this requires the processed materials to exhibit compatible viscosity ranges. For this reason, we have selected chalcogenide-based glass compositions with the desired rehological characteristics. Their optical, thermal, and mechanical properties were assessed to evaluate material processability. Following, the glasses are integrated together with shape-memory polymers within fibered structures. The resulting elongated objects have the ability to be spatially oriented and can be deformed in a controlled manner. They can memorize a permanent shape, temporarily adopt a deformed configuration, and recover their original form when exposed to an external stimulus. Finally, the response of the glass inclusions to mechanical stress and the influence of bending on light transmission are explored, along with preliminary mechanical assessments of the fibers.

*Speaker

Keywords: Chalcogenide Glass, Microstructured fibers, Multimaterial fibers, Infrared transmission, Fiber drawing

Mechanistic Study of Crystallization in Alkali Aluminosilicates: The Role of Ti, Zr, and P_2O_5 as Nucleating Agents

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Glass-ceramic materials offer a wide range of applications, from military to biomedical fields (Fu et al., 2020). Among them, alkali aluminosilicate glass-ceramics (Li, Na, K) exhibit mechanical properties very similar to those of natural teeth. Since the 1980s, they have been employed as dental restorative materials (Zhang et al., 2023), providing more reliable alternatives to composite resins (Malament et al., 2001). The aim of this study is to assess the feasibility of developing a multilayer material by co-fritting ternary aluminosilicate glasses (Li, Na, K) and to investigate the physicochemical behavior at the interface after sintering at temperatures close to the glass transition temperature (T_g). The glasses were synthesized with the following compositions: 70 mol

Keywords: Glass, ceramics, Crystallisation, Biomaterials, Dental Materials

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Sintering and cell proliferation of ink-jetted bioactive glass scaffolds with different crystallization tendencies.

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The sinterability of powder compacts and scaffolds 3D-printed via binder-jetting was studied for bioactive glasses (BG) of different crystallization tendencies. To this end, the BGs 13-93 (54.6 SiO2 - 1.7 P2O3 - 22.1 CaO - 6.0 Na2O - 7.9 K2O - 7.7 MgO mol%) and F3 (44.8 SiO2 - 2.5 P2O3 - 36.5 CaO - 6.6 Na2O - 6.6 K2O - 3.0 CaF2 mol%) were considered, and compacts and scaffolds made from powders of different particle size fractions were studied by heating microscopy, differential thermal analysis, X-ray powder diffraction, and microscopy. Compared with their uniaxial pressed counterparts, 3D-printed specimens showed lower green body densities and increased sintering rate, but due to the greater shrinkage required, complete densification is delayed. The slow crystallizing BG 13-93 densified completely prior to crystallization for all particle size and green body density values studied. For BG F3, which crystallizes more readily, only the particle size fraction < 32 μm densified completely for both manufacture ways. The use of coarser particle size fractions limited the densification due to surface crystallization-induced sinter retardation. On the other hand, these powder size fractions allow to better stabilize the complex shape and porosity of sintered scaffolds. Printed scaffolds with regular cylindrical cavities, e.g., showed a good cell proliferation and ingrowth for both BGs, whereas the surface crystallization of BG F3 seems to affect the initial cell attachment and further proliferation.

Keywords: Bioactive glass, Additive manufacturing, Crystallization, Cell proliferation

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CuO nano crystals on bioactive glass surfaces

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As a minor component of bioactive glasses (BG), copper can stimulate the proliferation of human endothelial cells, improve the differentiation of mesenchymal stem cells, and promote in vivo angiogenesis. At higher concentrations, copper can cause cytotoxic effects, but still offers antibacterial, antifungal, and antiviral properties, which are promising, e.g., for wound healing applications.

Enhanced cell proliferation was found for the copper-doped BG F3-Cu 44.8SiO2-2.5P2O3-35.5CaO-6.6Na2O-6.6K2O-3.0CaF2-1.0CuO (mol%). Sintered powder compacts showed in vitro cytocompatibility and supported the proliferation of MC3T3-E1 pre-osteoblast cells. During the initial incubation stage, however, BG F3-Cu samples proved to be temporarily cytotoxic.

This can be explained by the formation of superficial CuO nanocrystals on heat-treated BG surfaces. A Cu+ ion excess, frozen from the melt-temperature Cu+/Cu2+ redox equilibrium during quenching, acts as the driving force for Cu+ migration to the glass surface and its oxidation to CuO (Cu2+) surface crystals. Consequently, even a low copper content can lead to the undesirable formation of cytotoxic CuO crystals during powder processing. As this effect occurs well below the subsequent surface crystallization of the glass, however, it can be independently tuned without major drawbacks on the BG after processing.

Keywords: Bioactive glass, Crystallization, Cell proliferation, Redox, Copper

*Speaker

Paving the way for bioactivity

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Bioactive glasses have the same main components as the soda-lime silicate glasses of our everyday lives. Many of their properties, however, are very different – and some of them indeed need to be, most notably their reactivity with water. This talk looks into how compositional differences between bioactive and conventional silicate systems are reflected in their respective molecular structures, and how this, in turn, controls key bioactive glass properties such as early-stage reactions with water, surface layer formation in physiological solutions as well as the behaviour of cells and bacteria in vitro.

Keywords: bioactive glass, dissolution, ion release, corrosion

*Speaker

Copper-Doped Fluoride-containing Bioactive Glasses Inhibit Streptococcus mutans Activity and Biofilm Formation for Caries Prevention

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Introduction
While fluoride has significantly reduced global caries prevalence, excessive fluoride exposure causes adverse effects. Low-fluoride bioactive glasses (FBGs) offer controlled fluoride, calcium, and phosphate release to form acid-resistant fluorapatite for remineralization, but they exhibit limited inherent antibacterial activity. Copper is a well-documented antimicrobial agent effective against bacteria and viruses. This study aimed to investigate whether incorporating copper into low-fluoride bioactive glasses could enhance their antibacterial properties against dental caries pathogens.

Methods
A series of copper-doped (0–5 mol%) low-fluoride (1 mol%) bioactive glasses (FCuBGs) were synthesised via the melt-quench technique. The effects of copper on glass structure, bioactivity, cytocompatibility, and efficacy against *Streptococcus mutans* (*S. mutans*) were systematically evaluated. The caries-preventive potential of FCuBGs was further assessed *in vivo*. Critically, the underlying antibacterial mechanism of Cu-doped FBGs against *S. mutans* was elucidated for the first time.

Results
Structural analysis indicated that copper does not directly bind to fluoride or orthophosphate but is likely present in the form of Si-O-Cu2+ linkages. Glasses with lower copper content (≤ 2 mol%) demonstrated good cytocompatibility. All tested glasses exhibited high bioactivity and significant inhibition of *S. mutans* metabolic activity and biofilm formation. In a rat caries model, the FCuBG-treated group developed fewer bacterial colonies and less severe carious lesions compared to controls. A strong positive correlation was observed between copper content and antibacterial efficacy, confirming that copper doping is a viable strategy to augment the antibacterial function of FBGs.

Conclusion

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Copper-doped fluoride bioactive glasses (FCuBGs) represent a highly promising material for dental applications, such as in fissure sealants, varnishes, and preventive additives, due to their combined remineralization and enhanced antibacterial capabilities. This work provides fundamental insights into the mechanism of action of FCuBGs, supporting their development for effective caries management.

Keywords: Bioactive glass, copper, fluoride, caries prevention, antibacterial

Li_2O-doped borophosphate glasses as promising biomaterials: Tailoring degradation for bone tissue engineering without compromising bioactivity

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Borophosphate glasses are recognized as promising bioactive materials, mainly due to their controllable dissolution and ion release profiles. The bioactive properties of these glasses are influenced by the B2O3/P2O5 ratio and the incorporation of alkali and alkaline-earth modifiers into the network. This study aimed to investigate the physical properties, *in vitro* bioactivity, antibacterial activity, and biocompatibility of borophosphate glasses with Li2O addition for use as biomaterials. Five samples of the system 50B2O3-20P2O5-15CaF2-(15-x)Na2O-xLi2O (x = 0, 2.5, 5, 7.5 and 10 mol%) were prepared by melt-quenching method. The glasses were characterized by density, molar volume, X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), Vickers microhardness, *in vitro* bioactivity in simulated body fluid (SBF) for 28 days, pH measurements, mass loss in SBF, antibacterial activity using the disk diffusion method, and cell viability assays in RAW 264.7 (murine macrophages) and GM07492A (human fibroblast) cells at different concentrations (500, 750, and 1000 μg/mL). The XRD patterns confirmed the amorphous structure of the samples. The density and molar volume values showed nonlinearity as a function of Li2O addition, suggesting the occurrence of the mixed alkali effect (MAE) in these glasses. FTIR spectra indicated vibrational modes attributed to borate and phosphate groups in the glass structure. After SBF immersion, the bioactivity of the samples was confirmed by XRD and FTIR analyses, which revealed calcium phosphate brushite (DCPD) and hydroxyapatite (HA). All glasses showed inhibitory action on bacterial growth, confirming the antimicrobial properties of these materials. Cell viability in both cell lines exceeded 70%, indicating the absence of cytotoxic effects, in accordance with ISO 10993-5:2009, for all the samples. The addition of up to 10 mol% Li2O to the glass samples can control degradation, as demonstrated by pH and mass loss results, without compromising the bioactivity behavior. These findings suggest that the studied glasses are promising for applications in tissue regeneration, as well as for combating post-surgical infections caused by bacteria commonly found on the human skin.

Keywords: Li, containing glasses, MAE, bioactivity, bioactive glasses, antibacterial activity, cell

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viability.

Bioglass and hybrids for Ionic Medicine

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This talk will focus on how controlled release of ions from bioactive glasses can have different therapeutic benefits. It will then explain how these properties can be introduced into sol-gel hybrid materials. Bioactive glasses bond to bone via a hydroxycarbonate apatite layer and stimulate bone growth. The ability of the dissolution ions to activate osteoblasts has been termed "osteostimulation", approved by the FDA. These findings led to investigations into the effect of ions on promoting blood vessel growth, which can be enhanced by copper and cobalt ions.
Now, bioactive glasses are used in trauma surgery for non-union fractures and are found to have antimicrobial properties, with treatment of osteomyelitis in patients that were not responding to antibiotics. Cotton-like borate-based bioactive glasses have been found to heal diabetic ulcers that were not healing during conventional treatment, which could be due to borate release during their dissolution in the wound bed. Mesoporous nanoparticles can deliver ions into cells and we have found that zinc delivery can kill cancer cells without harming other cells.
While bioactive glasses can regenerate bone, they are brittle. Inorganic/organic hybrids can give mechanical property control and can be 3D printed into scaffolds. Scaffolds with a pore size of _˜ 250 mm guided bone marrow stem cells down a chondrogenic route, producing articular cartilage-like matrix. Sheep studies showed scaffolds with 250 mm pores promoted excellent cartilage regeneration, while defects remained for scaffolds with 500 mm pores were used. For bone regeneration, the challenge is introducing osteostimulation by incorporating calcium into the silicate network using calcium alkoxide precursors.

Keywords: Bioglass, bioactive glass, ionic medicine, sol, gel, inorganic/organic hybrids

*Speaker

Weight Reduction for Pharmaceutical Vials in the Context of Decarbonation

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This study presents a lightweighting approach applied to molded glass primary packaging intended for the pharmaceutical industry, in the context of decarbonation, in particular the reduction of customers' Scope 3 emissions.
Product safety, compliance with regulatory requirements and Pharmacopeia standards, product quality and performance are critical for our customers. Without compromising these aspects, the weight reduction strategy was implemented on specific vial formats and routes of administration. Overall, the analysis indicates that SGD Pharma vials are already relatively optimized in terms of weight-to-volume ratio, due to their design. Two case studies will be presented: one presenting Finite Element Analysis (FEA) in comparison with experimental technical data, and the other one to highlight the environmental benefits and customer's challenges.

Keywords: Weight Reduction for Pharmaceutical Vials, Molded Glass Primary Packaging, Decarbonation, Weight to Volume Ratio, Digital Simulations: Finite Element Analysis, Pharmaceutical Industry Constraints

*Speaker

SGD Pharma Siliconized Vials: Protecting the Integrity of Sensitive Drugs

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SGD Pharma's siliconized vials offer a premium packaging solution specifically engineered for the most sensitive pharmaceutical formulations. At the core of their performance lies a unique internal siliconization process that creates a thin, uniform, and highly adherent silicone layer on the inner surface of the glass.
The silicone layer acts as a protective shield for the glass against chemical reactions with the drug solution, preventing the leaching of metal ions, such as aluminum. This is essential for maintaining the chemical integrity of sensitive molecules, especially biologics, which are prone to degradation through oxidation, aggregation, or fragmentation when exposed to leachables.

The hydrophobic nature of the silicone barrier minimizes physical interactions between the drug product and the glass surface. This is particularly beneficial for high-viscosity formulations, as it prevents adhesion to the vial walls, ensuring smooth product flow, complete restitution, and accurate dosing down to the last drop. Results are improved usability and reduced product waste.

In lyophilization processes, siliconized vials deliver superior performance by significantly reducing the risk of cake cracking and minimizing product adherence to the inner surface. The hydrophobic silicone layer helps maintain a smooth separation between the freeze-dried product and the glass, resulting in a more uniform and compact cake structure. This homogeneity is essential for ensuring consistent product quality, facilitating efficient reconstitution, and preserving the visual appearance of the final dosage form-key attributes for both patient safety and regulatory compliance.
In summary, SGD Pharma's siliconized vials combine the mechanical strength of molded glass with the hydrophobic efficiency of silicone coating-delivering superior protection, optimized drug recovery, and enhanced stability for today's most advanced therapies.

Keywords: molded glass vials, silicone, hydrophobic coating, barrier properties, lyophilization

*Speaker

Targeted incorporation of phosphorus into mesoporous bioactive glasses preparation by Evaporation Induced Self Assembly method

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The optimization of phosphorus incorporation into highly mesoporous bioactive glasses (MBG) (80SiO2-15CaO-5P2O5) using nonionic block copolymers as structure guiding via an Evaporation-Induced Self-Assembly (EISA) method was investigated. This synthesis strategy produces MBGN with uniform and controllable pore size and with relatively high *in vitro* bioactivity in bone formation. The aim of this work is to achieve the desired P2O5 content of the MBG produced by EISA method. TEOS and Ca(NO3)2*4H2O were used as precursors for SiO2 and CaO respectively. The incorporation of the desired phosphorus content is achieved by modifying the process conditions to promote the hydrolysis of the original phosphorus precursor triethylphosphate (TEP). In more detail, the amount of the originally prescribed TEP, type or quantity of solvents were changed. The process of adding TEP was also partially modified in order to enhance the hydrolysis of TEP.
In addition, the phosphorus precursor TEP was successfully replaced with a new phosphorus precursor. Using the new phosphorus precursor results in a higher phosphorus incorporation extent and therefore the targeted phosphorus content in the prepared MBGN can be achieved more efficiently.

The work also involves preparing co-doped MBG according to an optimized process. The prepared MBGs were characterized by TEM, FTIR, XRD and BET. Their chemical composition of prepared MBGs were verified after decomposition by ICP-OES to confirm the gained composition achieving.
Acknowledgement: This item was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I01-03-V04-00040 and APVV 22-0062 project.

Keywords: TEP, EISA, MBG, phosphorus content

*Speaker

Light-Driven Bioactive Systems for Antimicrobial and Regenerative Therapies

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Mesoporous bioactive glass (MBG) is a versatile material widely explored for regenerative medicine thanks to its intrinsic bioactivity and highly ordered porosity, which together provide a suitable platform for loading and controlled release of therapeutic molecules. In this study, we introduce a light-responsive bioactive nanoplatform integrating zinc phthalocyanine (ZnPc), a highly effective photosensitizer, into MBG nanoparticles for photodynamic therapy (PDT). The resulting ZnPc@MBG particles, with diameters between 100 and 160 nm, are uniformly dispersed as evidenced by SEM and TEM analyses. Complementary structural characterization (XRD, FTIR, XPS) confirms the formation of a heterogeneous nanocomposite while indicating a reduction in specific surface area upon ZnPc loading.
Despite this decrease, the nanoparticles preserve their characteristic bioactivity, demonstrated by the formation of hydroxyapatite-like layers after incubation in simulated body fluid. In vitro experiments confirm excellent cytocompatibility under dark conditions, whereas activation with red light (660 nm) triggers a clear dose- and time-dependent decline in cell viability, validating the PDT functionality. In vivo evaluation using *Galleria mellonella* larvae further demonstrates biocompatibility at concentrations up to 50 μg/mL. Upon irradiation, ZnPc@MBG exhibits strong antimicrobial activity against *Staphylococcus aureus*, achieving both minimum inhibitory and minimum bactericidal concentrations at 50 μg/mL.

Overall, this study presents a multifunctional nanoplatform that effectively merges photodynamic performance, intrinsic bioactivity, and antibacterial efficacy. Such a combination highlights its promise for future clinical applications, particularly in the fields of infection management and tissue regeneration where targeted, stimuli-responsive therapeutic strategies are increasingly needed.
Acknowledgements
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*Speaker

Keywords: mesoporous bioactive glass, zinc phthalocyanine, photodynamic therapy, antimicrobial activity

Multifunctional Bioactive Nanoglasses for Hemostasis and Soft Tissue Regeneration

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Bioactive nanoglass materials represent a novel class of inorganic amorphous medical materials, characterized by unique biocompatibility, biodegradability, and bioactivity. They have shown significant potential in various applications such as tissue repair, bioimaging, tumor treatment, and drug delivery. This work report a multilayer-structured bioactive glass nanopowder (BGN@PTE) by coating the poly-tannic acid and ϵ-polylysine onto the BGN via facile layer-by-layer assembly as an integrative and multilevel dressing for the sequential management of wounds. In comparison to BGN and poly-tannic acid coated BGN, BGN@PTE exhibited the better hemostatic performance because of its multiple dependent approaches to induce the platelet adhesion/activation, red blood cells (RBCs) aggregation and fibrin network formation. Simultaneously, the bioactive ions from BGN facilitate the regulation of the inflammatory response while the poly-tannic acid and antibacterial ϵ-polylysine prevent the wound infection, promoting the wound healing during the inflammatory stage. In addition, BGN@PTE can serve as a reactive oxygen species scavenger, alleviate the oxidation stress in wound injury, induce the cell migration and angiogenesis, and promote the proliferation stage of wound repair. Therefore, BGN@PTE demonstrated the significantly higher wound repair capacity than the commercial bioglass dressing Dermlin™. This multifunctional BGN@PTE is a potentially valuable dressing for full-thickness wound management and may be expected to extend to the other wounds therapy.

Keywords: Nanoscale bioactive glass, Surface Engineering, Soft tissue regeneration

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Dual ion doped cerium-based mesoporous bioactive glasses as multifunctional platforms for advanced therapeutic applications

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Mesoporous bioactive glasses (MBGs) have gained increasing attention as multifunctional materials for tissue regeneration and drug delivery, owing to their high surface area, ordered porosity, and tunable composition.(1) Cerium-doped MBGs (MBGs-Ce) are of particular interest due to the coexistence of Ce^{3+}/Ce^{4+} redox states, which impart catalase- and superoxide dismutase-like antioxidant activity, supporting the management of oxidative stress typically associated with implantation and inflammatory processes.(2) Building on these properties, we investigated the enhancement of MBGs-Ce through dual doping with therapeutic inorganic ions (TIIs) such as Cu, Ag, Zn, and Mg, and explored further functionalization with biomolecules including polyphenols or common drugs. MBGs with single and dual dopants were synthesized via the sol-gel EISA method, maintaining the characteristic ordered mesoporous structure. Their physicochemical properties were examined through XRPD, SEM, and SSA analyses, confirming the preservation of the amorphous structure and high porosity after doping. The materials were tested for bioactivity (hydroxyapatite formation) in simulated body fluid, antioxidant behavior via catalase- and SOD-like assays, antibacterial effects against Gram-positive and Gram-negative bacteria, and loading efficiency through elemental analysis.(3-5) The results reveal that dual doping with Cu, Ag or Mg does not compromise bioactivity, leading to hydroxyapatite formation within 7–14 days, while Zn-containing compositions inhibit apatite precipitation, suggesting alternative applications. Cu- and Ag-doped glasses exhibit significant antibacterial activity, with Cu displaying the strongest microbial inhibition. All Ce-containing compositions show marked antioxidant behavior, while dual-ion systems further enhance SOD-like activity. Functionalization with biomolecules is readily achieved thanks to the mesoporous architecture, and polyphenols additionally improve antioxidant performance. Overall, MBGs-Ce/Cu, MBGs-Ce/Ag and MBGs-Ce/Mg emerge as promising candidates for multifunctional drug delivery systems for hard tissue regeneration, combining bioactivity with antibacterial and antioxidant properties. Conversely, MBGs-Ce/Zn may be advantageous in applications where delayed bioactivity is preferred, such as early soft tissue healing. These findings highlight the potential of dual-ion and biomolecule-loaded MBGs as versatile platforms for next-generation therapeutic strategies. **References** (1) Zhu H. *et al.* 2021, 10.1016/j.actbio.2021.05.006 (2) Zambon A. *et al.*, 2021, 10.1021/acsbiomaterials.1c00414 (3) Lusvardi G. *et al.*, 2022, 10.1021/acsbio-

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Keywords: Mesoporous glasses, cerium, dual, ion doping, antioxidant, antibacterial, drug delivery

Multifunctional Bioactive Glass Nanoparticle Composite Dressings for Promoting Diabetic Wound Healing

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Diabetic wounds are often difficult to heal due to susceptibility to infection, excessive inflammatory responses, and impaired angiogenesis, which severely affect skin function and threaten patients' health and lives. Achieving rapid repair of such wounds remains a major clinical challenge. Owing to the multifunctional properties of bioglass, the development of bioglass nanoparticle (nBG) composite materials with antibacterial, anti-inflammatory, and pro-angiogenic effects offers a promising strategy for addressing the problem of impaired diabetic wound healing. Based on this concept, our group designed and prepared several types of nBG composite materials and characterized their physicochemical properties. In vitro studies were conducted to investigate the effects of these composites on key cell types involved in wound healing, their ability to promote angiogenesis, and their regulatory effects and mechanisms on macrophage polarization. Furthermore, animal experiments were performed to explore how these materials regulate cellular behavior and enhance diabetic wound repair. The results demonstrated that the prepared materials possessed excellent physicochemical properties suitable for wound repair. In vitro experiments revealed that the dressing could activate the Hif-1α/VEGF signaling pathway to promote endothelial cell angiogenesis. Meanwhile, it could also activate related signaling pathways to induce macrophage polarization toward the M2 phenotype, which further enhanced endothelial angiogenesis via paracrine mechanisms. Animal experiments showed that the material effectively modulated macrophage polarization at the wound site to suppress excessive inflammation, upregulated VEGF expression, restored vascular networks, accelerated granulation tissue formation and collagen deposition, and ultimately promoted diabetic wound healing. In conclusion, the developed nBG composite dressing exhibits excellent physicochemical properties, effectively regulates multiple cellular behaviors within diabetic wounds, and significantly promotes wound repair. It holds great potential for applications in diabetic wound healing and broader skin tissue regeneration.

Keywords: Bioactive Glass, Angiogenesis, Macrophages, Diabetic wound healing

*Speaker

From Egg to bone: biological relevance of the "shell/membrane", bioactive glasses and PHA trio for the additive manufacturing of scaffolds in facial cleft regenerative medicine

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Cleft lip and/or palate is a congenital malformation with an incidence of 1 in 700–1,000 births in France. Secondary alveolar bone grafting (SABG) restores the continuity of the alveolar bone in orofacial clefts, enabling the establishment of functional dental occlusion. A long-term investigation of dental and periodontal outcomes in patients with cleft defects treated by SABG using 45S5 bioactive glass demonstrated a high success rate of 71.4%1. However, this type of galenic formulation has led to failures due to granule leakage and low mechanical properties of the graft. Therefore, alternative technologies need to be explored. Digital data flows collected from 3D imaging combined with additive manufacturing now make it possible to shape scaffolds before they are surgically inserted. This study aims to evaluate the design of scaffolds by additive manufacturing using innovative materials, with a focus on their physicochemical and biological properties to support bone regeneration. Polyhydroxyalkanoate (PHA) is a biosynthesized, biocompatible, and bioassimilable polymer that can be used as a matrix for scaffolds incorporating bioactive glass. Eggshell membrane (ESM) possesses antibacterial properties and contains type I, V, and X collagen, with a composition similar to that of the extracellular bone matrix; but ESM alone shows limited mineralization capacity2. It is hypothesized that the combination of the bioinduced phosphocalcic mineral load of bioactive glass will enhance the nucleation potential of ESM, thereby improving its mechanical and biological performance. PHA, bioactive glasses and ESM showed significant results for cell proliferation of osteoblasts, endothelial and stem cells at 1 and 3 days. Bioactive glasses are synthesized via melt-quenching (45S5)3 or sol–gel (92S6 P123)4 processes. The scaffolds are fabricated using additive manufacturing technology through selective laser sintering (SLS) or robocasting, which enables precise shaping of the cleft defect and control of scaffold porosity.

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Keywords: bioactive glasses, scaffold, biomaterials, additive manufacturing, bone regeneration

Synthesis and characterization of membranes composed of Carboxymethyl Cellulose and Biosilicate

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This work focusses on the synthesis and characterization of membranes based on carboxymethyl cellulose (CMC). An environmentally friendly process was employed to minimize the presence of hazardous solvents during the preparation of the biomaterials. Moreover, CMC-based hybrids were prepared by blending with polyethylene glycol (CMC-PEG). Biosilicate (BioS), cobalt-doped BioS (Co-BioS), and lithium-doped BioS (Li-BioS) were synthesized and their particles were incorporated into the CMC-PEG membranes. Citric acid (CA) was also used with the aim of crosslinking the membranes in order to enhance their intermolecular interactions. Incorporating PEG, BioS, Co-BioS, and Li-BioS led to an improvement in the morphology of the CMC membranes. Fourier Transform Infrared (FTIR) analysis and Differential Scanning Calorimetry (DSC) indicated that PEG and CMC polymer chains exhibited miscibility at the molecular level, stabilizing the polymeric network. The membranes exhibited swelling and later dissolution in water, likely due to weak or incomplete crosslinking among the polymeric components. The incorporation of the glass-ceramics into the polymeric network maintained the morphological and structural stability of the membranes and released bioactive ions such as calcium, cobalt, silicon, lithium, and phosphate that can stimulate angiogenesis and enhance wound healing. These ions play a key role in tissue regeneration by promoting cell adhesion, proliferation, and differentiation, as well as exhibiting hemostatic and antibacterial properties. Thus, these CMC-PEG membranes, incorporated with BioS to enhance their biological properties, could be used for wound healing.

Keywords: Membrane, Biosilicate, PEG, CMC, wound healing.

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In-vitro study of biophotonic fibers with red upconversion for biophotonic application

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Borate bioactive glass with the $26.93SiO_2$–$26.93B_2O_3$–$22.66Na_2O$–$1.72P_2O_5$–$21.77CaO$ (in mol

Keywords: Bioactive, Glass, Upconversion, Fibers, Rare Earth

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Mg- and Bi-Based Silicate Bioactive Glasses for Advanced Biomedical Applications

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Bioactive glasses with specific compositions tailored for targeted regenerative medical applications have emerged as promising biomaterials. In this study, we investigate the bioactive properties of a novel quaternary glass composition, SiO2-CaO-Li2O-MgO-Bi2O3, synthesized through microemulsion-assisted sol-gel methodology using base-catalysis. The incorporation of Lithium improves ionic mobility and accelerates apatite nucleation kinetics, while Magnesium acts as a bioactive network modifier, promoting osteogenic signalling and improving mechanical compatibility with bone tissue. Bismuth is incorporated to provide radiopacity for bioimaging applications. It serves as a radiosensitizing agent, improving scope for therapeutic potential in advanced biomedical applications. The microemulsion sol-gel synthesis ensures precise control over cation distribution, and base catalysis regulates particle size, facilitating enhanced ion release profiles. The *in vitro* bioactivity assessment was conducted via immersion studies in simulated body fluid (SBF) at 37∘C, with evaluation of ion release kinetics (Si4+, Ca2+, Li+, Mg2+), pH evolution, and hydroxyapatite formation on the glass surface. Results demonstrate synergistic effects between the constituent oxides, with lithium and magnesium ions promoting accelerated bioactive response and superior ion exchange characteristics compared to conventional bioactive glass systems. The bismuth component contributes additional functionality for imaging-guided therapeutic applications. This multifunctional composition exhibits significant potential for bone regeneration, drug delivery, and emerging cancer therapy applications. The chosen approach provides a scalable, controlled synthesis platform for fabricating advanced biomaterials with enhanced bioactivity and therapeutic versatility.

Keywords: Bioactive glass, Microemulsion sol, gel synthesis, Magnesium and Bismuth incorporation, Ion release kinetics, Hydroxyapatite formation, Bioimaging applications

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The Role of Coloring Agents on Amber Borosilicate Glass for Pharmaceutical Application

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Ultra-violet radiation can trigger chemical reactions in many pharmaceutical products and thus damage drug stability. To avoid these risks, light-sensitive drug products need to be stored in special containers that can block specific ranges of wavelength, thus allowing safe storage in prolonged periods of time.
Besides the use of special coatings, amber-colored glass is the ideal solution to block undesirable radiation.

The amber color of borosilicate glasses is obtained by the combined presence of Iron (Fe) and Titanium (Ti) ions and is very sensitive to thermal treatments.

For this reason, the basic transmission of amber tubular glass containers will change, darkening after glass tubing converting and annealing.

Light-Transmittance properties testing is defined in the Pharmacopoeias and represents a key step during the development phase to ensure long-term shelf life of the drug products.
The current investigation offers a comprehensive understanding of the impact of colorants on borosilicate glasses and the influence of thermal processes on the behavior of iron compounds in the glass matrix.

Keywords: Amber color, Borosilicate Glass, Light Transmittance, Pharma Packaging

*Speaker

pH-sensitive, antibacterial, bioactive glass-based material for advanced wound dressings

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Epithelial wounds are classified as acute when they close within days to weeks, and as chronic when healing is delayed, shows no measurable progress, or recurs after apparent closure (1). Among the various indicators of the wound environment, pH serves as a key biomarker of healing status: acidic pH values are typically associated with acute, healing wounds, whereas alkaline conditions are characteristic of chronic or infected wounds (2). Since infections and biofilms affect approximately 60–100% of chronic wounds, continuous pH monitoring together with effective antimicrobial activity is essential for optimal wound management and healing (3). To address this need, this work proposes the development of a multifunctional bioactive glass-based composite material for advanced wound dressings, providing pH-sensing, and antibacterial functionalities in addition to promoting healing. The composite consists of a biocompatible electrospun polyvinyl alcohol (PVA) matrix embedded with SiO2-CaO-P2O5 bioactive glass (BG) particles synthesized via a Sol-Gel route, and the natural pH-responsive dye curcumin. The PVA fibrous matrix provides mechanical integrity and flexibility to the wound dressing; the silicate-based BG particles enhance healing through the release of therapeutic ions (Si, Ca, and P); and curcumin enables real-time colorimetric pH monitoring along with antibacterial activity, as demonstrated in previous studies (4).
Preliminary semi-quantitative characterization indicates favorable mechanical performance of the polymer fibers, evidenced by the apparent flexibility of the obtained dressings; bioactivity of the BG particles, confirmed by the formation of a hydroxycarbonate apatite (HCA) phase after 12 hours of immersion in a simulated body fluid (SBF); and pH-sensitivity, demonstrated by a distinct color change of the dressing from bright yellow to dark orange and then dark red upon contact with buffers solutions ranging from a pH from 4 to 10. Verification of the *in vitro* antibacterial effect of the dressings is part of the ongoing characterization.

Keywords: wound dressings, composite, polymeric fibers, bioactive glass, curcumin, pH sensitive, antibacterial

*Speaker

Experimental glass fibers for biomineralization and reinforcement of glass ionomer cement used in dental applications

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Glass ionomer cement (GIC) is used as a filling material in dental restoration to fill cavities and restore teeth. Biomineralization and mechanical properties are important for achieving a successful outcome. Unreactive E-glass fibers are commonly used as a reinforcing material to improve the mechanical properties of GICs. However, a more reactive material contributing to biomineralization would be of interest to use instead of E-glass.
New glass compositions were produced with bioactive glass S53P4 as a reference. Glasses with increasing aluminum and strontium contents, and fixed fluoride content, were tested to potentially improve the mechanical properties and enhance the biomineralization of GICs. Thin glass fibers were of interest for the final application. However, as the glass fibers were hand-drawn in-house from the glass melt, the thickness varied, and it was not possible to produce thin, uniform fibers.

Glass particles (Ø 300-500 μm) and glass fibers of the new compositions and reference S53P4 were tested *in vitro* in simulated body fluid for two weeks. Changes in solution pH and ion concentrations, as well as changes to the material surface, were studied over time. The hydrolytic resistance of glass particles was investigated in accordance with ISO 719. The compressive load and strength were tested on glass ionomer cement samples with 25% of the glass ionomer powder replaced with the produced glass powders (Ø $<$ 45 μm).

The results showed that the glasses with aluminum, strontium, and fluoride dissolved more slowly, while still showing some surface changes, compared to the highly reactive bioactive glass S53P4. Similarly, when investigating hydrolytic resistance, the new glasses showed a better chemical durability, class 2, compared to class $>$ 5 for S53P4. Compared to S53P4, the compressive load and strength of GIC samples improved with the addition of powders from the new glasses, being close to that of commercial GIC.
The results indicate that with a more controlled fiber-drawing temperature range and overall process, thinner fibers with uniform diameters can be produced from the alumina- and strontia-containing melts. However, more research is needed to optimize the glass composition to achieve the desired biomineralization and mechanical properties of GICs.

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Keywords: bioactive glass, glass fibers, dentistry, in vitro, hydrolytic resistance

Impact of phosphorous on dissolution kinetics of bioactive glasses

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The bioactivity of silicate-based glasses is known to increase with phosphorus content. However, the overall effect of phosphorus on bioactive properties remains poorly understood. This study explored the impact of phosphorus content on the in vitro bioactivity of melt-quenched bioactive glasses. The glass compositions were derived from bioactive glass S53P4 (Bonalive®) so that the P2O5 content was decreased from 4 to 2 (glass S54P2) and 0 wt% (glass S55P0) by maintaining their molar ratio of Na2O/CaO constant. Simultaneously, the network connectivity decreased from 2.54 in S53P4 to 2.40 in S55P0. Glass particles (500-800 μm) were immersed in simulated body fluid under static conditions for 168 h and in dynamic conditions at flow rates of 0.04 and 0.2 mL/min for 96 h. The concentrations of the ions released into the solution were measured using ICP-OES, while the changes in the surface layer morphology of the glass particles were studied using SEM-EDXA. Despite its higher silica content and lower network connectivity, significantly less silicon was released from S55P0 than from the other two glasses under all conditions. Calcium and phosphate ions partly precipitated within the silica-rich gel at S53P4 and S54P2. Further, thicker pure calcium phosphate layers were measured for these compositions than for the phosphate-free glass. The higher silicon release from the phosphate-containing glasses suggests that neither the calcium phosphate within the silica-rich gel nor on the glass surface significantly retard the overall glass dissolution compared to phosphate-free glasses. As phosphorus is considered to be released as the orthophosphate group from bioactive silicate glasses, it was assumed that the calcium phosphate within the gel forms a surface structure that favours the dissolution of the underlying bulk glass. The presentation will discuss in more detail the impact of phosphorus on the dissolution kinetics of bioactive silicate glasses.

Keywords: Bioactive glass, dissolution kinetics, network connectivity, in vitro bioactivity

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In Vitro Bioactivity and Antibacterial Potential of Selenium-Doped Mesoporous Bioactive Glass Particles for Bone Tissue Regeneration Applications

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Selenium (Se), a biologically active metalloid, has attracted significant attention for its broad therapeutic potential across various biomedical domains, including antioxidant defense, immune modulation, and tissue regeneration. As an essential component of selenoproteins, selenium plays a crucial role in maintaining cellular redox balance, supporting thyroid function, and promoting wound healing. Recent research has focused on incorporating selenium into biomaterials, particularly bioactive glasses (BGs) and bioceramics, to enhance their regenerative and antimicrobial performance. Selenium-doped bioactive glasses (Se-BGs) represent a new generation of multifunctional biomaterials with superior biocompatibility, bioactivity, and controlled ion release behavior. The integration of selenium ions into the BG matrix not only preserves the inherent osteoconductivity of the glass but also introduces additional therapeutic properties such as antioxidant protection and anti-inflammatory activity. Moderate Se incorporation has been shown to promote osteoblast proliferation, stimulate angiogenesis, and accelerate hydroxyapatite formation, all of which are essential for effective bone tissue regeneration. Furthermore, Se-BGs exhibit potent antibacterial efficacy against drug-resistant microorganisms, reducing the risk of post-implant infections and improving overall tissue integration. These unique characteristics make Se-BGs highly suitable for applications in bone grafts, chronic wound management, and orthopedic implants. Beyond regenerative medicine, selenium's intrinsic redox activity offers promising avenues in cancer therapy, targeted drug delivery, and immunomodulation. This presentation provides an overview of recent advances in selenium-doped bioactive glasses, including synthesis strategies, structural and physicochemical characteristics, biological performance, and future directions. The growing body of evidence underscores the potential of Se-BGs as versatile biomaterials capable of combining structural support with therapeutic functionality, paving the way toward next-generation bioactive systems for clinical applications in regenerative and personalized medicine.

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Keywords: Selenium, doped bioactive glass, Bone tissue engineering, Antibacterial activity, Regenerative medicine

Rare-Earth Ion–Doped Mesoporous Bioactive Glasses: Multifunctional Platforms for Bone Regeneration

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Bioactive materials, particularly mesoporous bioactive glasses (MBGs), have emerged as a new generation of biomaterials capable of promoting tissue regeneration, bone repair, and controlled drug delivery. Their highly ordered mesoporous architecture offers a large surface area, tunable pore size, and versatile surface chemistry, enabling enhanced bioactivity and functionalization. For clinical translation, these materials must simultaneously exhibit bioactivity, biocompatibility, and antibacterial performance to ensure strong bone bonding, non-toxicity, and effective infection control. This presentation highlights the synthesis and multifunctional evaluation of SiO_2–CaO–P_2O_5–Li_2O–Ga_2O_3 MBGs and their rare-earth ion–doped counterparts (Tb^{3+}, Sm^{3+}, and Eu^{3+}; 0.5–2 mol

Keywords: Mesoporous bioactive glasses (MBG), Rare earth Ions, Biocompatability, Bone tissue engineering, Theranostic applications

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Innovative compositions of bioactive glasses and glass-ceramics with regenerative and therapeutic purposes

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Bioactive glasses have been extensively studied for their potential in bone tissue regeneration due to their ability to form a chemical bond with living bone. This occurs through a well-established mechanism involving rapid ion exchange between the glass surface and surrounding biological fluids, ultimately leading to the formation of biologically active hydroxyapatite (HAp). Research has recently shown that the controlled release of specific ions from these glasses can activate various biological processes that support the regeneration of both hard and soft tissues. These include promoting bone growth, stimulating human endothelial cell proliferation, and enhancing angiogenesis. Additionally, certain elements exhibit antimicrobial and anti-inflammatory effects.
In recent years, significant efforts have focused on enhancing the biological performance of bioactive glasses by incorporating targeted amounts of active elements such as Sr, Cu, Ag, Zn, and Mn into their formulations. In this context, the lecture will present the work carried out by the DISAT GLANCE Research Group, which has been dedicated to designing new bioactive glass compositions, doping them with therapeutic ions and studying how their release influences regenerative pathways and therapeutic outcomes.

Keywords: bioactive glasses, ion release, tissue regeneration, therapeutic compositions

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From Bone Bonding to Ionic Medicine: The Evolution and Clinical Impact of Bioactive Glass

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Bioactive glass, first developed by Professor Larry Hench in the late 1960s, represents a milestone in the field of biomaterials. Hench's pioneering work led to the development of the 45S5 bioactive glass composition, which demonstrated for the first time that a synthetic material could form a stable bond with living bone. Since this initial discovery, bioactive glass has been the subject of intensive research and continuous development, resulting in a deeper understanding of its structure–property relationships and its broad potential for medical applications. The biological activity of 45S5 bioactive glass is primarily based on its interaction with the physiological environment. Upon implantation, the glass surface undergoes a series of reactions that culminate in the formation of a hydroxylapatite layer, enabling a direct bond to bone tissue. Beyond this well-established surface bonding mechanism, the controlled release of glass constituents in ionic form plays a crucial role. These ions, such as calcium, phosphate, sodium, and silica species, actively influence cellular behavior, including osteogenic differentiation, angiogenesis, and immune modulation. This recognition has led to the concept of "ionic medicine," in which the therapeutic effects of bioactive glasses are attributed not only to their structural properties but also to the biological signaling functions of their ionic dissolution products. By modifying the glass composition and by the introduction of various ions with therapeutic activity, it becomes possible to tailor these ionic effects and thereby influence specific biological responses. In clinical practice, 45S5 bioactive glass has become an established biomaterial in orthopedic surgery. Its applications include the treatment of bone infections, where its antibacterial properties and bone-regenerative capacity are particularly advantageous, as well as the reconstruction of bone defects following resection of benign tumors. Furthermore, bioactive glass is increasingly used in revision arthroplasty to manage bone loss and support stable reimplantation. Future research aimed at achieving a more precise understanding of the biological mechanisms underlying bioactive glass interactions with tissues is expected to further expand its indications. Such advances may open new therapeutic avenues, including potential applications in the treatment of bone tumors and other complex skeletal pathologies.

Keywords: bioactive glass, bone regeneration, ionic medicine

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Control of phase transition in buried BaTiO3 microcrystals via ion-exchange-induced stress in glass: Experimental and finite element analysis

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Ion exchange (IE) treatment of alkali silicate glasses induces an in-plane compressive stress of up to 1 GPa within the glass surface. The IE-induced stress generation is unique to these glasses; however, IE treatment has primarily been used to increase the shock resistance of glass covers and cases for mobile gadgets such as smartphones. Herein, we propose applying IE treatment to control the physical properties of crystal particles buried within glass via an induced stress field. Barium titanate was selected as the test crystal because increasing its ferroelectric-paraelectric transition temperature of 120∘C would be useful for many industrial applications. Barium titanate crystal particles were buried within a soda-lime glass plate, after which the plate was subjected to IE treatment to induce a stress field. The experimental observations were compared with the mesoscale stress analysis results obtained using the finite element method. Findings indicated that the induced stress field increased the transition temperature of the crystal particles from the ferroelectric tetragonal system to the paraelectric cubic system by 30∘C on average. Based on a comparison with previous studies reporting pressure-induced changes in the transition temperature, we concluded that the increase in the transition temperature can be primarily attributed to the induced tensile stress. Such an anomalous and mesoscale stress field is difficult to produce in microparticles by typical loading methods. The proposed approach is expected to help realize stress-engineered functional materials without requiring mechanical loading.

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Understanding Oxygen-Driven Plasticity in Amorphous Alloys via Multiscale Simulations and Ab Initio Trained Machine Learning Force Fields

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Predicting the mechanical response of metallic glasses (MGs) remains challenging, as conventional atomistic models often rely on empirical force fields that fail to capture complex deformation mechanisms or multicomponent chemical interactions accurately. Here, we develop a multiscale modeling framework to investigate the brittle-to-ductile transition in ZrCu- and PdSi-based metallic glasses, with particular emphasis on the role of oxygen concentration and structural state. A machine-learning force field (MLFF) is trained on ab initio density functional theory data and subsequently employed in large-scale molecular dynamics simulations to access system sizes and deformation regimes beyond the reach of first-principles methods. The MLFF is systematically validated by comparing ground-state properties and elastic constants with corresponding DFT results. Mechanical behavior is analyzed under compressive loading through stress–strain responses and vibrational indicators, including the participation ratio and phonon order parameter. The simulations capture the transition from localized shear-band-dominated plasticity to more homogeneous deformation as a function of oxygen content and structural state. These results demonstrate that ML-based interatomic potentials provide a reliable framework for linking atomistic deformation mechanisms to macroscopic mechanical behavior in metallic glasses.

Keywords: Glasses, Machine Learning potentials, Brittle, to, Ductile crossover

*Speaker

Atomistic simulations of glasses made FAIR

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Atomistic simulations are integral to the knowledge and design of glasses, but are nonetheless challenging due to slow structural dynamics, complex workflows, and issues of data management. With advances in high-throughput modeling and machine-learned interatomic potentials, it is worth increasing the Findability, Accessibility, Interoperability, and Reusability (FAIR) of these simulations. Here we present a Python package for the automated setup, execution, and analysis of atomistic simulations of glasses. The software package has semi-to-fully automated modules for the setup of molecular dynamics simulations, preparation of glassy systems, calculation of properties (elastic moduli, viscosity), and structural analysis of the resulting atomic configurations across short- and medium-range order. The computational and workflow management capability is based on the pyiron framework. Showcases of the automated glass preparation, property calculation, and analysis will be presented. The package includes a dedicated web application programming interface for use by large language models. We therefore provide an extensible platform for standardized, FAIR, AI-assisted atomistic simulation of glasses.

Keywords: Atomistic Simulations, FAIR, Glasses

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Nanostructuration of sillicate glasses using water: a multiscale simulation investigation

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Understanding how water interacts with glass remains a central question in glass science, as the glass industry moves toward decarbonized processes using innovative processes such as hydrogen-fired furnaces, where water becomes an inherent by-product. Water is expected to lower key characteristic temperatures of glass, such as the glass transition, softening, or crystallization temperatures, but its broader impact remains uncertain: how will hydration affect structural, mechanical and optical properties. Nanoconfined water is known to exhibit slow dynamics, high viscosity, and can even adopt a glassy state(1). Exploiting these distinctive features, we examine how confined water modifies the mechanical behaviour of silica glass across nano to macroscopic scales. Specifically, we vary the hydration level and perform a thorough comparison of different interatomic potentials, including ReaxFF(2) and DCRP(3), to capture the diversity and evolution of water–silica interactions. We further investigate the influence of water content, pore sizes, and spatial distributions on the structural and mechanical responses of the glass network. This work offers new insight into the interplay between hydration, nanoconfinement, dynamics of water, and mechanical properties in silicate glasses, and opens perspectives for understanding water-rich environments relevant to materials engineering, geosciences, and industrial processes. (1) Leoni, Fabio, Carles Calero, and Giancarlo Franzese. 'Nanoconfined Fluids: Uniqueness of Water Compared to Other Liquids'. ACS Nano 15, no. 12 (2021): 19864–76. https://doi.org/10.1021/acsnano.1c07381. (2) Fogarty, Joseph C., Hasan Metin Aktulga, Ananth Y. Grama, Adri C. T. Van Duin, and Sagar A. Pandit. 'A Reactive Molecular Dynamics Simulation of the Silica-Water Interface'. The Journal of Chemical Physics 132, no. 17 (2010): 174704. https://doi.org/10.1063/1.3407433. (3) Mahadevan, T. S., and S. H. Garofalini. 'Dissociative Water Potential for Molecular Dynamics Simulations'. The Journal of Physical Chemistry B 111, no. 30 (2007): 8919–27. https://doi.org/10.1021/jp072530o. **Keywords:** LAMMPS, Molecular Dynamics, Water–glass interactions, Nanoconfined water, Silicate glasses, Hydrous Glasses, Mechanical properties, Interatomic potentials, Pores, Nanoconfinement, Nanoporosity

*Speaker

Better Together? Multitask versus Singletask Learning for Modeling Glass Properties and Tackling Glass Forming Ability Prediction

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This talk explores the intersection of glass science and machine learning, focusing on two recent advances from our group. First, we investigate whether multitask learning improves glass property modeling compared to singletask approaches. Second, we tackle the challenging problem of predicting Glass Forming Ability (GFA) in oxide liquids. For the multitask learning study, we compared GlassNet (a multitask model) against singletask models using random forests and XGBoost, both excellent algorithms for medium-sized datasets (less than 100,000 examples). Through extensive hyperparameter tuning, we found that no single paradigm consistently outperforms the other. Our results suggest that combining singletask and multitask strategies provides the best approach for modeling diverse glass properties. In our GFA prediction study, we analyzed a labeled dataset of over 50,000 examples, framing the problem as binary classification: will a given composition form a glass or not? This remains one of glass science's most difficult modeling challenges. We achieved 82% accuracy and an 88% F1-score. While not exceptional, this model is practical and provides a foundation for future research. The methodologies presented here also offer valuable insights for researchers pursuing inverse design of glass materials.

Keywords: property prediction, machine learning, glass forming ability

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Machine Learning potentials for Amorphous Solid Electrolytes in Sodium All-Solid-State Batteries: investigating the Mixed Glass Former Effect

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All-solid-state sodium batteries (ASSSBs) are promising candidates for large-scale energy storage. Compared to conventional lithium-based liquid electrolytes, sodium solid-state electrolytes (SSEs) exhibit high energy density, resistance to dendrite formation, and rely on the more abundant and inexpensive sodium. Among them, sodium thiophosphate (NaPS) glasses stand out for their remarkable ionic conductivity. Experimental studies have shown that doping with silicon (NaPSiS) and with oxygen (NaPSO) can further enhance electrochemical stability. However, the relationship between the composition, structure, and properties of sodium glassy solid electrolytes remains poorly understood. Molecular Dynamics (MD) simulations are powerful tools to investigate these systems, yet they are hindered by the lack of classical interatomic potentials, while the high computational cost of ab initio methods limits their feasibility to small systems. Machine Learning techniques, such as the MACE framework, offer an accurate alternative for developing interatomic potentials.
In this work, we developed Machine Learning Interatomic Potentials (MLIPs) for NaPSiS compositions to investigate the Mixed Glass Former Effect. The studied systems follow the formula y Na_2S + (1–y)(x SiS_2 + (1–x) PS5/2) with x = 0.5 or 0.67 and y ranging from 0.1 to 0.9, for which experimental data are available. We compared structural features, sodium diffusion, mechanical properties, and NMR spectra obtained using both foundation models (MP0 and MATPES) and fine-tuned models. This analysis also highlights which structural motifs promote or hinder sodium ion mobility, providing insight into the composition–structure–conductivity relationship in sodium-based solid electrolytes.

Keywords: machine learning, MACE, glassy solid electrolytes

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Machine-learning-driven advances in modelling amorphous materials

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Machine-learning-based interatomic potentials (MLIPs) are now becoming mainstream simulation tools in chemistry and materials science. In this presentation, I will highlight some recent advances in the MLIP-driven modelling and understanding of amorphous solids. These studies range from fundamental research questions – such as the atomic structure of amorphous elements – to device-scale simulations of phase-change memory materials which encode digital "ones" and "zeroes" in data-storage devices. I will then discuss future perspectives for MLIP methodology, including automation (1), and the role that these approaches might play in the computational "design" of amorphous materials with target properties (2).
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Keywords: machine learning, ML interatomic potential models, molecular dynamics

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Atomistic Modeling of Alteration Phenomena at the Surface of Silicate Glasses

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This work presents an atomic-scale study of the aqueous alteration of sodosilicate glasses performed using reactive molecular dynamics simulations. We tested several approaches to set up a realistic modeling of the glass/water interface. The analyses carried out revealed the first hydration mechanisms resulting in the formation of silanol (Si-O-H) groups. We were able to identify certain factors that appear to influence the kinetics of the alteration mechanisms. These results pave the way for rational optimization of the durability of functional glasses.

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A Methodological Review of Techniques for Constructing Multi-Phase Glass Models using Molecular Dynamics.

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Multi-phase glasses are well known in industry and concern glass-ceramics (applications include cookware, dental implants, etc.), porous glasses (applications include ion exchange, membrane technology, etc.), optical glasses (applications include lenses and fibers) (1). These wide uses stem from their high thermal shock resistance and excellent chemical durability. One class of oxide glasses where crystalline and/or amorphous precipitates can form is sodium-borosilicate based glasses. These secondary phases play a crucial role in altering the physical, mechanical and fracture properties in comparison to the parent (as formed) glasses. Nonetheless, the specific mechanisms by which the two phases influence mechanical properties at the atomic scale remain poorly understood. Moreover, the interface structures, crystalline-amorphous or amorphous-amorphous, do play an important role on the mechanical properties (2). Experimentally it is hard to investigate how small scale phase separation scales up to influence the overall mechanical properties. Molecular Dynamics (MD) simulations have the potential to provide a wealth of information concerning this issue. Conversely, the formation of the precipitates is not compatible with temporal constraints; thus, they must be inserted by hand. Literature exemplifies several techniques to form phase separated MD simulation boxes, including atom swapping techniques (2), "dig-insert" (3), and "cut-combine" (3). The poster presentation herein will summarize the current literature on how to invoke phase separation in MD simulation boxes. (1) Feng et al. Corros. Mater. Degrad. 2021, 2(3), 412–446; https://doi.org/10.3390/cmd2030022 (2) Feng, W. Stress Corrosion Cracking of Sodium Borosilicate Amorphous Phase Separated Glasses. PhD thesis, Université Paris-Saclay, 2022. (3) Jan, A. Impact des effets balistiques sur les propriétés de la couche de gel des verres nucléaires simplifiés: une approche de simulation Monte Carlo. PhD thesis, Université de Montpellier, 2020. (4) Deng, B. & Harris, J. T. A novel approach to generate glass-ceramics samples for molecular dynamics simulations. Comput. Mater. Sci., 186:110008, 2021

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A combined experimental and computational investigation to understand the effect of MgO on the structure-property relationships in soda lime silica glass

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The influence of MgO on the structural, mechanical, and thermal properties of soda–lime–silica (SLS) glass was investigated through a combined molecular dynamics (MD) and experimental approach. Ten glass compositions were designed to isolate the effect of MgO substitution across three series: NM-x (Na_2O replaced by MgO), CM-x (CaO replaced by MgO), and Mg-x (simultaneous substitution of SiO_2, Al_2O_3, Na_2O, and CaO by MgO), along with a baseline glass without MgO. Two classical interatomic potentials were assessed to evaluate the sensitivity of Mg coordination in different potentials. Structural analysis using MD, supported by ^{29}Si, ^{27}Al, and ^{23}Na MAS NMR and Raman spectroscopy, revealed that Mg exhibits mixed four- to sixfold coordination, with an average coordination number near five. The coexistence of Na^+ and Ca^{2+} was found to critically influence charge compensation. Substituting Na_2O with MgO (NM-x) increases network connectivity and oxygen packing due to Mg's higher field strength and partial network-forming character, resulting in higher elastic moduli, increased glass transition temperature (T_g), and reduced thermal expansion. Replacing CaO with MgO (CM-x) produces similar but less pronounced effects, whereas simultaneous multi-oxide substitution (Mg-x) decreases connectivity and leads to denser but less polymerized structures, and shows increase in elastic properties. Quantitative structure–property relationships (QSPR) derived from MD descriptors accurately capture these trends, linking changes in coordination environments, Qn species, and ring statistics to macroscopic properties. Overall, the results demonstrate that Mg plays a composition-dependent role in SLS glasses, governed by its dual structural character and by the interplay of Na^+–Ca^{2+} charge compensation, and that validated MD simulations can reliably predict structure–property relationships in complex multicomponent glasses.

Keywords: molecular dynamics, simulation, structure, nmr, raman

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Modelling and Simulation to Address Unique Industrial Challenges and Unconventional Applications of Glass

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You may have heard the saying, "All models are wrong, but some models are useful." In our experience, even simplified or unconventional models can guide meaningful decisions—especially when grounded in deep material expertise. This talk presents a perspective shaped not by access to the latest simulation platforms, but by a strong understanding of glass and a focus on the heart of the problem. At Glass Technology Services, we apply finite element analysis to address complex commercial challenges involving glass. A fundamental understanding of the material allows us to focus on targeted modelling that helps customers and collaborators understand specific behaviours. Past examples include stress accumulation during laser welding of glass to dissimilar substrates, the behaviour of glass-metal seals under high pressure, and the performance of highly tempered glass in demanding environments. These studies have informed design decisions, supported product development, and helped mitigate risks in real-world applications. We'll also explore more recent work modelling structures formed by breakage forces and surface texture to create functional cutting edges in glass. These geometries, shaped by the material's intrinsic fracture behaviour, suggest new possibilities for design driven by the properties of glass itself—rather than imposed constraints. In specific applications, working with the natural behaviour of glass can offer practical advantages, such as reducing the need for post-processing and helping to preserve the material's inherent strength. Thermomechanical modelling has also been applied creatively. In the Innovate UK-funded Ultraweld project, we simulated changes in fictive temperature to investigate stress development during ultra-fast laser welding. In other cases, manually constructed thermal gradients were used to estimate reactive stresses, which then served as boundary conditions in simplified models to explore the effects of thermal toughening. This presentation will highlight how a deep understanding of glass enables focused, effective modelling—even when the problem is unconventional. This session will demonstrate how focusing on the unique behaviours of glass can lead to more suitable and informative models—helping us address complex challenges by working with the material rather than against it.

Keywords: Finite element analysis, Fracture behaviour, Thermomechanical simulation, Material led design, Stress analysis, Laser welding

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Atomic-scale structure, V-coordination disorder and Na-ion transport pathways in Na–V–P–O glasses for cathode materials

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Na-V-P-O glasses and glass-ceramics are promising sodium-ion battery cathode materials, where charge storage and transport depend on structural disorder, variable V oxidation states and the mobility of Na ions. Yet the combined influence of V local environments, access to multiple oxidation states and the balance of bridging versus non-bridging oxygens on Na-ion transport has remained elusive.

We leverage structural, bonding and dynamical analysis using first-principles molecular dynamics and refined databases used for machine-learning–accelerated simulations to evaluate how mixed V valence, coordination disorder and network connectivity govern Na mobility and underlying conduction mechanisms (1-3). Our results show that V centres span several oxidation states, each linked to broad coordination motifs within the phosphate–vanadate network. These motifs shape the formation, connectivity and stability of regions that support or
limit Na migration.

Large-scale simulations reveal spatially heterogeneous transport, with Na pathways emerging from distinct network arrangements influenced by local V valence and coordination. By connecting chemical-bonding features, structural motifs and transport behaviour, this work establishes a quantitative framework for tailoring Na-V-P-O glasses for improved cathode performance.

(1) Wendji et al. Quantitative assessment of the structure and bonding properties of 50VxOy-50P2O5

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(2) Wendji et al. Enhanced structural description of sodium vanadium phosphate glasses: A combined
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applications, Chem. Commun. 61, 10993 (2025).

Keywords: Glasses, Molecular Dynamics, Na, ions, Vanadium, Battery, Cathode Materials, Machine Learning

Insights into the chemical bonding, electronic structure and local environments of Na-V-P-O glasses for cathode materials by first-principles and machine learning simulations

Antonio Familiari * [1,2,3], Marco Bertani [3], Steve-Dave Wansi Wendji [1,2,4], Remi Piotrowski [5], Jean Godet [5], Gaëlle Delaizir [5], Alfonso Pedone [3], Guido Ori [1]

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\\ Understanding charge storage in Na-V-P-O glasses requires a clear picture of V oxidation states, bonding patterns and the electronic structure that defines their chemical-physical properties. We combine first-principles molecular dynamics, machine-learning accelerated simulations and detailed electronic-structure analysis to examine how local environments in the glass differ from those in crystalline NaVPO phases. \\ \\ Wannier-function based bonding analysis reveals distinct signatures of V–O interactions, including the presence and strength of single, double/vanadyl-type bonds across the distribution of V polyhedra. These bonding motifs track closely with the oxidation state of V, which we assess through local magnetic moments and and charge partitioning trends. Comparison with crystalline NaVPO references highlights how disorder broadens the range of accessible valence states and stabilises broadened bonding fingerprints. \\ \\ The combined structural and electronic descriptors show how mixed valence, variable coordination and the spread of V-O bond orders shape the glass network and influence the availability of redox-active sites. This framework clarifies the link between bonding chemistry and electrochemical function in Na–V–P–O glass cathodes and demonstrates the value of integrating Wannier analysis, local magnetism and machine-learning tools to characterise disordered transition-metal glassy networks. \\ \\ (1) Wendji et al. Quantitative assessment of the structure and bonding properties of 50VxOy-50P2O5 glass by classical and Born–Oppenheimer

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Learning, Vanadium

Bimodal or Continuous? Unifying the Magnesium Coordination Model in Diopside Glass Using Ab Initio Molecular Dynamics

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The coordination environment of magnesium (Mg) in silicate glasses remains debated due to inconsistencies in interpreting NMR, diffraction, and simulation results. This study revisits the 25Mg NMR spectra of diopside (CaMgSi2O6) glass, comparing data collected at 14.1 T (1) with published results at 35.2 T (2) to assess how magnetic field strength influences the interpretation of 25Mg NMR data in terms of the Mg local environments. Moderate-field spectra suffer from severe quadrupolar broadening, while ultrahigh-field data have been interpreted as evidence for a bimodal distribution corresponding to four- and six-coordinated Mg. However, the possibility of a continuous distribution, including five-coordinated species, cannot be excluded.

We use simulations parameterized by $\Delta = \sigma$ / (δ1cs - δ2cs) to determine the limits under which bimodal distributions can be identified at different fields. Here, σ denotes the width of the distribution of quadrupolar coupling constants (experimentally accessible via NMR lineshape analyses) and δ1cs - δ2cs is the chemical shift difference between distinct Mg sites, hypothesized to reflect four- and six-coordinate Mg species. The results show that ultrahigh-field NMR greatly improves the ability of detecting a bimodal Mg coordination number distribution, by reducing the effect quadrupolar broadening on the spectra. Yet, the absence of definitive reference data for 25Mg chemical shifts in 4-, 5-, and 6-coordination makes unambiguous spectral assignments difficult.

To address this issue, *ab initio* molecular dynamics (AIMD) simulations were performed for 33 distinct local Mg environments in diopside glass, followed by CASTEP 25Mg chemical shift calculations. The results support a continuous distribution of Mg–O bond lengths between 2.0 and 2.5 Å. The AIMD output reveals Mg in four- (43%), five-(45%), and six-coordination (12%). producing an average Mg coordination number of 4.7±0.1. This result compares to previous pair distribution function (PDF) analyses yielding = 4.4 (3). Based on the AIMD study, a 25Mg chemical shift scale as a function of mean Mg–O distance is established, though no clear correlation with coordination number is found. These findings confirm the necessity of ultrahigh-field NMR for the structural interpretation of 25Mg spectra and highlight the remaining challenges in quantifying Mg speciations in silicate glasses.

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Keywords: 25Mg solid state NMR, diopside glass, Mg, coordination, ab initio simulations

Elastic Properties of Sodium Silicate Glasses: Insights from Brillouin Light Scattering, Classical MD, and XGBoost Prediction

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Predicting the nonlinear elastic response of sodium silicate glasses remains a significant challenge due to the interplay between composition, temperature, and atomic structure (1,2). To address this, we present a unified simulation–machine learning framework. \\ We integrate classical molecular dynamics (MD) using the SHIK potential with Brillouin light scattering (BLS) spectroscopy. Comparative analysis shows the SHIK potential (1) captures the nonlinear trend in the longitudinal elastic constant C_{11} with Na2O content, notably an initial decrease followed by an increase above $\sim$ 15 mol

Keywords: Sodium silicate glasses, Elastic properties, Brillouin light scattering, Molecular dynamics, Machine, learning potentials, XGBoost, Nonlinear elasticity, Structure–property relationships, Na_2O composition, Amorphous materials

*Speaker

Next Generation Glass with Glass Futures: Building a Digital Furnace

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Glass Futures is a not-for-profit research organisation, built by its members from across the global glass industry with the overarching goal of decarbonisation of the glass-making process and its upstream and downstream activities. Based out of the Glass Futures Centre of Excellence in St Helens, UK: the remit of the organisation is to enable its members from across the glass supply chain and beyond to collaborate in areas which affect all parties. A key shift in focus of the business has been towards digitization of its assets to enable members to run digital experiments that yield real results.

At the heart of the Glass Futures Centre of Excellence is a 30 tonnes/day pilot-scale glass furnace, capable of producing either flat or formed-glass. The facility has been designed to enable the glass industry to develop and trial new technologies at an industrially relevant scale, without risk to their commercial manufacturing assets. The facility is controlled through a single, central control system that allows complete oversight and control of the facility from one location.

In this paper, the challenges and triumphs of building a digital furnace and full-plant digital twin will be discussed. The journey of classifying, deploying and developing various artificial intelligence and machine learning technologies to allow for greater insights into a fully connected glass plant will be explained. Finally, the steps taken to develop and validate bespoke furnace models that have allowed the physical furnace to be brought into the digital age – allowing experimentation without emissions – will be highlighted.

Keywords: AI, Machine Learning, Digital twin

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Surface Alteration of Silicate Glasses via Atomistic Modeling

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Understanding the mechanisms of glass alteration and corrosion at an atomic level remains a fundamental scientific and industrial challenge. Molecular dynamics (MD) simulations are essential for studying the underlying processes at the atomic scale during initial water-glass interactions. Using realistic dry surface models, we conducted classical MD simulations in order to study the formation and the characteristics of the glass-water interface for various silicate compositions. Our findings demonstrate that both the nature of the modifier (alkali and alkaline earth) and the overall network connectivity dictate the kinetics of ion-exchange and the final structural properties of the hydrated interface layer.

Keywords: silicate, atomistic modelling, alteration, glass, water interface

*Speaker

EXAFS-constrained Reverse Monte Carlo modeling of amorphous structures: the case of GeO_2 glass under compression

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Among experimental structure characterization techniques, X-ray absorption is particularly useful for highly disordered materials (e.g. glasses, liquids) because of its sensitivity to local ordering around the photoabsorber atoms. It is a complementary technique to X-ray or neutron scattering experiments, which, for such materials, primarily provide information on the distribution of interatomic distances in both the short- and medium-range. For experiments under extreme pressure and temperature conditions, it has the additional advantage of selectively probing the sample, with minimal contribution from the sample environment, apart from attenuation. \\ Through Reverse Monte Carlo it is possible to combine both XAFS and scattering experimental signals to obtain realistic atomic models, which represent short- and medium-range order equally well and provide a wide range of structural descriptors (e.g. pair and bond angle distribution, atom ring analysis, coordination etc.). \\ \\ Here we report recent developments of the RMC-GnXAS code for X-ray Absorption Spectroscopy (EXAFS) analysis (1). A key enhancement is the direct use of the total neutron and X-ray scattering structure factor $S(Q)$ as a constraint. This eliminates the need for partial pair distribution functions for multi-atomic systems, which cannot be easily derived experimentally, especially for studies under extreme conditions such as at high pressure. Additionally, coordination number constraints were incorporated to improve model accuracy when dealing with glasses. These features were validated by analyzing the structure of GeO_2 glass at ambient conditions and subsequently used for analysing data of GeO_2 subject to high pressure. \\ \\ The RMC refinement was constrained by experimental EXAFS data, neutron scattering structure factor $S(Q)$ data from literature (2,3), and atomic coordination numbers. The resulting model is compared with available studies (4,5,6). \\ \\ (1) Iesari, F., et al., Springer Proc. Phys. 204, 29–48 (2018). \\ (2) Salmon, P. S., et al., J. Phys.: Condens. Matter 19, 41 (2007). \\ (3) Salmon, P. S., et al., J. Phys.: Condens. Matter 24, 41 (2012). \\ (4) Peralta, J., et al., J. Phys.: Condens. Matter 20, 14 (2008). \\ (5) Anh, N. M., et al., Computational Materials Science 177, 10 (2020). \\ (6) Matsutani, K., et al., J. Chem. Phys. 161, 20 (2024).

Keywords: Reverse Monte Carlo, X, ray absorption, EXAFS, oxide glasses, disordered materials

*Speaker

characterization, neutron scattering

Tuning the electronic properties of chalcogenide glasses with non-equilibrium doping: a pathway to carrier-type reversal

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The class of chalcogenide glasses is of significant technological relevance due to their utilization in various solid-state devices, such as phase-change memory, thin-film transistors, light-emitting diodes, neuromorphic information processing, and analog in-memory computing chips. Intrinsically, chalcogenide glasses exhibit a p-type semiconducting behaviour, and the effort to obtain n-type conductivity corresponds to an arduous task. Carrier-type reversal to enable the formation of semiconductor p-n junctions is a necessary condition for the development of future diverse electronic and optical applications. In this study, the target is to achieve an understanding, at the atomistic level, of the non-equilibrium doping mechanisms in glassy chalcogenide materials in order to rationalize the modifications in the local atomic structure and electronic properties of the glassy host. Non-equilibrium doping of Bi in an amorphous GeTe4 structure was modelled by carrying out *ab initio* molecular-dynamics simulations, in which the kinetic energy from a highly energetic Bi atom is suddenly transferred to a group of atoms that happen to suffer a collision within the amorphous network. A stochastic-boundary-conditions approach, with the application of a Langevin thermostat, was implemented to model accurately the non-equilibrium dynamics of the events. The final atomic geometry of the doped glass model was optimized, and the electronic structure was calculated by using a hybrid density-functional theory calculation. We illustrate that the non-equilibrium doping events result in new electronic states lying at the bottom of the conduction band, which can serve as charge-hopping "stations", allowing the charges to move more freely through the material. The results highlight a decrease in the degree of localization of every electronic state near the tails of both band edges, indicating an enhanced carrier mobility. An increase of the defective octahedral environments of Ge atoms is associated with the new defect electronic states appearing in the band gap. Similarly, Bi atoms have adopted local atomic environments with higher coordination. Overall, we demonstrate that Bi non-equilibrium doping in amorphous chalcogenides can potentially lead to carrier-type reversal, and we unravel the type of defects responsible for the impurity states in the band gap of the doped chalcogenide glass model.

Keywords: glassy chalcogenides, nonequilibrium doping, bismuth, molecular dynamics simulations, defects, hybrid functionals

*Speaker

Bridging Scales and Disciplines: Machine Learning for Understanding and Designing Glassy Materials

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The field of glass science is undergoing a transformation driven by artificial intelligence and machine learning. This talk will present a comprehensive journey in developing AI-driven approaches for understanding, predicting, and designing glassy materials, spanning from domain-specific language models to physics-informed simulations and autonomous discovery systems. The presentation will begin by introducing a suite of computational tools that form the foundation of AI-enabled glass research: MatSciBERT, a materials-aware language model; LLaMat, a large language model for materials science; PyGGi, a computational framework for glass property prediction; and MatSKRAFT, one of the largest databases of glasses. Following this, we will discuss how the integration of molecular dynamics simulations with machine learning can be used to bridge the gap between atomistic mechanisms and macroscopic properties in glasses. Applications ranging from property prediction in multicomponent oxide glasses to understanding irradiation effects in nuclear waste glasses, and from automated literature mining to structure-property relationships will be showcased to demonstrate how data-driven approaches complement traditional computational methods. Building on these foundations, the talk will present a vision for the future of computational glass science, where large language models work in concert with agentic AI systems to enable truly autonomous materials discovery. The presentation will conclude by highlighting both the transformative opportunities and the fundamental challenges that must be addressed to realize the full potential of AI in accelerating the discovery and design of next-generation glassy materials.

*Speaker

Multiscale computational simulation of quantum dots doped glasses

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Quantum dot (QD)-in-glasses have attracted enormous attention for their potential application in lighting, lasers and solar cells. Performance of this material is still below the expectations since the poor emissive properties seriously hinder their commercial applications. We developed a multiscale computational methodology by combining classical molecular dynamics (MD), *ab* initio MD, time-dependent density functional theory (TDDFT) and nonadiabatic MD (NAMD) to investigate the impact of QD/glass interface on the charge carrier dynamics of quantum dots doped glasses. The atomic and electronic structure of CdSe, PbS and perovskite QDs doped glasses have been investigated. Results of this study draw a complete picture of the charge recombination dynamics of QDs in glasses and promote mutual understanding that would benefit the development of functional glasses containing QDs.

Keywords: molecular dynamics, density functional theory, quantum dot, glasses

*Speaker

From Structure to Conductivity: Probing Na Diffusion in Amorphous Solid Electrolytes with ML Potentials

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All-solid-state sodium batteries are emerging as a promising technology for grid-scale energy storage due to their safety, low-cost processability, electrochemical stability, and the abundance of raw materials. To become commercially viable, a solid Na electrolyte must be developed that combines high ionic conductivity, electrochemical stability, resistance to dendrite growth, and cost-effective production. Among the candidate materials, amorphous Na thiophosphate glasses are particularly promising because their ionic conductivity approaches that of liquid electrolytes. However, these materials suffer from atmospheric reactivity. To overcome this limitation, partial substitution of sulfur with oxygen has been proposed to preserve the conductivity of sulfur-based glasses while gaining the stability typical of oxides.
These systems have been extensively studied experimentally using conductivity measurements, NMR, IR, and Raman spectroscopy, but they still lack a theoretical framework capable of correlating atomic structure with ionic conductivity. To address this, molecular dynamics (MD) offers a powerful approach. We employed ab-initio MD and developed a Machine Learning Interatomic Potential (MLIP) using the MACE framework, exploiting a fine-tuning approach to refine a pretrained model for accurate simulations of the studied systems.
Ab-initio MD was used to validate the MLIP and analyze the short-range order of these glasses, correlating the Na environment with NMR data. ML-MD enabled simulations of larger structures and longer timescales, allowing the investigation of medium-range order and its effect on Na diffusion, identifying structural motifs that hinder or promote ionic conduction. This approach provides a pathway to a deeper understanding of the structural mechanisms governing ionic conduction in solid electrolytes and may guide the design of new compositions with tailored properties.

Keywords: Na amorphous electrolytes, Molecular Dynamics, Machine Learning Interatomic Potentials, All, solid, state batteries

*Speaker

Atomic scale inspired model for shear banding in silicate glasses

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This study investigates the atomic-scale origin and continuum description of shear band formation in silicate glasses. While ductile behavior in small systems can be captured by local constitutive models, larger-scale simulations reveal pronounced strain localization consistent with experimental observations. Using molecular dynamics on a large sample containing 400k atoms, we applied athermal shear deformation. The stress–strain response exhibited initial quasi-elastic behavior, followed by peak softening and eventual plateauing. Reloading confirmed irreversible structural changes and memory effects. Energy partitioning into elastic and plastic contributions revealed that localized plasticity dominates once shear bands emerge. Coarse-grained analyses showed a well-defined shear band with enhanced densification, stiffening, and reduced local strength, consistent with experiments and prior simulations. Importantly, softening was linked not to material damage but to structural reorganization within the band. To capture this collective behavior, we extended the plastic energy density formulation with a gradient term analogous to phase-field fracture models, identifying a characteristic length scale. However, unlike classical gradient plasticity predictions, shear band widening remained limited, suggesting the need for refined incremental non-local models. These findings highlight the multiscale interplay between atomic rearrangements and continuum descriptions in shear localization.

Keywords: silicate, shear band, molecular dynamics, gradient plasticity

*Speaker

Developing Linear Machine Learning Potentials for Multicomponent Glass Systems

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\\ Understanding the atomistic mechanisms behind the complex behaviors of industrial glasses is crucial for designing advanced glass products. These mechanisms are thought to originate from atomistic structures, yet modeling glass structures remains a significant challenge even for simple glass systems. Industrial glasses are typically multicomponent, composed of various oxides, making structural analysis almost impossible using experimental approaches alone. Therefore, combining experimental data with atomistic simulations is regarded as essential for modeling multicomponent glass structures. \\ \\ A major challenge in this context is the development of accurate and efficient interatomic potentials. Among machine learning frameworks for interatomic potential modeling, we focused on linear models for their interpretability and computational efficiency. Using the PolyMLP framework, we systematically explored combinations of descriptor and functional forms for the atomic energy models. PolyMLP unifies concepts from established linear approaches such as EAM and SNAP and aligns with ACE. To represent local atomic environments, we employed O(3) invariants, mathematical quantities preserving rotational and reflectional symmetry, ensuring descriptors represent essential atomic geometry consistently regardless of coordinate system. Linear ridge regression was applied for parameter fitting, and hyperparameters were optimized through grid search. Training datasets were generated by random perturbations to elemental through quaternary crystal prototypes from ICSD and AFLOW. \\ \\ We found that achieving both high computational speed and high predictive accuracy within a linear model remains challenging. No single best model emerged; instead, a clear trade-off between speed and accuracy was evident across hyperparameter choices. Furthermore, while crystal-based training has been considered sufficient for metallic systems up to ternary alloys, it appears sparse for ternary oxide glasses, limiting predictive performance for silicate glasses. This observation underscores the need for more sophisticated data generation strategies tailored to multicomponent oxide glasses. \\ \\ We aim to examine how strategies for generating training data influence the trade-off. Predictive power will be assessed by comparing calculated properties with experimental measurements. These efforts may offer insights into designing reliable simulation strategies for multicomponent glass systems.

Keywords: Atomistic simulation, Machine learning potential, Interatomic potential

*Speaker

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Improving predictive modeling in Glass Science through intelligent subsampling

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In recent years, the rapid rise of machine learning has profoundly transformed glass science, where these techniques have long been used to build empirical property–composition models. Such models have proven successful in predicting various physical and chemical properties, and their applicability has even extended beyond glass materials. However, even in an era dominated by advanced algorithms, analyzing large datasets continues to present methodological challenges. "Brute-force" approaches-processing entire datasets without discrimination-often lead to inefficiencies and limited interpretability. In contrast, intelligent subsampling, which consists in selecting a representative subset of data, offers a more efficient and insightful alternative.
At CEA, this topic has been a central focus of research for nearly a decade, particularly for predicting glass melt viscosity. This property remains especially challenging to model because of its huge variability-spanning up to six or seven orders of magnitude-over temperature and composition scales. Although modern machine learning methods have demonstrated increasing predictive power by leveraging extensive glass databases, viscosity predictions can still be uncertain when only sparse data are available near the composition of interest.
By combining statistical design of experiments, multilinear regression, and modern machine learning algorithms, this work conducted in collaboration with EDF and Orano illustrates how integrating intelligent subsampling with both classical and contemporary modeling approaches leads to robust and efficient predictive models.

Keywords: Glass Melt Viscosity, Machine Learning, Prediction, Database

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Advanced Modelling for Regenerator Design Optimization: Driving Energy Efficiency in Glassmaking

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[2] Glass Service – Czech Republic

Reducing the carbon footprint of the inherently energy-intensive glassmaking process is a major challenge. Achieving this goal will require a gradual technological transition, starting with incremental improvements to existing solutions and progressing toward groundbreaking innovations in the long term. \\ When it comes to mature technologies, regenerative furnaces have already delivered substantial energy savings in the glass industry over the last decades. Despite this progress, ongoing efforts by SEFPRO and Glass Service indicate that further optimization of regenerators is still possible. An optimal regenerator design should strike the best balance between energy efficiency (and thus CO_2 reduction), maintenance requirements, lifetime, and, of course, CAPEX. \\ \\ Recent enhancements to Darcy porous wall models for standard checker bricks and Cruciforms® geometries now enable more accurate numerical simulations to address regenerator optimization. This advanced modeling approach can simultaneously define the most efficient and durable packing configuration and determine the most appropriate regenerator chamber size, while respecting typical space and CAPEX constraints. It also allows seamless integration of regenerators with the furnace in a comprehensive and reliable simulation. \\ The first part of the presentation will cover the methodology used to build an extended library of Darcy porous wall models. Then, we will present a concrete regenerator optimization case study for a cross-fired furnace. Specifically, we will show how chamber dimensions can be reduced without compromising regenerator efficiency, thanks to careful engineering of packing configurations tailored to the specific requirements and conditions at each furnace port.

Keywords: regenerator, fuel consumption, CO2 emissions, CAPEX, Cruciforms

*Speaker
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Decoding Medium-Range Order in Sodium Oxysulfide Glasses: Dataset Sensitivity of Machine Learning Interatomic Potentials

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Understanding and accurately reproducing the medium-range order (MRO) of multicomponent glasses remains one of the key challenges in computational glass science. In this contribution, we investigate the ability of machine learning interatomic potentials (MLIPs) to describe the structural complexity of sodium oxysulfide glasses, a promising class of solid electrolytes for sodium-based batteries. Using MACE-, DeePMD-, and GRACE-type MLIPs, we assess how the choice and composition of the training dataset influence the prediction of structural motifs such as edge- and corner-sharing tetrahedra, the distribution of bridging versus non-bridging oxygen and sulfur atoms, and the evolution of density and coordination networks across the Na–P–S–O compositional space.(1) We show that even when MLIPs achieve low training errors and stable molecular dynamics, subtle biases in the dataset-such as missing undercoordinated configurations or overrepresented crystalline motifs-can lead to pronounced artifacts in the simulated MRO. Fine-tuning strategies on composition-specific datasets mitigate these issues, but the accurate reproduction of disproportionation reactions and network rearrangements remains elusive. This work highlights the fundamental role of dataset curation and representation in developing transferable MLIPs for disordered materials and discusses possible routes to systematically improve the description of MRO through active learning and structurally informed sampling.

References

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Keywords: Machine Learning Potentials, MD simulations, glassy electrolytes

*Speaker

Amorphous-Amorphous Transitions in Compressed Glasses

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Pressure-induced transformations from low- to high-density silica glass are investigated using percolation theory (1). Molecular dynamics simulations of SiO_2 glass models with up to 1,000,000 atoms under pressure reveal the emergence of percolating clusters with increasing SiO_z coordination number z. The criticality of the transitions is demonstrated, enabling the extraction of the critical exponents, including the fractal dimension of the percolating clusters at the critical pressures (2). Exponents for the tetrahedral percolating cluster (SiO_4–SiO_4) align with standard percolation expectations, whereas those for transitions involving higher-coordination polyhedra suggest a new universality class, more consistent with correlated percolation. The critical pressures are related to density and bulk-modulus anomalies, demonstrating the physical relevance of the approach. Percolation theory thus provides a long-range structural indicator for analysing amorphous systems and offers a theoretical framework for studying polyamorphism and amorphous–amorphous phase transformations.

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*Speaker

Insights into the Structure-Property Relationships and Conduction Mechanisms in Glassy Sulfide Electrolytes

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Understanding the relationship between atomic structure and ion transport is essential for advancing glassy sulfide electrolytes as next-generation solid-state battery materials. Building upon a recently developed Born–Mayer classical force field tailored for crystalline and glassy chalcogenides, this work investigates how local structural motifs, network connectivity, and modifier concentration govern mechanical stability and ionic conductivity in sulfide glasses.

Classical molecular dynamics simulations are employed to probe the influence of composition and temperature on the microscopic conduction mechanisms, including ion migration pathways and their correlation with network depolymerization and Q^n-species distributions. Preliminary analyses reveal trends linking structural disorder to enhanced mobility and mechanical response, offering an atomistic perspective consistent with experimental observations.

This study provides a unified framework for exploring the interplay between structure, dynamics, and transport in sulfide glass electrolytes, paving the way for rational design of solid-state battery materials with optimized performance and stability. **Keywords:** glass, electrolyte,

conduction, classical, molecular, dynamic

*Speaker

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Establishment of Generalized Empirical Force Fields for Sulfide Glasses and Crystals Used as Superionic Electrolytes in All-Solid-State Batteries

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A generalized Born–Mayer empirical force field has been developed for both crystalline and glassy chalcogenide systems, encompassing sulfide materials containing network formers (e.g., SiS_2, GeS_2) and alkali or alkaline-earth modifiers (e.g., Li_2S, MgS, CaS). The model integrates fractional charges, short-range Born–Mayer repulsion, long-range dispersion, and harmonic two- and three-body interactions to accurately describe the local structure and connectivity of bridging sulfur atoms between Group III–V polyhedra. Parameterization is achieved through a least-squares minimization against crystallographic data from crystalline phases, further refined by optimizing simulated scattering functions to match experimental X-ray and neutron data for glasses. The resulting force field reproduces key structural features of sulfide glasses, including network depolymerization, Q^n-species distributions, and ring disintegration. Moreover, simulations reveal consistent trends across unreported alkaline-earth thiosilicate and thiogermanate glasses, highlighting similar structural roles of Mg, Ca, and Ba to their alkali counterparts. This transferable and experimentally validated potential opens new perspectives for classical molecular dynamics studies of structural, mechanical, dynamic, and electrochemical properties of disordered sulfide electrolytes and their interfaces, directly relevant to the design of next-generation all-solid-state batteries. **Keywords:** Molecular, dynamic, electrolytes, classical, force, field

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Experimental and Theoretical Characterization of the Prototypical Na_2S–SiS_2 Electrolyte Glass: Conductivity Enhancement Is Driven by Network Depolymerization

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The structural, dynamic, and electrical properties of the Na_2S–SiS_2 glass system are investigated using first-principles molecular dynamics, X-ray scattering, and impedance spectroscopy. This sulfide electrolyte is a model candidate for all-solid-state batteries. Two compositions, Na_2S–SiS_2 and $2Na_2S$–SiS_2, were studied to examine the effect of alkali addition. The simulated structures, validated by excellent agreement with experimental data, reveal progressive network depolymerization described by the Q^n formalism. At high Na content, the glass consists mainly of isolated SiS_4^{4-} tetrahedra, with homopolar S–S and Si–Si defects also present. S–S bonds are associated with enhanced ionic mobility, while Si–Si linkages form $(Si_2S_6)^{6-}$ units. Conductivity follows Arrhenius behavior, with the $2Na_2S$–SiS_2 glass exhibiting 2.9×10^{-5} S·cm^{-1} at room temperature, comparable to thiogermanate analogs. These results highlight key structure–property relationships governing ion transport in sulfide glasses and support their potential for solid-state battery applications. **Keywords:** structure, property, solid, state, battery, electrical, properties, ab initio, molecular, dynamic

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Refractory corrosion – a problem that could be predicted?

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The corrosion of refractory materials is a critical aspect for the lifetime of a furnace operation. Whilst some parts of the furnace are almost untouched after stopping production, others are almost completely dissolved. It is therefore of the highest importance to identify the critical areas, use appropriate methods for protecting them, and monitor them during production.

Since AS Glass Service (GS) is now part of SEFPRO, cooperation on corrosion modelling has become much easier. GFM (software internally developed in GS for glass melting process simulations) provides the necessary boundary conditions for SEFPRO's corrosion model. The result of such cooperation is a corrosion profile in the examined area. After identifying the critical part in the furnace, different methods can be used to enhance the lifetime of the critical structure.

An example of such an approach will be demonstrated. The target of this cooperation is to prolong the lifetime of the glass furnace and thus help decrease the costs and increase the sustainability of production. **Keywords:** GFM, mathematical modeling, refractory corrosion, sustainability

*Speaker

Vitrification and structural analysis of vanadate glasses in MD simulations using ReaxFF potential

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Vanadium oxides are a very interesting group of materials due to the wide variety of their physical and chemical properties originating from the multiple existing valence states of vanadium. This in particular enables them to conduct electricity by polaron hopping, which can be greatly increased by thermal nanocrystallization of vanadate glasses. The phenomenon of increased conductivity in nanocrystalline vanadium oxide so far has not been explained quantitatively, though a critical role of glass-crystal boundaries is suspected. Accurate simulations of vanadate glasses using MD will be a step in that direction.

In this work, we used MD simulations to obtain vanadium oxide glass structures by simulating melt-quenching with ReaxFF reactive potential. This potential has previously been successfully used to simulate the catalytic properties of vanadium oxides, though to our knowledge, it has not yet been applied to vanadate glasses. We investigated the structure of glass and verified it against experimental data obtained by EXAFS and XRD by comparing radial distribution functions as well as bond lengths and angles in different coordination polyhedra. The RDFs show a very good agreement with experiments, and we successfully reproduced the bond length distribution seen in crystalline compounds containing vanadium. We studied the influence of the maximum temperature before quenching on the structure and showed that ReaxFF reproduces the phenomenon of temperature-induced reduction of vanadium.

These results pave the way for further MD study of vanadate glass-ceramics, which brings us closer to the goal of understanding the grain boundary region's role in polaronic conductivity.

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*Speaker
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How AI Transforms Visual Inspection in Glass Bottle Manufacturing

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Automated visual inspection has long been a key component of quality control in glass bottle production.

Traditionally based on deterministic rules and handcrafted image processing, these systems excelled at detecting well-defined defects but struggled with the natural variability inherent to glass materials.

Today, artificial intelligence is redefining this field. By learning directly from examples rather than relying on predefined rules, AI models demonstrate remarkable robustness to challenges such as reflections, color variations, bubbles, dust, and surface irregularities.

This presentation traces the evolution from classical machine vision to modern AI-driven inspection, highlighting how deep learning enables more reliable detection and classification of complex defects.

We will also explore the unique challenges posed by glass—its transparency, reflections, varying thickness, and engraved markings—and how tailored AI approaches can overcome these obstacles to achieve higher accuracy, consistency, and efficiency in quality inspection. **Keywords:**

Artificial Intelligence, Digitalisation, Deep Learning, Glass defect detection

*Speaker

Modeling the Structural and Vibrational Properties of $MgSiO_3$ by MD Simulations

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Density functional theory and classical molecular dynamics simulations are key tools for unveiling physical phenomena in materials science and for rapidly generating a plethora of data for machine learning approaches. In this work, we developed an effective two-body interaction potential to describe the orthoenstatite mineral ($MgSiO_3$). This specific silicate mineral was chosen because it is a important component of the Earth's mantle and lower crust, and understanding its properties is fundamental. The developed potential considers steric repulsion, Coulomb interactions resulting from charge transfer between ions, charge-induced dipole attractions due to the electronic polarizability of the ions and van der Waals attraction. The proposed potential was subsequently used to study structural and dynamical properties of $MgSiO_3$ as a function of temperature. Molecular Dynamics results for the neutron and X-ray scattering static structure factors of amorphous $MgSiO_3$ were obtained at the experimental density and compared with available experimental data, showing very good agreement. The phonon vibrational density of states was computed for both crystalline orthoenstatite and its amorphous state, and compared with Raman scattering measurements, which also confirmed the accuracy of the model.

Keywords: Enstatite, MgSiO3, molecular dynamics simulation

*Speaker

Molecular Dynamics Simulations of Sodium Borosilicate Glasses to Open Access Datasets

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Sodium borosilicate glasses have a number of applications in the world today (telescope mirrors, lighting, lab ware, kitchenware, electronics, etc.). Optimizing a wide range of physical, thermodynamic and mechanical properties is necessary to ensure their best performance in each use. However, literature focuses on a select number of compositions; making optimization of the glass as a whole unreachable. This is in part due to sample lost between different tests, multiple batches, expense of sample fabrication, etc. Molecular Dynamic simulations invoking complex interatomic empirical potentials aid in overcoming this drawback. These simulations provide a means to gather different structural, physical, thermodynamic and mechanical properties on the same glass sample. Additionally, multiple simulations can be setup to sample homogeneously large sections of the phase diagram.

MD simulations were carried out to model glasses of different chemical compositions $xSiO_2$–yB_2O_3–(1–x–y)Na_2O where x and y vary from 0 mol% to 100 mol% in 5 mol% increments and $x + y \geq 50$ %. These simulations revealed a wealth of data, including densities, elementary structural units present in the glass, enthalpies of mixing, elastic moduli, and Poisson's ratio, and were carried out using two different empirical potentials (1, 2) to understand the potential-dependent character of data. This presentation will focus on select physical, thermodynamic and mechanical properties presented in (3–5). Lastly, it will highlight the open access dataset produced during this work (4, 5), which could be used for the development of new potentials.

*Speaker

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Keywords: Molecular Dynamics Simulations, Sodium Borosilicate Glasses, Open Access Datasets

Atomic and Electronic Signatures of Alkali Modification in Silicate Glasses: Insights from Ab Initio Simulations

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Using *ab initio* molecular dynamics within the framework of density functional theory, we investigate the influence of alkali modifiers (Li, Na, and K) on the structure and electronic properties of binary silicate glasses. It is revealed that increasing cation size leads to progressive network depolymerization, characterized by a higher fraction of non-bridging oxygens, broader Si–O–Si angle distributions, and more open medium-range structures. The creation of non-bridging oxygens introduces localized O $2p$ states that shift the valence band upward, effectively narrowing the band gap and enhancing the polarizable, partially ionic character of the network. Vibrational spectra display systematic softening of low-frequency modes and shifts in Si–O stretching bands, consistent with reduced network rigidity and altered local bonding environments. These findings elucidate the atomic-scale mechanisms by which alkali modifiers govern the structural and electronic responses of silicate glasses.

Keywords: Silicate glasses, Alkali modifiers, Ab initio molecular dynamics, structure, electronic properties

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Topology-Based Structural Analysis of Medium-Range Order, Domain Formation, and Crystal-like Local Ordering Leading to Rapid Nanocrystallization in Oxyfluoride Glasses

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Understanding the mechanism of hierarchical structural ordering during glass formation is essential for elucidating the spontaneous nanocrystallization observed in oxyfluoride glasses. In this study, we investigated the structural evolution of BaF_2–ZnO–B_2O_3 oxyfluoride glass during cooling by combining classical molecular dynamics (MD) and machine-learning molecular dynamics (ML-MD) simulations. To capture the domain formation behavior unique to multi-anion systems, chromatic topological data analysis (chromatic TDA) was introduced, allowing the evolution of medium-range order to be quantified from a chemical-topological perspective. As the cooling rate decreased, long-lived topological rings in the Ba–F subnetwork became increasingly dominant, indicating enhanced topological ordering. Real-space analysis of the local composition variance,

Keywords: molecular dynamics simulation, nanodomain, topology, nucleation, chromatic DTA

*Speaker

Crystallization Pathways of Neutron-Irradiated Amorphous Quartz by Molecular Dynamics Simulation

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Neutron irradiation of alpha-quartz causes amorphization with a reduction in density. Experiments show that this densification saturates at elevated temperatures, a behavior known as the thermal healing effect, which implies recrystallization. However, the atomic mechanisms responsible for restoring long-range order remain unclear. Here, we simulate neutron-irradiated alpha-quartz and capture its crystallization transition at the atomic scale. Amorphous structures with 40-80% crystallinity are generated by irradiation simulations, and their recovery is examined using annealing and well-tempered metadynamics (WTMetaD). While annealing partially repairs local SiO4 defects, only WTMetaD reproduces nearly complete recrystallization. The analysis reveals that Si atoms migrate through void channels along the threefold helical axis, enabling occupation of crystalline sites and driving the thermal healing effect.

Keywords: Neutron irradiation, Molecular dynamics, Phase transition, Defect

*Speaker

First principles study of crystalline phases of glass network-forming elements

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Machine-learning potentials have been developed and applied very rapidly in all fields of materials science, including the glass community. Key gradients to develop good machine-learning potentials are high-quality training data by first principles calculations based on the density-functional theory. Choosing a good form of the exchange-correlation functional is crucial for generation of high-quality data. However, it has been very difficult especially for boron, one of the major network-forming elements. Previously, for crystalline phases of boron oxides, we tested three forms of exchange-correlation functions, CA-LDA, PBESOL-GGA, and PBE-GGA, which have been widely used for many materials; although PBESOL and PBE were demonstrated to be rather good to describe structural and energetic properties, respectively, none of them could reproduce structural and energetic properties simultaneously (1). In this study, we investigate the performance of r2SCAN (2), one of the meta-GGA functionals, in addition to LDA and GGA, for crystalline polymorphs of SiO_2, Al_2SiO_5, and B_2O_3. We demonstrate that r2SCAN can successfully describe both structural and energetic properties simultaneously for these polymorphs. Therefore r2SCAN is very promising to generate high-quality training data for machine-learning potentials for glasses.

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Keywords: Densty, functional theory, exchange, correlation functionals, crystalline phases of network, forming, element oxides

AI-Driven Optimization of Glass Production: Overcoming Industry Challenges with Celfos

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The glass industry operates in an increasingly complex environment, with rising demands for quality, energy efficiency, and cost optimization. Furnace operators play a critical role in navigating these challenges, yet they face an overwhelming volume of process variables and data points to analyze in real-time. This raises the following question: How can we provide operators with actionable insights, reducing guesswork and improving confidence?

Traditionally, furnace control systems have focused on stabilizing temperatures, yet temperature stability alone does not guarantee optimal glass quality. Aligning operational performance, reliability, and glass quality requires a deep understanding of the dynamic, time-transient behavior of glass furnaces. The challenge lies in the broad residence time distribution, influenced by multiple variables, and the difficulty of identifying key process parameters that impact glass quality. Moreover, conventional systems struggle to adapt to sensor deterioration or replacement, leading to data inconsistencies and reduced reliability.

This presentation introduces Celfos, an AI-powered system that enhances operational decision-making by linking process settings to glass quality. By combining advanced neural network models with time-transient CFD analysis (GTM-X), Celfos provides insights into complex furnace dynamics and delivers precise quality predictions.

Celfos combines historical furnace data and real-time process parameters with qualitative GTM-X models. It works for all common glass and furnace types and is control system independent. The neural network is trained to correlate these inputs with glass quality metrics, enabling predictive quality control and adaptive decision-making, even when sensors degrade or are replaced.

Celfos is a dynamic, adaptive system that brings the glass industry closer to a future of precision and efficiency, designed to support operator expertise. **Keywords:** Artificial Intelligence,

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Atomistic Mechanisms of Irreversible Transformations in Silica: From Shock-Induced Densification to Defect-Driven Amorphization

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The structural diversity of silica (SiO_2), from its crystalline polymorphs to its amorphous state, dictates its complex and often divergent behavior under extreme pressure. While this topic has been extensively studied in the past, atomistic mechanisms governing irreversible transformations remain debated. This work combines molecular dynamics (MD) simulations with experimental data to investigate these mechanisms in amorphous silica.

We model shock-compression of silica glass to ~ 36 GPa, replicating conditions of dynamic shock-recovery experiments. The simulations qualitatively reproduce the experimentally observed permanent densification. By analyzing simulated structures, we demonstrate that this densification arises from collapse of the medium-range order, primarily through a reduction in Si–O–Si bond angles and a shift to smaller ring sizes, while the network transforms into a heterogeneous mixture of four-fold coordinated domains and regions containing a significant fraction of five- and six-fold coordinated silicon. Analysis reveals that this densification is not uniform and leads to the emergence of a nanoscale polyamorphic structure, characterized by domains of a highly compacted network embedded within a matrix of less-densified material. This structural heterogeneity provides a more nuanced basis for interpreting the corresponding X-ray Diffraction and Raman Scattering data.

In a complementary study, we investigate transformations of α-quartz under quasi-static compression up to 100 GPa, through the coesite, stishovite and post-stishovite regimes. Our simulations suggest that the commonly observed "pressure-induced amorphization" does not look like an intrinsic failure of the crystal, but a kinetically driven process rooted in the frustrated phase transitions transitions. Transformation introduce almost unavoidable stacking faults and defects, as for example coesite structure is geometrically incommensurate with the parent quartz lattice. While an infinitesimally slow compression allows these defects to vanish during the subsequent transformations, a slow, quasi-static compression rate preserves these faults. Resulting structures consist of competing, misaligned domains separated by defect boundaries, which appear as disordered, amorphous-like state in simulated XRD patterns.

These simulations distinguish two distinct pathways of irreversible change: continuous net-

*Speaker

work collapse in the glass involving polymorphic appearing structural arrangements, and defect-mediated amorphization in the crystal, highlighting the critical role of structural inheritance and kinetic trapping in determining silica's high-pressure behavior. **Keywords:** MD simulation,

Glass structure, FSDP, radial distribution function, bond, angle distribution

Thermodynamic database development for novel agentic workflows designed for glass synthesis and application modelling

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Thermochemical data form the fundamental basis for microstructure simulations and, consequently, for the prediction of glass properties. To enable the continuous and sustainable advancement of process technology in glass manufacturing, a stronger integration of computer simulations into process monitoring and control is essential. Since manufacturing conditions and glass specifications can vary widely across different application domains, a comprehensive and physically consistent description of the underlying thermodynamic database is of central importance.

However, the "materials genome" of glass materials remains largely unexplored. The increasing use of recycled raw materials further complicates this picture, as the imperfect separation of material streams leads to the incorporation of minor components and impurities that can strongly affect glass properties. Their quantitative impact must therefore be reflected in reliable thermochemical and process models.

In this work, we present the development of a novel thermodynamic database tailored for oxide glass systems, covering essential components such as B_2O_3, SiO_2, Li_2O, Na_2O, CaO, Al_2O_3 and related multi-component systems. The database is established within the CALPHAD framework, combining experimental data with atomistic simulation results to ensure consistency and predictive capability across broad compositional ranges. Derived thermodynamic quantities provide access to critical material characteristics, including the melting point, viscosity, phase separation behavior, and crystallization tendencies.

The integration of this thermochemical database into agentic workflows enables dynamic material screening, process parameter optimization, and the assessment of impurity tolerance in recycling scenarios. By embedding physically consistent thermodynamic models within adaptive AI-based agents, reliable extrapolations into previously uncharted composition spaces become feasible. This approach represents a significant step toward the realization of flexible and sustainable simulation environments for process engineering in glass technology and beyond. **Key-**

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words: Calphad, Thermochemical modelling, AI assisted materials design, glass manufacturing, process optimization

Designing High Young's Modulus Soda-Lime-Silica Glass with Reinforcement Learning and Genetic Algorithm

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The current global energy transition is driving the rapid development of the photovoltaic (PV) industry, leading to a surge in demand for PV glass. Meanwhile, the performance requirements of "thinness and lightness" for optical functional glass necessitate high Young's modulus, which further exacerbates the challenges in traditional glass research and development.This study targets the design of high-modulus soda-lime-silica glass and proposes an inverse design method integrating "reinforcement learning (RL) and genetic algorithm (GA)". A reward function conforming to the physical properties of glass is constructed via RL to guide the GA in efficiently searching the composition space within the soda-lime-silica system. This addresses the issues of slow convergence and deviation of optimal solutions from practical application requirements in traditional inverse design. Currently, we have verified the feasibility of the RL-GA approach and demonstrated the importance of introducing density as a physical feature through feature importance analysis. In subsequent work, we will further validate the positive impact of RL on practical glass preparation through experiments.In our vision, this method can significantly accelerate the research and development process of high-modulus soda-lime-silica PV glass. Additionally, it enables accurate composition-property mapping in the inverse design framework, effectively integrating data-driven approaches with physical knowledge. This research not only provides a new paradigm for the high-modulus design of optical functional glass but also offers technical support for the efficient innovation of key materials in the energy sector through the application of RL in PV glass research and development.

Keywords: Machine Learning, Reinforcement Learning, Glass

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The Capriccio method as a versatile tool for quantifying the fracture properties of glassy materials under complex loading conditions with chemical specificity

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Molecular dynamics (MD) simulations are widely used to provide insights into fracture mechanisms while maintaining chemical specificity. However, particle-based techniques such as MD are limited in terms of accessible length scales and applicable boundary conditions, which restricts the investigation of fracture phenomena in typical engineering settings. In an attempt to overcome these limitations, we apply the partitioned-domain Capriccio method to couple atomistic MD samples representing silica glass with the finite element (FE) method. With this approach, we perform mode I (rectangular panel under tension, three-, and four-point bending), mode II as well as mode III (rectangular panel under in-plane or out-of-plane shear) simulations. Thereby, we investigate multiple criteria to identify the onset of crack propagation based on the virial stress, the number of pair interactions, the kinetic energy/temperature, the crack velocity, and the crack opening displacement. The approach presented provides quantitatively plausible results for the critical stress intensity factors KIc, KIIc, and KIIIc. This contribution shows that the Capriccio method is a flexible means of performing fracture simulations that take into account boundary conditions typical of experimental test setups with atomistic specificity near the crack tip. While also pointing out the current limitations of the Capriccio method, we demonstrate its potential to integrate atomistic insights into FE models with significantly larger overall dimensions.

Keywords: Fracture mechanics, Multiscale modeling, Molecular dynamics, Finite element method, Glassy materials

*Speaker

Predicting heterogeneous dynamics in supercooled liquids using angular-dependent structural indicators

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Establishing a robust and interpretable connection between static structure and heterogeneous dynamics remains one of the central challenges in glass physics. Here, we propose a modified form of the conventional two-body structural entropy S2 that incorporates both long-range and angular dependencies. Using this extended structural descriptor, we predict particle-level dynamics in two-dimensional model glass formers with distinct liquid fragilities. For a "fragile" Lennard–Jones mixture, the correlation coefficient between structure and dynamics reaches up to 85% near the time scale at which dynamical heterogeneity is maximal. In contrast, in a "strong" silica-like system, the correlation is only moderate. We attribute this contrast to the fact that the dynamics of fragile systems are governed by large-scale cooperative rearrangements that generate pronounced heterogeneity, whereas strong glass formers are dominated by localized, short-range motions. These findings deepen the microscopic understanding of structure–dynamics correlations in liquids and provide a foundation for extending such analyses to three-dimensional systems.

Keywords: Dynamic heterogeneity, Structural descriptor, Structure dynamics correlation, Fragility

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Symmetry Transitions Beyond the Nanoscale in Pressurized Silica Glass

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Silica is the paradigmatic network glass-former and understanding its response to pressure is essential for comprehending the mechanical properties of silica-based materials and the behavior of silicate melts in the Earth's interior. While pressure-induced changes in the short-range structure—particularly the breakdown of tetrahedral symmetry—have been well documented, structural transformations on larger length scales remain poorly understood. Here, we numerically investigate the three-dimensional structure of silica glass as a function of compression up to $P \approx 100$ GPa. Using a novel many-body correlation function, we reveal a complex medium-range order: While for $P \lesssim 10$ GPa, one finds tetrahedral, octahedral, and cubic symmetries, the structure at higher Ps exhibits alternating cubic and octahedral particle arrangements. The P-dependence of the corresponding structural correlation length displays two distinct maxima, with the first one corresponding to the anomalous compressibility of silica. We rationalize the identified complex structural organization on intermediate range scales by a pressure- and scale-dependent interplay between directional bonding, packing efficiency, and network stiffness.
Keywords: glass, silica, pressure, structure, atomistic simulations

*Speaker

The origin of over-coordinated defects in chalcogenide glasses

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The nature of point defects in chalcogenide glasses has been the subject of study ever since Kastner, Adler and Fritzsche, and Mott, Davis and Street, first proposed, fifty years ago, a model of over- and under-coordinated defects (valence-alternation pairs, VAPs) to explain the diamagnetic nature of such defective glasses in the absence of light.

For instance, chalcogen-based VAPs are C^{1-} and C^{3+} defects, where the numeral is the coordination number, and $+/-$ the electronic charge, of a chalcogen atom, C. Over-coordination at C^{3+} centres can be understood in terms of the formation of dative bonds between filled p-like lone pairs (LPs) on one atom and empty p-like bonding orbitals on adjacent atoms.

In the case of pnictogen-containing chalcogenide glasses, VAPs can also occur: namely, P^{2-} and P^{4+}, where P is a pnictogen. In this case, over-coordination at P^{4+} centres arises, instead, from sp^3 hybridization to form four sp^3-hybrid bonds at a P atom.

However, exceptions from these conventional over-coordination cases have been found from DFT-based simulations of chalcogenide glasses: in the case of As_2S_3, an As^{4-} centre; and, in the case of Se, a neutral Se^{40}–Se^{30} pair.

It will be shown that these unusual over-coordinated defect configurations can only be understood in terms of "hyperbonding", rather than normal dative bonding or sp^3 hybridization. In this hyperbonding scenario, a bonding interaction between a filled p-like LP and an empty antibonding orbital leads to a weaker coordinate bond and overcoordination at the atom hosting the antibonding orbital. **Keywords:** chalcogenide glasses, coordination defects, valence, alternation pairs, dative bonding, hyperbonding

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Agro-waste deriven crack resistant glass for smart display devices

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Globally, a substantial amount of agricultural waste is generated every year, with India being a major contributor to it. Specifically, the trend in rice husk production is on the rise and is projected to continue increasing. The prime challenge with this waste is its natural degradation due to the presence of high content of silica and lignin. This underlines the significance of harnessing the potential of rice husk-derived silica, which is key to addressing various challenges and opportunities. One particularly promising application of rice husk-derived silica is the development of advanced and crack-resistant smart glasses that may substantially reduce maintenance costs and enhance durability when used for various applications. Over the past few years, various fabrication techniques, such as aerodynamic levitation and post-processing methods like ion exchange strengthening, relaxational toughening, and intrinsic toughening, have been proposed to achieve the desired crack-resistant properties. However, these techniques have limitations for industrial use, including restrictions on sample size and the introduction of unwanted modifications to the glass composition. Consequently, there is a pressing need for a breakthrough in the development of glass that combines ultra-hardness, self-healing capabilities, and crack resistance in a cost-effective manner for commercial applications. Present work proposes a novel pathway that replaces expensive aerodynamic levitation techniques with the conventional melt-quench technique. This change promises to revolutionize large-scale production for industrial applications, making it more economically viable. Key to our approach is the use of silica derived from agro-waste, such as rice husk, as the primary component of the glass. This not only reduces the liquidus temperature but also enhances the overall strength of the glass structure, thus facilitating production through the melt-quench technique.

Keywords: Smart glass, crack, resistant, ultra, hard, industrial applications, production from waste, environment, friendly, display applications.

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Structure–Property Relationships in Iron Phosphate Oxide Glasses as Cathode Materials for Lithium-Ion Batteries

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Developing sustainable and high-performance materials remains a major challenge for next-generation lithium-ion batteries (LIBs). Conventional crystalline cathodes are often limited by their structural rigidity, whereas glassy materials can deliver high specific capacities depending on their composition (1). Among them, phosphate-based glasses offer a versatile and scalable alternative, owing to their amorphous framework that provides a large free volume and enhanced structural flexibility for lithium insertion and extraction (2).

In this work, we investigate iron phosphate oxide glasses as cathode materials for LIBs. The influence of synthesis conditions and iron content on the amorphous structure, transport properties, and electrochemical performance is systematically examined. Electrical conductivity was characterized by electrochemical impedance spectroscopy (EIS), while galvanostatic cycling demonstrated promising specific capacities and good reversibility. To elucidate the underlying redox mechanisms, Mössbauer spectroscopy was performed on pristine and cycled electrodes at various states of charge.

Our results show that fine-tuning the glass composition allows for precise control of both structural disorder and electrochemical behavior, paving the way for sustainable glass-based cathodes in advanced lithium-ion batteries.

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Keywords: Iron Phosphate Oxide, battery, cathode

Luminescent Rare-Earth Garnet Microcrystals Synthesized from Electronic Waste by Controlled Cooling of Melted Glass

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The growing global demand for rare earth, essential in the manufacture of electronic devices, permanent magnets, lasers, catalysts, optical amplifiers, telecommunication fibers, and luminescent materials, has placed these elements at the center of a complex geopolitical and economic network. Recovery of REEs from electronic waste, known as urban mining, has emerged as a promising strategy to mitigate environmental impacts and reduce dependence on primary mineral sources. Although fluorescent lamps are gradually being replaced by LED lighting, they remain widely used worldwide. Due to the presence of mercury, improper disposal of fluorescent lamps poses serious health risks and causes soil and groundwater contamination. Mercury vapor is essential for lamp operation: when excited by an electric current, it emits radiation at 254 nm, which in turn excites phosphors composed of orthophosphates, aluminates, or borates doped with Y^{3+}, Tb^{3+}, Eu^{3+}, La^{3+}, and Ce^{3+} ions, emitting visible light. The spent lamps were processed using an AirCycle Corporation Bulb Eater® vacuum system equipped with filters that separate mercury vapor from the phosphor powder coating the lamp walls. Quantitative analysis by ICP–MS confirmed significant concentrations of Y, Ce, Eu, Tb, and La in the recovered material. In this context, the present study proposes the use of fluorescent lamp waste as a precursor for synthesizing rare-earth garnet ($RE_2Ga_5O_{12}$, RE = rare earth) microcrystals through an innovative glass crystallization method based on the controlled cooling of a heavy-metal oxide melt. Precursor oxides were weighed to obtain a $PbO–GeO_2–Bi_2O_3–Ga_2O_3$ glass composition, to which 3, 5, and 7 wt% of fluorescent lamp waste were added. The mixture was melted in a Pt crucible at 1250 °C/1 h, then subjected to a controlled cooling ramp, leading to the formation of thousands of micrometer-sized single crystals. After synthesis, the glass matrix was dissolved in concentrated HCl, leaving luminescent rare-earth garnet microcrystals that emit under UV excitation due to Eu^{3+} and Tb^{3+} transitions. The materials were characterized by SEM–FEG, EDS, optical microscopy, X-ray diffraction, and photoluminescence studies, including lifetime and quantum yield analyses, demonstrating a sustainable approach to converting hazardous waste into high-value luminescent micro white-light emitters. **Keywords:** glasses, e,

*Speaker

waste, rare, earth, single, crystals, garnets

Initial alteration rate of glasses irradiated with various particles beams

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High-level long-lived radioactive wastes are vitrified and intended for deep geological disposal. The alteration of glass by groundwater is the main source of radionuclide release, and the very long-term behavior of glass packages must be studied. The radionuclides contained in the glass cause it to self-irradiate and modify its structure, properties, and alteration kinetics (1).

Due to the difficulty of working with radioactive materials, the effects of self-irradiation are usually simulated by external irradiation with ions or electrons (2). Depending on the particles used, the interactions with the glass are different and representative of alpha decay, beta decay, or gamma transitions. The pre-irradiated glass is then altered under different conditions to study the impact of irradiation on its behavior. Several studies indicate increased alteration for pre-irradiated glass (3, 4).

In this study, a recent SRCA (Stirred Reactor Coupon Analysis) protocol allowing several samples to be altered simultaneously under initial rate conditions was used (5). This protocol is particularly useful in the case of pre-irradiated glass because it requires only a small sample area, unlike the static protocol (3), and facilitates comparisons. The initial alteration rate was thus measured for several glasses, varying their compositions, pre-irradiation conditions, and/or alteration conditions (pH and temperature).

*Speaker

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Keywords: irradiation, durability, nuclear, initial alteration rate

New Raw Materials Opportunities: Overview and Anorthosite Case Study

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Glass Futures is a not-for-profit, membership-based, research organisation, with its Global Centre of Excellence in St Helens, UK. The remit of the organisation is to enable its members from across the glass supply chain and beyond to collaborate in areas affecting all parties, with a particular focus on decarbonisation of the glass-making and upstream and downstream activities. One key area of interest is in the development of raw materials which are cost-effective, efficient and low-carbon.

Glass Futures' facility houses a 30 tonnes/day pilot-scale glass furnace, designed to enable industry to develop and trial new technologies (e.g. alternative fuels, CCUS) at an industrially-relevant scale, without risk to commercial manufacturing assets, providing increased confidence for investment. It has a state-of-the-art batch house with eleven silos, providing outstanding flexibility for developing new opportunities.

Gudvangen Stein, a Norwegian family-owned company established in 1956, operates one of the world's largest active anorthosite deposits, ca. 400–500 million tons. Mining is fully underground, with crushing operations powered by hydroelectric energy, producing CO_2 emissions as low as 3 kg/ton of material.

The company is developing anorthosite as a potentially low-carbon raw material for the glass industry, characterised by a balanced SiO_2–Al_2O_3–CaO composition. Current engineering activities are focusing on reduction of iron and sodium-sulphate levels, and precise particle sizing to align with specifications for container, float, and fibre-glass applications.

Following the completion of its fuels programme in Q1 2026, Glass Futures and its members will begin a new programme on batch and raw materials developments—an overview of this programme will be presented.

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Additionally, the paper will explore an opportunity to develop anorthosite, currently in use in the wool and fibre sectors, as an Al_2O_3-bearing raw material for the container and float sectors, utilising Glass Futures' 30 tonne/day pilot line. Currently, container and float manufacturers in Europe have limited choice of Al_2O_3-bearing materials—development of anorthosite would therefore improve choice/pricing. As a CaO-rich material, anorthosite also allows for a reduction in limestone usage, and therefore in process CO_2 emissions, and previous data from existing customers suggest that anorthosite may enable more efficient furnace operation. **Keywords:**

Raw Materials, Resource Efficiency, Low, carbon

The reuse of the cover glass to enhance solar energy sustainability in the Brazilian context

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The rapid expansion of solar energy in Brazil has been pivotal in sustaining a high share of renewable electricity generation. By 2025, the country reached 60 GW of installed photovoltaic capacity, with approximately 42 GW derived from small-scale distributed systems and over 3.1 million grid connections. Projections indicate that these figures will double within the next decade, underscoring the urgent need for a comprehensive end-of-life management strategy for solar panels. Cover glass accounts for roughly 70% of a panel's weight, and the increasing adoption of bifacial modules is further increasing glass use in these devices. However, Brazil's glass recycling rate remains low-just above 25%-primarily due to high transportation costs and the limited market value of cullet. Moreover, approximately 95% of cover glass in new panels contains antimony, a scarce and toxic element that necessitates specialized recycling processes. This study explores alternative pathways for reusing glass from photovoltaics in the development of new glasses and ceramics, aiming to promote a more circular economy and mitigate environmental risks associated with the leaching of toxic substances and landfill disposal of these glasses. We recently demonstrated the production of oxyfluorides with high transparency and a lower melting temperature. Here, we explore potential applications for this material, including optics and photonics, thanks to its high transparency and stability, as well as the development of glass-ceramics exhibiting new features such as antimicrobial activity. Finally, we discuss the potential to develop other glass-ceramics utilizing glass from solar panels as the primary raw material, with a particular focus on the search for environmentally friendly matrices and their applications.

Keywords: Recycling, cover glass, toxicity, oxyfluorides, bioactivity

*Speaker

Mild alkali activation of glass for sustainable and recyclable 'unfired' construction materials

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Several types of glass cullet pose difficulties in recycling, due to contaminations from other materials and risks of noxious gas emissions in remelting. Fine fractions, since they concentrate impurities, are the most critical. These forms of 'waste glass' have been increasingly considered in the formulations of new cementitious materials, known as geopolymers. These materials rely on extensive dissolution of silicate and alumino-silicate feedstock in concentrated alkaline solutions, in a first step. Stable gels with zeolite-like architecture (with SiO4 units bridged to AlO4 and BO4 units, the latter stabized by alkali ions) form upon drying of suspensions, embedding unreacted material. The present contribution aims at presenting the possibility to achieve stable glass-based 'skeletons' by attacking fine glass powders with diluted alkaline solutions (

Keywords: Waste glass, alkali activation, gelation, foams

*Speaker

Phosphosilicate-Based Glass Fertilizers with Controlled Nutrient Release: A Sustainable Alternative to Conventional Fertilizers

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Glass fertilizers (GFs) have attracted growing interest as sustainable alternatives to conventional fertilizers due to their ability to incorporate multiple nutrients within a single solid matrix and to enable controlled nutrient release through compositional design. In this study, GFs within the P2O5–SiO2–CaO–K2O system were synthesized via the traditional melt-quenching method to achieve tunable dissolution behavior. The materials were characterized by Raman and FTIR spectroscopies, DSC, SEM-EDS, and solid-state 31P NMR. Structural analyses revealed that increasing SiO2 content leads to depolymerization of the phosphate network, modifying the connectivity of Qn structural units. In vitro dissolution tests were performed in deionized water and in a citric acid/sodium citrate buffer, and elemental release profiles were quantified by ICP-OES. The results demonstrated a gradual and composition-dependent release of nutrients, with post-dissolution analyses indicating the preferential leaching of (PO4) and (SiO4) units from the glass network. Furthermore, preliminary in situ tests using forage plants showed enhanced dry mass production compared to the control group. These findings highlight the potential of phosphosilicate-based glass fertilizers to combine compositional tunability with controlled nutrient delivery, offering an environmentally friendly pathway for improving fertilizer efficiency in agriculture.

Keywords: Glass fertilizers, Controlled nutrient release, Phosphosilicate glasses, Sustainable agriculture, Dissolution kinetics

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A comparative study on immobilization of ERV2 chloride salt simulant in ceramics, glass and glass-ceramic waste forms

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This work evaluates and compares the effectiveness of different solidification matrices of ceramics, glass, and glass-ceramics for stabilizing a simulated chloride-bearing radioactive salt residues generated from electrochemical reprocessing (ER) of spent nuclear fuel. Chloride salts present particular challenges due to their corrosive nature and limited solubility (< 1wt% Cl) in conventional borosilicate glass systems, making material selection critical for long-term containment. Ceramics often offer high chemical durability and tailored crystal phases, while glasses provide compositional flexibility and homogeneous waste incorporation. On the other hand, glass-ceramics can combine advantages of controlled crystallization forming the target crystalline phases within a glassy matrix to enhance stability. By comparing the physical, chemical, and structural properties, this study aims to support the identification of robust waste forms for safe nuclear waste management. In this study, the chloride containing simulated salt was mixed in fixed ratios with calcium phosphate powders and calcined at various temperatures from 400 to 700C to prepare the ceramic waste forms. Aluminoborophosphate glass frits of composition Na2O-Al2O3-P2O5-B2O3 (wt.%) were prepared by melting at temperatures from 1200-1300C. The simulated salt and the calcium phosphate ceramic waste forms were mixed with the glass frits and cold-pressed sintered at 7000C for 4 h in order to develop the glass-ceramics. The synthesized waste forms were subsequently characterized for thermal, structural and leaching properties. The confining matrices were analyzed to find out their chloride retention capacities with respect to the elements of interest. The matrices were characterized and leached for contact times up to 14 and 28 days at room temperature and at 400C. Leaching results were evaluated and compared in terms of normalized releases with similar results reported in literature.

Keywords: Nuclear waste immobilization, Glass, Glassceramics

*Speaker

Chlorine Incorporation in Iron Phosphate and Borate Glasses for Nuclear Waste Immobilization

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Chlorine is a volatile element commonly found in various types of waste, including legacy radioactive waste and waste generated by molten salt reactors. The presence of chlorine in these wastes represents a significant challenge for long-term immobilization, as its vitrification in conventional borosilicate glasses is hindered by the low solubility of chlorine, leading to volatilization losses and potential degradation of the glass matrix.
In this context, iron phosphate glasses have emerged as a promising alternative for nuclear waste immobilization due to their ability to accommodate a wide range of elements and their favorable chemical durability. This study focuses on the mechanisms of chlorine incorporation in P2O5 - Al2O3 - Fe2O3 - X (X = CaO, Na2O, SrO) and B2O3 - Al2O3 - Fe2O3 - X glass systems.
The effects of the nature of alkali and alkaline-earth elements, synthesis routes, and chlorine precursors were systematically investigated in order to enhance chlorine solubility in the glass matrices. The objective is to identify the key parameters governing chlorine incorporation and retention, thereby contributing to the development of durable glass formulations for the immobilization of chlorine-bearing nuclear wastes.

Keywords: Chlorine, Nuclear Waste Immobilization, Iron Phosphate Glass, Borate Glass, Physicochemical Properties

*Speaker

Rare earth-doped borogermanate glasses from electronic waste for advanced magneto-optical applications

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In recent years, the global demand for rare earth elements (REEs) has increased significantly, becoming critical due to environmental overexploitation (1). Although rare earth elements are relatively abundant in the Earth's crust, their distribution is limited. Additionally, the REE market is dominated by a few countries, creating further challenges worldwide. Currently, a wide range of electronic devices with advanced technologies are being manufactured, improved, and rapidly replaced, which means that new chemical compositions must be developed, increasing the demand for several elements, including REE. The utilization of urban mining to recover REEs such as Nd, Eu, and Tb for the synthesis of new vitreous materials presents a promising strategy (2). Magneto-optical (MO) glasses are of growing interest for their potential in developing MO sensors. Borogermanate glasses enable the solubilization of high concentrations of rare earth (RE) ions. This work presents the synthesis and characterization of borogermanate (BGeB) glasses incorporating e-waste (wst) from fluorescent lamps containing rare earth (RE) ions with high paramagnetic moments, such as Tb and Eu. Borogermanate glasses with x = 0, 10, 20, 30, and 50 %wst were prepared using the melt-quenching method at 1400 °C. Characterization techniques included Differential Scanning Calorimetry (DSC), X-ray Diffraction (XRD), Photoluminescence (PL), UV-Vis-NIR absorption spectroscopy, and MO characterization. XRD patterns confirmed the amorphous nature of all samples, and DSC curves identified glass transition temperatures (T_g) of around 516 °C. The transmission spectra of BGeBx%wst glasses revealed a broad optical transmission window (0.55–1.6 μm), with notable Tb and Eu transitions observed in emission spectra. The maximum Verdet constant achieved was -40.8 rad T^{-1} m^{-1} for the BGeB50%wst glass. This study emphasizes the importance of recycling e-waste containing RE ions and demonstrates the potential of oxide glasses doped with Tb and Eu for advanced magneto-optical applications.

Acknowledgements

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*Speaker

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Keywords: Magneto, optical Glasses, Earth rare elements, urban mining

Investigation by EPR spectrosccopy of glass from smartphone touchscreen and screen protector for radiationdose assessment in case of radiological accident

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Glass has been used for decades to estimate received radiation dose of individuals in case of radiological exposure, with Ag doped phosphate mostly or with soda-lime glass as found in watch. Radio-induced point defects in glass are formed in proportion of absorbed radiation dose. Electron Paramagnetic Resonance (EPR) spectroscopy is a method of choice for this application, allowing identification and quantification of the different point defects induced by irradiation and therefore allowing dose assessment. We will present the results concerning the point defects identification in irradiated alkali-alumino-silicate glass used in commercial smartphone touch screen and screen protector. We will also disucss the impact of the glass composition on the formation of those point defects and also the UV irradiation impact. The presentation will also provide a description of the performance of the proposed method for dose assessment in the context of radiological accident. This method is up to now the only method conidered for triage purposes in case of large scale radiological accident, as no other restrospective dosimetry method provides sufficient measurement capacity.

Keywords: alkali aluminosilicate glass, irradiation, point defects, EPR spectroscopy, dosimetry, smartphone

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A multi parameter approach for predicting initial dissolution rate of silicate glasses

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The prediction of a glass's initial dissolution rate is crucial for various applications in industry, nuclear waste management, and healthcare. The primary limitations of existing approaches are the lack of dissolution behavior classification and the choice of appropriate and robust criteria to relate the glass composition to its dissolution rate. This work introduces congruence-focused, multi-variable, and MD-agnostic methodology to estimate dissolution rate of silicate glasses. The employed criteria reliably discriminate between congruent and incongruent dissolution behaviours and the corresponding descriptors demonstrate reasonable ($R^2 > 0.9$) and proportional correlation with $\ln r_0$ for all studied glasses. Therefore, holistic structural models that consolidate the fundamental chemistry and topology of the glass network offer a systematic means to capture complex property relationships and evaluating durability through r_0. **Keywords:** glass, dissolution, initial dissolution rate, model

*Speaker

Recycling of LAS Glass-Ceramic Cooktop Waste using Laser Directed Energy Deposition (LDED)

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Lithium-Aluminium-Silicate (LAS) glass-ceramics, widely used for cooktops, present significant recycling challenges due to their unique composition and high thermal stability, making them incompatible with conventional glass recycling. This study investigates the feasibility of Laser Directed Energy Deposition (LDED) as a closed-loop manufacturing route to transform 100% waste cooktop panels into functional components, focusing on the retention of the material's semi-crystalline properties.

Waste LAS cooktop panels were ground and sieved into precursor powders. An in-house designed and constructed LDED system equipped with a continuous-wave CO_2 laser ($\lambda = 10.6\ \mu$m) was employed. To mitigate thermal shock, the alumina substrate was pre-heated and all laser processing was carried out inside a controlled chamber. The study analysed the effects of laser intensity, powder mass flow, scanning strategy, and particle size on geometry, microstructure (XRD, SEM), and mechanical properties.

This study successfully demonstrates that LDED is a viable technique for the additive manufacturing of LAS glass-ceramic waste. The process, supported by in-situ substrate pre-heating, fabricates new parts that uniquely retain the functional β-quartz crystalline phase of the original material. This opens a promising recycling path for cooktop waste, enabling its transformation into high-value components while conserving its specific properties.

Acknowledgment

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words: Glass recycling, Lithium Aluminium Silicate (LAS) glassceramics, laser based additive manufacturing

Recycling Technologies and Applications of Borosilicate Glasses

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Borosilicate glasses, known for their thermal resistance, chemical inertness, and mechanical strength, play a crucial role in technical applications as well as in the pharmaceutical industry. Despite their widespread use and versatility, most borosilicate glass wastes (BSGW) end up in landfills or are incinerated, rendering this valuable resource useless. This review provides an overview of recycling strategies for borosilicate glasses, with emphasis on technological approaches and potential applications spanning building and construction, insulation and filtering, functional materials, and materials for radiation shielding or nuclear waste immobilization, as well as opportunities for material recovery within the ceramics and glass industry or a source of boron or other critical raw materials. A brief description of the review policies, such as the European Union's goal of fully recyclable packaging by 2030, and limitations and challenges for glass recycling, will also be given. New perspectives based on laser processing of borosilicate GW are also shown and aimed to open pathways toward full recyclability of these materials. This approach contributes not only to improved environmental sustainability but also promotes the use of BSGW in advanced technological applications.

Keywords: glass recycling, borosilicates, laser processing

*Speaker

Everglass Database: Development of a Python-Based Tool for Visualization of Glass Properties and Modelling Applications

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This paper presents the development of a simple, friendly and easy to use Python-based software tool, named EVERGLASS DATABASE, designed to facilitate the visualization and management of experimental data in the field of glass science. The program features an intuitive graphical user interface (GUI) built with Tkinter that allows users to import CSV files containing chemical composition, viscosity data, physical properties, and general thermal data of different glasses. The tool integrates plotting routines based on Matplotlib to generate interactive viscosity curves using the Vogel–Fulcher–Tammann (VFT) equation and data tables with export capabilities. Developed within the framework of the EU-funded EVERGLASS project, this database offers an open-source resource designed to enhance accessibility and usability for researchers and students in glass science. In particular, it provides detailed information on several commercial glasses, with potential applications in laser-morphing for glass recycling. Furthermore, the database integrates valuable glass data useful for simulations using the MESHFREE-based thermal-fluid GFDM-CFD model applied to laser processing of glass. Acknowledgements: This work was supported by the European Union Pathfinder project EVERGLASS under grant agreement No 101129967.

Keywords: Everglass database, glass properties, python, based software, laser morphing, glass recycling, modelling

*Speaker

Introducing high-temperature stability to glass foams

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Glass foams consist of a glass skeleton with gas-filled pores. Industrially, glass foams are produced from sintering of mainly waste glass, making glass foam production a sustainable method for glass recycling, by eliminating the energy-consuming melting step. The glass foams have high mechanical strength, and low density, resulting in low thermal conductivity, and does thereby exhibit great potential in thermal insulation of buildings. In order to prevent or slow down spread of fire in a building, superior high-temperature stability of the insulation material is of uttermost importance. A recent method utilizing hot-stage microscopy has been developed to quantify the high temperature stability of mineral wool insulation. Comparing the high-temperature stability of mineral wool to that of commercial glass foams have shown poor stability of the glass foams, leading to structural collapse. In this study, the aim is to develop high-temperature stable glass foams. Crystallization of the glass phase during or after foaming has been found to prevent foam collapse until the temperature reaches the melting point, by providing a more rigid network. Therefore, controlled nucleation and crystallization of the glass foams resulting in ceramic foams upon high temperature treatment will be examined as a potential opportunity to optimize the high-temperature stability. To obtain controlled nucleation new glass foam compositions will be produced by combining different waste glass sources and additives, including nucleation agents, in different ratios. The high-temperature stability of these glass foams will be measured and compared to commercial glass foams and mineral wool samples. Differential scanning calorimetry and X-ray diffraction will be utilized to evaluate the potential crystallization of the glass foams during the foaming process and the subsequent reheating of the foams. Furthermore, the glass foams with the most promising high-temperature stabilities will be further evaluated based on porosity and thermal conductivity with intend to ensure applicable thermal insulation properties.

Keywords: Glass foam, high temperature stability, thermal conductivity

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Secondary Raw Material Use in Glass Manufacturing

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Glass manufacturing has a long history of using "waste" materials as raw materials in furnaces, from the use of wood ashes in preindustrial manufacture, through to extensive use of cullet and blast furnace slag in the modern era. This presentation will give an overview of recent work carried out by Glass Technology Services and partners to identify and characterize new sources of materials that would otherwise be sent to landfill or low value end uses. Using examples from our research we will outline methods for the beneficiation of these materials whilst maintain a environmental advantage from their use. Highlighting the opportunity for glass manufacturers to achieve hight levels of recycled content despite scarcity of good quality cullet. Adoption of these new materials will lead to a more sustainable glass industry by reducing reliance of virgin raw materials, reducing energy and carbon emissions. Additionally, it encourages industrial symbiosis and promotes resource efficiency across other industries by reducing landfill and promoting a circular economy.

Keywords: Raw materials, circular economy, sustainability, waste

*Speaker

Hydrothermal treatment and foaming of waste glass: the mechanism and optimization for low-density foamed glass

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The global accumulation of waste glass presents environmental challenges and offers opportunities for sustainable materials production. Foamed glass, a lightweight and thermally insulating material, is already commercially produced using waste glass. However, the energy-intensive process of glass foaming could be improved in terms of sustainability and performance. This study focuses on explaining the mechanism of foaming of hydrothermally treated glass and practical utilization of various waste glasses.

Previous studies have shown that hydration of glass powders affects their sintering behavior—enabling the foaming. However, the explanation of the foaming mechanism is still lacking. The central question addressed in this study is how foaming of hydrothermally treated glass proceeds and whether it can maintain desirable foam properties. Furthermore, the process was tested using glycerol in an air atmosphere.

Cathode-ray tube panel, flint, and mixed-color container glass powders were treated in a saturated steam atmosphere, inducing structural changes, including the incorporation of bound water and carbonate species, which were characterized using X-ray diffraction (XRD) and Fourier-transform infrared (FTIR) spectroscopy. The foaming behavior was analyzed using heating stage microscopy and thermogravimetric analysis coupled with mass spectrometry (TG/MS), while foamed samples were evaluated for density, porosity, and thermal conductivity. Furthermore, the composition of the gas inside the pores of the foam was determined with gas chromatography.

Results show that hydrothermal treatment reduces the onset foaming temperature, enhances expansion, and enables preparation of low-density foams in air when combined with glycerol. Carbonates formed after the hydrothermal treatment are the main driving force for foaming, while particle size and hydration level critically influence foam morphology. Foams achieved highly porous structures with low apparent densities, demonstrating the potential of this approach.

Hydrothermal treatment could offer a viable route for producing sustainable foamed glass from waste in an energy-efficient manner. Controlling crystallization and optimizing additive

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systems may further improve thermal and mechanical properties, paving the way for practical applications in insulation and circular economy strategies. **Keywords:** Foamed glass, Waste glass,

Hydrothermal treatment

Surface-Enhanced Raman Scattering Performance and Applications of Ag/Ag3PO4 composite SERS fiber probe

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With the increasing discharge of pollutants into air, water, and soil, the rapid and sensitive detection and treatment of chemical pollutants, including toxic organic dyes and heavy metal ions, have become critical for minimizing potential threats to the ecological cycle and human health. In the current research, an in-situ degradation approach for toxic substances is proposed, combined with surface-enhanced Raman scattering (SERS). Two types of fiber probes based on a silver nanoparticles/silver phosphate (Ag/Ag_3PO_4) microcube and tetrapod composite were fabricated using a sequence of ion exchange, chemical reduction, and subsequent coating processes. Notably, both probes demonstrated detection limits as low as 10^{-14} M using crystal violet (CV) analyte. Additionally, the tetrapod composite probe was modified with 4-mercaptopyridine (4-MPY) to enhance Hg^{2+} detection capability, achieving a detection limit of 10^{-12} M for Hg^{2+}.

Under light exposure, the microcube fiber probes degraded 95.0% of CV and 94.8% of PATP within 60 min, while the tetrapod fiber probes degraded 93.2% of CV and 98.0% of PATP within 60 min, and 82.3% of Hg^{2+} within 30 min, as monitored in situ. Finite element method analysis suggested that the high electromagnetic field intensity generated by Ag/Ag_3PO_4 resulted from the close packing of Ag nanoparticles. Furthermore, the SERS fiber probes exhibited outstanding stability, selectivity, and reusability. This research suggests that the recyclable Ag/Ag_3PO_4 microcube and tetrapod composite fiber probes hold significant potential for the detection and in situ monitoring of the degradation of trace environmental contaminants. **Keywords:** SERS,

Silver phosphate, Silver nanoparticles, In situ monitoring, Photocatalytic degradation

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Synchrotron computed tomography for bi- and tri-dimensional structural characterization of glass devitrification at the MARS beamline.

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The global transition to low-carbon energy sources will require a significant contribution of nuclear energy to achieve emission goals. One of the concomitant challenges of nuclear energy production is the disposal of radioactive wastes. Vitrification is today the best solution for radioactive waste disposal. Glass waste forms have long been considered as some of the safest and most chemically durable waste form classes, thus allowing for very long-term immobilization (thousands to millions of years) of radionuclides and preventing their entry into the biosphere.

Research on nuclear glasses focuses primarily on processing and long-term durability, with two key challenges: (i) increasing the loading of radioactive elements and (ii) controlling crystallization. When crystallization occurs, the material becomes a glass-ceramic, which may stabilize certain elements but can also degrade performance. For minor actinides, research often relies on non-radioactive surrogates such as cerium due to radioprotection constraints, but these analogies are imperfect and do not fully capture actinide redox behavior.

While X-ray absorption spectroscopy is considered as the key technique for speciation determination in glasses, the determination of the presence of crystalline phases is quite uneven and not systematically investigated with XRD. These limitations call for the development of local structural probes as their hierarchical arrangement of structures across length scales results in improved properties.

A promising emerging approach is synchrotron Diffraction Scattering Computed Tomography (DSCT), which merges X-ray diffraction and fluorescence with computed tomography by scanning a pencil beam through the sample. Combined with full-field absorption-contrast tomography, DSCT enables the selection of specific 2D slices from a prior 3D dataset and allows the identification and spatial distribution of polymorphs. Crucially, it can extract scattering pat-

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terns from amorphous and crystalline phases with similar densities or compositions and enhances detection of weak signals from minor phases, significantly improving structural sensitivity.

In this study, full-field tomography and DSCT were applied to uranium-doped glass-ceramics that underwent devitrification. The resulting microscale chemical composition and crystalline phase distribution are analyzed and discussed. **Keywords:** tomography, DSCT, crystallization, glass ceramics, devitrification, x ray, uranium, actinides, synchrotron, nuclear waste

Low Carbon Fuels for the Glass Industry: Pilot trials and future opportunities

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Glass Futures is a not-for-profit, membership-based, research organisation, based at its Global Centre of Excellence in St Helens, UK. The remit of the organisation is to enable its members from across the glass supply chain and beyond to collaborate in areas which affect all parties, with a particular focus on decarbonisation of the glass-making process and its upstream and downstream activities.

At the heart of the new Glass Futures' facility is a 30 tonnes/day pilot-scale glass furnace, which has been designed to enable the industry to develop and trial new technologies at an industrially relevant scale, without risk to their commercial manufacturing assets, thus providing increased confidence for manufacturers looking to invest in low-carbon technologies such as alternative fuels, CCUS technologies and new raw materials.

The first phase of trials to be undertaken on this new pilot line will investigate a range of alternative, low-carbon fuel scenarios for glass furnaces, including hydrogen, biofuels and electric melting.

In this paper, an overview of the facility is provided along with an overview of findings from these initial trials into low carbon fuel scenarios. Future opportunities to make switching to low-carbon fuel scenarios more commercially attractive for the glass industry, such as dynamic fuel switching and pyrolysis technologies, will also be explored. **Keywords:** Electric melting, Hydrogen, Biofuels, Low, carbon fuels, Carbon capture, Pyrolysis

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Decarbonization by reducing energy consumption using Forglass Mixing Electrodes® technology in standard and hybrid furnaces.

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Forglass Mixing Electrode® (FME) is a tool that turns a glass furnace into a chemical reactor, in which the operator can influence the course of reactions and phenomena that make up the melting process and thus significantly accelerate it. FME systems enable the adaptation of increased shares of electrical power in fossil operated furnaces up to 50% without changing the rules of their operation, but with a significant improvement in their efficiency. The wide range of available operating parameters of FME systems (distribution of power and gas flow rates) provide previously unknown possibilities of quick and precise impact on the melting process. This is primarily expected during pull change, composition of glass or batch change, or troubleshooting.

The synergistic interaction of vertically directed convection currents forced by FME systems with natural currents generated by density gradients significantly accelerates the processes of batch-to-glass conversion, sand dissolution and gas bubble removal, resulting in a product with higher chemical and thermal homogeneity at each of these stages. FME is not simply the sum of the functionality and advantages and disadvantages of standard electrodes and bubblers operating separately.

The delivery of hot glass activated by FME systems accelerates the slowest reactions controlled by diffusion. The convective energy dissipation from vicinity of electrodes prevents refractory materials from overheating and directs the energy to the regions where it is needed, which is important in hybrid furnace. Placing gas release points at a height of 500–700 mm above the bottom also definitively removes the risk of erosive impact on the bottom often observed in the case of bubblers mounted in the bottom. **Keywords:** mixing electrode, melting process, glass furnace

*Speaker

Characterization of prepared 3D objects in borosilicate glass using a laser-based additive manufacturing process.

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With the rapid expansion of technology-driven sectors that rely heavily on advanced glass materials, the need for effective recycling solutions for specialized glass waste has become increasingly urgent. The current recycling framework, which addresses only a narrow range of glass types, must evolve into a more comprehensive and universal recovery strategy capable of processing and reusing diverse glass compositions on a truly circular basis.

In this work, emphasis is placed on borosilicate glass systems, which remain among the most difficult to recycle due to their high softening and melting temperatures, as well as their demanding chemical durability and compositional requirements. For systematic evaluation, the glass samples were fabricated using a laser-based processing method to examine how variations in the applied manufacturing conditions influence the properties of borosilicate glass. A comprehensive multi-technique characterization methodology was employed to assess the structural, microstructural, chemical, and optical responses of the processed materials. Cross-sectional imaging through scanning electron microscopy (SEM), complemented by energy-dispersive X-ray spectroscopy (EDS) and elemental mapping, enabled detailed examination of microstructural features and compositional homogeneity. Additional structural information was obtained through X-ray diffraction (XRD), while bulk chemical composition was verified using X-ray fluorescence (XRF). Confocal optical microscopy was used to quantify surface topography and

*Speaker

roughness, and UV–Vis–NIR spectrophotometry provided insight into the optical transmittance of the processed glass specimens. The combined results allow for a holistic correlation between the applied laser-processing parameters and the resulting morphology, elemental distribution, and optical performance, offering a deeper understanding of the process–structure–property relationships in laser-processed borosilicate glass. This innovative approach aims to establish a sustainable pathway for the efficient recycling and repurposing of advanced borosilicate glass systems.

Acknowledgment

This work has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101129967. Views and opinions expressed are however those of the author(s) **Keywords:** Glass recycling, borosilicate glass waste, laser based

additive manufacturing

Modification of glass composition as a route to improve foamed glass properties

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Foamed (cellular) glass is a durable, humidity-tolerant insulation material, yet crystallization that occurs during foaming raises the conductivity of the solid framework and diminishes closed-cell porosity, undermining thermal performance. This work evaluates whether tuning the chemistry of soda-lime–silica waste float glass—specifically the MgO, CaO, and Al_2O_3 contents—can control surface tension, viscosity, and crystallization behavior to improve the resulting foam. Nine distinct base-glass formulations were foamed and characterized by X-ray powder diffraction, gas pycnometry, and thermal conductivity testing. Compositions tailored in the Mg–Ca–Al system yielded markedly lower bulk densities (down to 88 kg m^{-3}) accompanied by higher fractions of closed pores relative to the unmodified glass. Optimized Mg–Ca–Al, Mg–Al, Ca–Al, and Mg–Ca variants delivered the best insulation metrics, achieving thermal conductivities of 38–38.8 mW m^{-1} K^{-1}. These findings demonstrate that adjusting the glass composition provides an effective means to suppress detrimental crystallization, stabilize foaming, and improve the thermal efficiency of foamed glass made from waste float glass. **Keywords:** foam glass, glass recycling, thermal conductivity, glass composition

*Speaker

Valorization of Mineral Wool Waste: properties of a new alkali-activated geomaterial to facilitate recycling

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Mineral wool waste represents a growing environmental challenge due to its non-biodegradability and limited recycling pathways. With an expected 2.82 million tons generated annually in Europe by 2030 (Yap et al., 2021) and EU targets requiring 70% reuse or recycling, new valorization routes are essential.

This work investigates the incorporation of mineral wool waste into alkali-activated materials (AAMs) as a sustainable valorization pathway. AAMs containing up to 90 wt% mineral wool waste were developed following an original formulation (patent No EP25190061.9). Ground granulated blast-furnace slag was used as a source of Si, Ca, and Al, while alkali and alkaline-earth activators (Ca–K–CO_3–OH system) provided activation. Several formulations were tested by varying the waste-to-binder ratio and activator composition. Samples were cured at room temperature under ambient conditions for durations ranging from 6 h to 1 month. Finally, the aim of this work is to understand the reactions involved during each step of curing time through mineralogical and crystallochemistry investigations.

Briefly, chemical analyses were performed by XRF. Neoformed phases were analyzed by XRD, FTIR, and solid-state MAS-NMR (^{27}Al, ^{29}Si). Petrophysical features were examined using SEM-EDS and X-ray μ-tomography. Finally, compressive strength tests were performed to assess mechanical performance.

Time-resolved analyses revealed the formation of C-A-S-H, Ca–Al AFm, and calcite at the expense of portlandite. Reaction kinetics differed between formulations but did not significantly

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impact mechanical properties (up to 30 MPa with 70 wt% mineral wool waste). However, phase abundance and distribution strongly influenced mechanical behavior.

These findings confirm the feasibility of low-energy AAMs with high mineral wool waste content, offering an effective recycling route for this industrial by-product. The materials exhibit good mechanical performance and controlled phase development under mild conditions. Pilot-scale production of the optimized mix is underway, highlighting strong industrial and circular economy potential.

References

Yap, Z.S., Khalid, N.H.A., Haron, Z., Mohamed, A., Tahir, M.M., Hasyim, S., Saggaff, A., 2021. Waste Mineral Wool and Its Opportunities—A Review. *Materials* **14**, 5777.

Patent No EP25190061.9 (2025) Launai, D., Robin, V., Bost, N., & Joussein, E.; Composite conformé préparé à partir de recyclats de laine minérale et d'un porteur de potassium non-cimentaire. **Keywords:** Alkaline activation, Mineral wool, Upcycling, Waste, Geomaterials

ENCAPSULATION OF SLUDGE ARISING FROM DISMANTLING OPERATIONS USING DEM&MELT TECHNOLOGY

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Dismantling operations of end-of-life nuclear facilities produces, or will produce, volumes of ILW-LL—long lived intermediate level activity waste, that need to be managed. Compared to the waste typically vitrified, the material studied here is extremely diverse in both chemical composition and physical form (solid deposits, sludge, or liquid solution), reflecting its origin and the recovery or storage methods applied during decommissioning operations. Sludges represent a significant part of the produced waste, and their conditioning remains a major challenge. One possible way to manage this waste is the encapsulation process, which principle lies on using a glass melt to immobilize sludge components, resulting in an inert mineral matrix composed of thermally treated sludge components dispersed in the glassy matrix. Encapsulation has the advantage of stabilizing the waste into an inert mineral matrix, and of reducing the waste volume to be stored, thanks to the high waste incorporation rate of this process and the evaporation of water initially contained in the sludge.

The In-Can vitrification/encapsulation tool DEM&MELT, developed by the consortium CEA (The Alternative Energies and Atomic Energy Commission), Orano and ECM Technologies proved to be flexible enough to accommodate a varied waste stream and particularly adapted to sludges/slurries from dismantling operations.

A study on sulphate-rich-sludge encapsulation was conducted from laboratory to pilot scale. Because of the waste composition and to prevent potential volatilization, the operating temperature had to be lower than that typically used for conventional vitrification, requiring low-viscosity glass melt. A specific glass frit was then developed with an optimized composition and a form compatible with the feeding system configurations. Waste loading ratio, temperature, and duration of the thermal treatment were investigated, and the microstructural of the final waste package was analyzed. A first assessment of the mechanical strength and material

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durability has been carried out, showing promising results. This work was carried out as part of the PROVIDENCE project, this project has been funded by the French government in the framework of “France 2030”. DEM&MELT is a partnership between Orano, CEA, ECM Technologies and Andra. It has been supported by the French government program “Programme d’Investissements d’Avenir”. **Keywords:** Encapsulation, In, Can Melter, Sulphate, rich sludge, low,

viscosity glass frit

Halides in glasses and melts – connecting immobilization, nuclear fuels, and optics

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Halide ions-fluoride, chloride, bromide, and iodide-are chemically versatile species that shape bonding, volatility, and redox behavior across natural and engineered systems. Their range in size and polarizability allows them to stabilize diverse compounds, influencing reactivity, structure, and optical properties in minerals, melts, and technological materials. In industrial and energy contexts, halides act as electrolytes, fluxes, and solvents, critical in metallurgy, catalysis, semiconductor processing, and molten-salt reactors (MSRs). This talk examines halide behavior in halide and oxide–halide glasses and melts, integrating insights from mineral structures and crystallization. Understanding anion coordination and bonding provides predictive control of melt stability and glass formation.

In optical materials, halides reduce phonon energy and extend infrared transmission (to _˜10 μm), enabling efficient rare-earth doping in systems such as ZBLAN for fiber amplifiers and mid-IR lasers. In molten-salt systems, fluoride salts underpin thermal MSRs, while chloride salts support fast-spectrum designs. In nuclear waste vitrification, halides affect sulfate retention and molten-salt layer formation in Hanford low-activity waste (LAW) glasses, with retention decreasing as anion size increases.

Halide outgassing from industrial processes, vitrification, and volcanism releases reactive halogens that alter atmospheric chemistry, ozone balance, and climate. Persistent fluorinated compounds (PFAS) further highlight the need for sustainable management of halogen species across gaseous and condensed phases. Together, these studies link environmental stewardship, nuclear and optical technologies, and materials sustainability through a unified understanding of halide chemistry.

Keywords: halide, fluoride, chloride, iodide, molten salt, optical glass, vitrification, Hanford

*Speaker

Energy-Efficient Melting of Borosilicate Glass using Cullet

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Integration of recycled cullet into borosilicate glass production offers significant potential for energy reduction, yet batch-cullet melting behavior remains insufficiently understood. This study systematically investigates melting characteristics across 0 - 100% cullet content, emphasizing the industrially critical > 50 % range where maximum energy savings occur. Cullet of commercial borosilicate glass and formulated batch compositions based on established technological standards is used. Time-to-melt is quantified as a function of cullet content, enabling direct correlation with energy consumption, and providing a quantitative framework for process optimization.

Keywords: Borosilicate glass, cullet melting, batch-cullet ratio, energy efficiency, melting, recycling optimization

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The role of bismuth on the incorporation of iodine in aluminoborosilicate glasses synthesized under high-pressure: An XPS and XAS study.

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Bismuth-aluminoborosilicate glasses have gained interest as a possible matrix for nuclear waste immobilisation, as Bi-based sorbents have enhanced affinity for volatile radioisotopes removal. Conjointly, it has been recently demonstrated that using high-pressure conditions is an interesting tool to improve volatile elements retention during glass synthesis. This study tries to combine these two fields showing significant improvement in 129-iodine incorporation into the structure of Bi-bearing glasses synthesised under high-pressure conditions (1 GPa and 1250∘C). Two series of aluminoborosilicate glasses have been investigated, either with high (_˜13 mol.% Al2O3) or low (_˜5mol.% Al2O3) Al2O3 and Bi2O3 content ranging from 0.5 to 16 mol.%. We used 127I as a source for iodine during the experiments. We show that I incorporation increases with increasing Bi2O3 and can reach up to 2.8 mol.%, which is much higher than Bi-free comparable glasses synthesised under the same conditions. O 1s XPS spectra demonstrates a clear change towards a general depolymerisation of the glass structure with increasing Bi2O3 content. It confirms the network-modifier role of Bi3+ cations in such a glass system and explains the increase in I content.
Investigation of the Bi local environments using Bi L3 edge XANES suggest that several redox states for Bi are present: Bi0, Bi3+ and Bi5+. Although the Bi3+ is the main species, the proportion of Bi0 seems to increase with increasing Bi2O3. The Bi EXAFS revealed that Bi3+ is only surrounded by oxygen and that there is no detectable replacement of oxygen atoms by iodine atoms. It implies that the incorporation of iodine is only related to the non-bridging oxygen proportion formed by Bi3+ cations and that there is an optimum quantity of Bi2O3 to add above which the presence of Bi0 could be detrimental.

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Keywords: Aluminoborosilicate, Bismuth, Iodine, High, pressure, Nuclear waste

Decarbonization Pathway of the Glass Industry, Challenges, Opportunities for Different Segments and Possible Solutions Regarding Different Energy Inputs

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The European Union has established stringent targets for CO_2 emissions over the next 30 years. By 2030, emissions must be reduced by 55% compared to 1990 levels, with the ultimate goal of achieving climate neutrality by 2050. It is evident that these ambitious targets cannot be achieved using current furnace designs.

The International Commission on Glass (ICG) has a pivotal role in fostering collaboration and knowledge exchange across regions by organizing conferences focused on sustainability.

To achieve meaningful reductions in carbon emissions, innovative furnace designs and new technologies must be developed. Such advancements require the use of validated Computational Fluid Dynamics (CFD) tools like the GS Glass Furnace Model (GS GFM). No glass producer would risk building a new furnace concept capable of melting over 100 tons per day without rigorous analysis, calculations, and CFD modeling. Recent trends show increasing interest in reducing carbon emissions through greater reliance on electric melting or hydrogen, similar to the widespread adoption of CFD modeling during the rise of oxy-fuel technologies. Now, with the next generation of large hybrid furnaces (with over 50% electric boosting) or fully electric melters.

These complex furnaces, with multiple heat inputs, also require advanced control systems, such as Model-Based Predictive Control, to optimize the balance between electricity and natural gas usage. This approach considers fluctuating costs and aims to maximize carbon reduction.

This presentation will address the following key topics:

- **Introduction**: The role of the ICG and the significance of glass in modern applications — the *Glass Age*.
- **Renewable Resources**: The importance of clean electricity for reducing carbon emissions and updates on global developments in renewable energy.

*Speaker

- **History of Electric Melting**: A brief overview of the evolution of electric glass melting technologies.
- **Segment-Specific Technologies**: Exploration of the most viable decarbonization technologies for various segments, such as crystal and tableware, container glass, borosilicate, fiberglass, and flat glass.
- **Case Studies**: Examples of large-scale all-electric and hybrid melters currently in operation, with a focus on the performance of a large hybrid melter.
- **Forehearth Electrification**: Insights into the potential for 70–90% energy and carbon emission reductions through electrifying forehearths.

Keywords: ICG, hybrid furnace, electric boosting, all, electric melting, CO_2 reduction, furnace design, forehearth design, energy audit, modeling, renewable energy

Recycling of LCD panels: thermo-rheological and structural behaviour of recovered glass

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Liquid crystal display (LCD) panels represent a significant portion of global electronic waste, with screens accounting for nearly 10% of the 62 million tons produced in 2022, yet less than one-quarter of this material is properly recycled. LCD panels consist of multilayered structures containing aluminoborosilicate glass, cellulose-based components, and indium–tin–oxide (ITO) coatings, with glass comprising roughly 85% of the total mass. In this work, we outline the main components of LCD panels, briefly describe the procedures used to recover the ITO layer and remove organic contaminants, and present the chemical composition and representative SEM features of the resulting purified glass. We also report differential scanning calorimetry data alongside high- and low-temperature viscosity measurements. Furthermore, we investigate the structure of this glass using spectroscopic methods. By establishing the composition–structure–property relationships of recycled LCD glass, this study provides the necessary framework for reprocessing this glass and integrating it into technologically relevant manufacturing pathways, examples of which are presented in this work.

Keywords: aluminoborosilicate, viscosity, metaluminous glass, recycling, energy transition

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TANGRAM initiative : Toward an integrative Approach of Nuclear Glass alteration in a Reactive environment from MultiscAle Modelling

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In France, high level wastes generated by spent nuclear fuel reprocessing are immobilized in a glassy matrix by a vitrification process. The glass waste packages are intended to be disposed in a deep geological repository (DGR), providing a passive and safe management solution to isolate the radionuclides (RN) from the biosphere. Glassy matrix is the first barrier designed to confine the RN by establishing chemical bonds between RN and the glass network formers. Understanding the ageing of the glassy matrix toward the various thermal, mechanical, chemical and radiological stresses encountered under geological disposal is therefore crucial to be able to build long term behavior model that support safety assessment of DGR.

In recent years, a new approach was designed to develop the future reference long term behavior model for nuclear glass with respect to French's DGR concept. This coordinated research program called TANGRAM – Toward an integrative Approach of Nuclear Glass alteration in a Reactive environment from MultiscAle Modelling, is being carried out by several CEA laboratories in collaboration with key players in the French nuclear industry (Orano, EDF) and waste management organization (Andra).

It follows the classical methodology of long-term behavior science based on the combination of experimental and modelling studies that has been designed after addressing the main lack of knowledge identified in an internal recent review work. Moreover, a multiscale modeling approach (Molecular Dynamic, Monte-Carlo, Phase field) has been developed to test and validate the atomistic and mesoscopic understanding of nuclear glass ageing. The objective is to use the atomistic and mesoscopic models to improve the reference macroscopic model (GRAAL2), based

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on geochemical modeling, that will be applied at the scale of the DGR. The predictive model will be progressively validated using experiments of increasing complexity.

The current presentation will expose the TANGRAM program and progress status. **Key-**

words: Nuclear glass, modeling, long term behavior, multi, scale modeling, disposal

Valorization of Lead Slag for Glass Fibers – A Zero Waste Approach

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Slags are a by-product of metal production. As the demand at least for some metals increases, the amount of slag produced per year does increase as well. But to date, our industry lacks a usage of these slags, while they can be used as abrasives (1) or building material (e.g. (2)), a significant amount of slag continues to be disposed of, leading to environmental and economic challenges. Those slags containing metals of hazardous nature, disposal is an increasing problem: Rain can leach out hazardous (heavy) metals and generally, disposal also equates to a high, but lost potential of valuable elements included in the slag. One example of this latter group is lead slag.

Within this study, carbothermic reduction was performed on lead slag with varying parameters and occurring liquid-liquid phase separation eventually leading to a metallic phase and a (glassy) secondary lead slag phase (which is mainly CaO-FeO-SiO_2). Depending on the chosen melting conditions, some metal oxides are selectively reduced and accumulate in the metal phase which may find application as a resource in the steel industry, while Zn and Pb can be collected as fumes from the gas phase in oxidic form. Depending on the degree of reduction, the slag phase is thus increasingly enriched in typical glass components like SiO_2, Al_2O_3 and alkaline earth elements as these are not reduced due to high affinity towards oxygen. Thereby, the quality of the resulting glassy material can be adjusted to approach known glass fiber compositions. Finally, the glasses were characterized and the production of glass fibers was studied.

The presentation covers the whole process from reductive smelting, resulting secondary slag glass quality and success of the fiber production process, thus opening a path to a zero-waste approach using hazardous lead slags as resource materials. Gained materials will also be compared to commercially available products.

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Partially crystallized glass melts: impact of crystallization on rheology

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In France, high-level and long-lived nuclear wastes are immobilized in alumino-borosilicate glass. The formulation of these glasses for radioactive waste conditioning balances two key objectives: maximizing waste incorporation into the glass matrix while ensuring both its technological feasibility and long-term stability. Currently, most alumino-borosilicate glasses formulated by the CEA and produced at ORANO's facility in La Hague are homogeneous materials, meaning they consist of a single amorphous phase. However, some chemical elements present in specific radioactive wastes are likely to form crystalline phases under the conditions of the vitrification process.

This study aims to determine the rheological behaviour of glass melts when undergoing crystallization. The systems of interest are simulated simplified nuclear glasses. Two initial compositions were selected to promote the apparition of either 1) Apatite (Ca2Nd8(SiO4)6O2) crystals, which generally have an acicular shape or 2) Cerianite crystals (CeO2), which generally show a cubic morphology.

The glasses were first elaborated between 1200∘C and 1450∘C (depending on the composition) and quenched to room temperature in order to obtain homogeneous glasses. For each glass composition, thermal treatments were performed under both quiescent and sheared conditions on separate portions of the material. Thermal treatments in quiescent conditions, combined with XRD and SEM post-mortem analysis, allowed the characterization of crystallization: its thermal domain, the nature, morphology, and certain amount of crystals. For thermal treatments in sheared conditions, the glass was put in a platinum-rhodium cylindrical crucible and inserted in a stress-controlled high temperature rheometer that can reach 1450∘C. A large gap Taylor-Couette geometry was used to perform steady state and step rate experiments at different temperatures. The rheological results are then interpreted based on the crystallization

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characteristics obtained under quiescent conditions. These results show that below a critical crystal fraction, the flow of the melt is described by a Newtonian behaviour. However, above this critical crystal fraction, viscosity increases and the material exhibits a shear-thinning behaviour with a yield stress that can be well described by a Herschel-Buckley model. Finally, the influence of shear rate on the crystallization dynamics is also investigated.

Keywords: Rheology, Crystallization, glass melt, modelling, settling

Recycling of Antimony-containing photovoltaic glass in the Float Glass Industry (GRISBI project - ANR-25-CE08-4864)

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The GRISBI project, starting in 2026, tackles a major barrier to recycling photovoltaic (PV) glass: the presence of antimony (Sb). PV glass, mostly manufactured by the roller process in China and containing ∼0.1 wt% Sb_2O_5, cannot currently be recycled in the European float glass industry because of poorly understood redox interactions between Sb and Sn under the reducing conditions of the float process. Consequently, this high-quality glass is downcycled, limiting resource efficiency and the sector's potential for CO_2 reduction.

GRISBI aims to provide the fundamental physico-chemical knowledge required to overcome this limitation. Its scientific ambition is twofold: (1) to elucidate the redox equilibria and

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reaction kinetics involving multivalent species (Sb, Sn, Fe) in soda-lime glass melts; and (2) to understand the coupled diffusion and redox phenomena occurring at the liquid Sn/glass interface during the float process. These insights will define the thermodynamic and kinetic conditions allowing safe incorporation of PV cullet into float glass production, while also opening new perspectives for Sb recovery – a critical metal for European industry.

The project combines complementary experimental and modeling approaches within a consortium of five academic and one industrial partner. Three work packages address successive scales and mechanisms:

- WP1 investigates Sb speciation, solubility, and redox equilibria in glass melts as functions of temperature, pO_2, and composition.
- WP2 quantifies gas-melt redox exchange kinetics using controlled bubbling experiments and mass-transfer modeling.
- WP3 explores interfacial reactions and diffusion at the molten Sn/glass boundary, integrating thermodynamic (Calphad) and microanalytical characterization.

By linking atomic-scale mechanisms to process-scale behavior, GRISBI will establish the scientific basis for recycling Sb-containing PV glass in float glass furnaces, promoting both circularity in the glass industry and the recovery of a strategically critical element for Europe. This poster will present the project approach and initial results concerning Sb incorporation in PV glass. **Keywords:** photovoltaic glass, Sb2O3, antimony solubility, oxido, reduction state, diffusion,

thermodynamics, kinetics

Reduced uranium solubility in alkali borate matrix: a synchrotron x-ray investigation

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Boro-silicate glass matrices such as the standard ISG glass are widely used glass compositions for the nuclear waste immobilization of minor-actinides. Improving processes and long-term durability of these glasses is performed by tackling the key challenges of i) increasing concentration of radioactive elements and ii) keeping crystallization under control. Indeed, when glass undergoes crystallization, it can help stabilizing some elements or not. Here, controlling the redox equilibria in the glass is crucial as it determines the element solubility in the glass.

In order to determine the role of the different components of these complex host matrices, we investigated the relation between the borate network and the actinides (uranium) through simplified binary alkali-borate glass compositions. The speciation of U(VI) in alkali borate glasses has been previously investigated revealing the presence as divalent uranyl species of various equatorial coordination depending on the glass composition.

The present work focuses on the determination of the chemical state of uranium in alkali borate glasses synthesized under various oxygen fugacities (f_{O_2}) using x-ray absorption spectroscopies (HERFD-XANES and EXAFS) and x-ray diffraction. The influence of the nature of the alkali and its concentration has been investigated.

Our results tend to show that samples with a low alkaline content (10%) show an abrupt change upon the decrease of the oxygen fugacity in the valence state of uranium from U(VI) to U(IV), correlated with crystallization of UO_2. This behavior is not observed for glasses with a high alkaline content (30%), where no crystallization was observed and uranium solubility in the glass was maintained. U(V) presence could be assessed for the 30 mol% potassium borate glass composition. These results highlight the crucial role played by the BO_3 to BO_4^- conversion and the mechanism of charge compensation within the glass structure. **Keywords:** uranium,

synchrotron, borate, tomography, crystallization, XANES, XRD, redox

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Development of low-carbon glass frits for glass enameling applications

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Enamels are mineral coatings mainly composed of glass frit, obtained by melting oxides such as bismuth, boron, zinc, and silicon, along with inorganic pigments dispersed in an organic medium. Applied to flat glass via screen or digital printing, the enamel is dried and fired, allowing the frit to partially melt and adhere to the substrate, forming a vitreous, partially ceramized layer that encapsulates the pigments. In automotive glazing, enamels are used around the edges of glass components (windshields, roofs, rear windows) to fulfill key functions: masking bonding areas and electronics, ensuring opacity, gloss, and color (typically black), and protecting adhesives from UV radiation. The frit, representing ∼80% of the enamel's mass, is central to processing compatibility and final performance. Its fusibility, linked to glass transition temperature (T_g) and viscosity, must align with glass forming cycles (450–550 °C), and thermal expansion (CTE $\approx 90 \times 10^{-7}$ K^{-1}) must match the substrate. Current frits, mostly silica-based, require melting temperatures above 1400 °C.

My research aims to develop high-performance frits with reduced carbon impact, considering cost, raw material availability, and health aspects. We are studying promising formulation alternatives, which offer lower melting temperatures and improved environmental profiles, while possessing properties of interest for our applications. To address this, I combine experimental synthesis and thermodynamic modeling. Glasses are prepared by melt-quenching and characterized using DTA-TGA, TMA, HSM, SEM, XRD and FTIR, etc.

In parallel, CALPHAD-based modeling enables the construction of quasi-ternary phase diagrams and liquidus projections, guiding compositions toward lower processing temperatures and enhancing understanding of enamel behavior during firing. **Keywords:** enamel, low melting glass, glass coating, frit, thermodynamic modeling

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Why sustainable glass chemistry and sustainable melting concepts cannot be uncoupled

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Sustainable glass production means for the industry to fight at two borders. One is the challenge to make glass melting processes more energy efficient and less CO2 emitting. The other is to also change the glass chemistry in such way that less CO2 is emitted (directly) by the raw materials. By discussing both, sustainable glass chemistry approaches and approaches for a sustainable glass melting, it will be explained why it is normally not possible to tackle one problem without considering the other. Based on soda-reduced and soda-free glass concepts for the container- and float industry it will be explained how certain glass parameters, such as electrical conductivity, crystallisation tendency, viscosity and other parameters inevitably effect the melting approach that can be taken to a more sustainable glass production. For instance, the chemical composition directly determines the electrical conductivity at given temperatures. If, for sustainability reasons, soda is strongly reduced and with that the sodium content in the glass, it directly leads to consequences in the electrical heating of such a glass, especially in sections with colder temperatures, as e.g. the forehearth.

Keywords: soda free glass, hydrogen combustion, melting conceps, sustainability

*Speaker

Sustainable Glass for Art and Craft

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Glass is an attractive, multifaceted material with unique characteristics, including transparency, translucency, brightness, and versatility. The glass sector is recognised for its high-quality products and continuous technological innovation. Its inherent advantages-high durability, excellent recyclability, and production from abundant, low-cost raw materials such as silicates and oxides-make glass a promising pathway toward a more sustainable future. However, conventional glass production still presents significant environmental challenges, including high energy consumption and reliance on costly or critical pigments required to produce coloured or luminescent glasses.

The research presented here directly addresses these challenges by creating sustainable glass formulations and reducing the environmental footprint of production, all while supporting artistic innovation and exploration. Different strategies are being explored: (i) developing materials that introduce new surface glass coatings; (ii) substituting elements on the EU Critical Raw Materials list traditionally used to produce coloured and luminescent glasses; and (iii) sourcing glass colourants and key constituents from waste materials -such as alumina- and calcium-rich sludge generated by EPAL Water Treatment Plants, which contains oxides essential for glass formation-as well as from naturally abundant alternatives like basalt from the Azores islands.

This research in sustainable glass not only advances the technical field but also promotes meaningful collaboration between artists, designers, scientists, and industry. Together, these exchanges are driving the development of innovative glass materials with unique properties.

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Keywords: sustainable, colour, luminescence, waste, natural resources

In-situ Vitrification of Contaminated Soils Using Geomelt® ISV™ Process: Characterization of vitrified materials

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The Solveris project aims to radiologically and chemically stabilize soils and waste present in wells or pits, until ultimate storage, by developing an industrial in situ vitrification process called GeoMelt® ISV™. The project involves five key partners: ASSYSTEM, BRGM, CEA, E.C.I. MECA, and VEOLIA. The main scientific challenge is to adapt and validate the GeoMelt® ISV™ technology, originally developed in the United States, to comply with French regulatory requirements for managing radioactive waste and contamination in subsoil.

The GeoMelt® ISV™ process works by inserting graphite electrodes into contaminated ground and heating the soil through the Joule effect to temperatures between 1200–1600 °C, causing the soil to melt. Upon cooling, a glass-like monolith forms.

During this project, soil vitrification tests were conducted at various scales. At a small scale, in the laboratory, multiple vitrification tests allowed for the testing of different key parameters such as the soil melting temperature and the cooling rate of the vitrified material. At a medium scale, a GeoMelt® ISV™ pilot test was carried out on 250 kg of soil from the CEA Cadarache training site, selected for demonstrating the feasibility of the process at full scale. At this scale, the process was first implemented at Richland (USA). The French in-situ trial is expected to take place in Cadarache in November 2025.

For all these different scales, final vitrified materials were analyzed. Electronic microscopy was used for the observation of the homogeneity and composition of the vitrified materials. Raman spectroscopy and X-ray diffraction analyses validated the amorphous nature of the vitrified materials and identified any potentially crystalline phases in presence.

This poster aims to present the vitrified materials obtained according to the elaboration conditions, from laboratory scale to in-situ scale. **Keywords:** Soil, Vitrified material, characterization,

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Behavior of a fractured glass block in an unsaturated water environment

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In France, high-level radioactive waste resulting from the reprocessing of spent nuclear fuel is vitrified. It is then planned to be stored in galleries excavated within a clay-rich geological layer at a depth of 500 meters. After several thousand years, liquid water from the geological site is expected to gradually penetrate the various engineered and natural barriers (clay, steel) and reach the glass package. Prior to this, however, the package will also be exposed to high relative humidity within the confined atmosphere of the disposal cell.
During their fabrication at the La Hague facility (France), the glass packages undergo fracturing due to thermal gradients that develop during cooling. This fracturing consequently increases the reactive surface area of the glass block. It is therefore essential to characterize the crack network and to study the behavior of fractured glass under alteration conditions in order to address several key questions: Does water condense within the crack network? If so, for which crack sizes and at what relative humidity? How does the glass behave in such a potentially biphasic environment? Finally, what will be the behavior of pre-altered fractured glass blocks upon re-immersion in liquid water?
To investigate these questions, centimeter-sized glass were prepared in the laboratory and fractured by thermal quenching. To study water condensation within the crack network, we developed an original in situ observation protocol based on X-ray tomography. Experiments were conducted to validate the feasibility of this approach. The first tests involved immersing fractured samples in water and then observing them by X-ray tomography. A comparative analysis of the grayscale levels between images obtained in the wet state and those acquired on the same samples in the dry state revealed the presence of water within the cracks. This method thus demonstrates that it is possible to detect water penetration or condensation in the crack network as a function of crack size and imposed relative humidity. These observations pave the way for

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a quantitative characterization of the hygroscopic behavior of fractured glass, enabling a more precise assessment of the conditions under which water condensation occurs and how it evolves over time.

Keywords: Tomography, cracks, fracturated glass, unsaturated water phase, water condensation, relative humidity

Viability of 100% Waste Borosilicate Labware as a Feedstock for Crack-Free Additive Manufacturing by Laser Directed Energy Deposition (LDED)

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Borosilicate glass (BSG) from labware waste is rarely recycled due to its high melting point and composition, which is incompatible with standard soda-lime glass recycling infrastructure. This study investigates the viability of Laser Directed Energy Deposition (LDED), a powder-based additive manufacturing (AM) technique, as a novel, closed-loop recycling pathway for 100% waste labware glass.

Waste borosilicate labware (DURAN, POBEL) was collected, cleaned, and processed using a jaw crusher and sieving to obtain a feedstock powder. An in-house designed and constructed LDED system, equipped with a CO_2 laser ($\lambda = 10.6$ μm) was used. Powder was delivered laterally via a helicoidal powder feeder. To mitigate thermal shock, parts were fabricated on a pre-heated substrate, inside a furnace chamber. The influence of key processing variables (laser intensity, powder mass flow, scanning strategy) on geometry was studied. Final parts were characterized by XRF/ICP-OES, XRD, SEM-EDS, UV-Vis Transmittance, and Vickers microhardness.

This work successfully demonstrates that LDED is a viable AM technique for the closed-loop recycling of waste borosilicate labware. By implementing in-situ substrate pre-heating, it is possible to produce dense, crack-free, and fully amorphous glass parts that retain their original chemical composition and mechanical hardness. This process offers a promising route to manufacture complex, value-added components from a problematic glass waste stream.

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innovation programme under grant agreement No 101129967, and Spanish Government, Project PID2022-138763OA-I00 financed by MCIN/AEI/10.13039/501100011033/FEDER, UE. **Keywords:** Glass recycling, borosilicate glass waste, laser based additive manufacturing

The Glass Crisis: Are Glass Containers Obsolete Before Net-Zero?

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Glass has many faces and it has allowed human mankind to explore the universe and understand nature, it connects people around the world and brings brightness and warmth to homes. The glass industry played a crucial role in the fight against Covid as it provided vials to safely store billions of vaccine doses, but the industry is facing a crisis due to economic, environmental and technological pressures.
In the race towards net-zero the lack of renewable energy, unfair regulations, and misleading advertisements, the pressure from alternative materials rises. Glass as beverage packaging material must compete with alternative materials like aluminum, PET, and different material composites. Each material claiming to be more environmentally friendly as less greenhouse gas emissions are related to the production process, or the transportation is environmentally friendly due to lightweight packaging, while hiding the end-of-life emissions.
Amongst other reasons the increased competition with alternative materials lead to a decrease of the global container glass manufacturing capacity by 5%. This paper aims to raise awareness of the ongoing market transition and to shed light on the environmental impact of materials.

Keywords: sustainablity, roadmap, net, zero, 2050

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Valorization of Waste Materials for the Production of Glass Products

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Millions of tons of waste residues, tailings and slags are produced annually and mostly deposited in dumps. The material and especially its valuable constituents are lost, although such waste materials do often contain a lot of valuable metal oxides. As a part of rECOmine consortium within German BMBF funded WIR! program the project "VeharstGlas" (BMBF grant number 03WIR1921A) is evaluating the potential for valorization of such materials as glass products, *i.e.* glass fibers for reinforced plastics and liquid water glass.
Therefore, a data base of inorganic waste materials, like ashes, slags and sands, was set up including key properties like chemical and structural composition. Although all of them do contain typical glass constituents such as SiO2, Al2O3 and/or alkaline earth oxides, such materials can also contain components decreasing the glass forming ability. In consequence, selection criteria for the materials were derived in respect to the targeted glass product. Regarding fiber glasses, a combination of different waste streams was used and recipes were derived using traditional least square method to approach properties of commercial glass fibers e.g. used in reinforcing applications. In a second path, water glass was produced from such waste materials either by direct dissolution in lye or via melting to glass before a dissolution in water.
We will present the results of the selection process of candidate waste materials, the development of the recipes, meltability tests and the final glass products, which will be compared to commercially available counterparts. The potential of waste materials as raw materials for glass products is finally evaluated.

Keywords: waste materials, recycling, glass fibers, water glass

*Speaker

Applying the concept of glass ceramics: Influencing Factors for Target Element Enrichment during Crystallization in Waste Stream Admixtures

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Engineered Artificial Minerals (EnAMs) may play a key role in slag valorization processes for the recovery of critical elements from e.g. waste materials applying metallurgical processes. However, such critical elements must be accumulated within those EnAMs during liquid-liquid phase separation and/or crystallization.
The study demonstrates, that the accumulation of critical elements within artificial minerals is possible applying homogeneous melting to waste stream admixtures and successive targeted crystallization of the resulting glass, *i.e.* a glass ceramic approach: By melting and additional (two-step) thermal treatment. The elemental enrichment is achieved via designated, chemistry depended phase formation processes meaning that the composition of the admixtures is systematically varied.
The presentation will focus on glass ceramics synthesized from two or more waste streams selected from a wide variety of rest and waste materials (e.g. slags, ashes, residues, tailings, etc.). Analysis will focus on spatially resolved chemical analysis (Laser ablation-ICP-TOF-MS, microprobe analysis), structure and texture analysis ((electron) microscopy, X-ray diffraction, Raman spectroscopy) and the separation path of target elements during phase separation processes.

Keywords: waste materials, recycling, critical raw materials, glass ceramics

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Re-Establishing the Center for Glass Research: Industry-Driven Innovation in Glass Science

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The Center for Glass Research (CGR) has been revitalized as a university consortium uniting Penn State, Missouri S&T, and Alfred University to advance glass science through industry-guided research. Building on the legacy of the original NSF-supported CGR, the modern center integrates more than 50 faculty members and a network of industrial partners to address challenges in energy, sustainability, and composition–structure–property relationships across a broad range of applications, including packaging, optics, biomedical devices, advanced manufacturing, corrosion resistance, mechanical and optical property control, low-loss glass design for 5G/6G systems, laser–glass microfabrication, and glass-ceramic solutions. A structured Industrial Advisory Board selects and evaluates projects on a biannual cycle, ensuring alignment with industry needs while enabling shared intellectual property and coordinated multi-institutional research. CGR also leads a national workforce development pipeline through hands-on laboratory experiences, internships, and cross-university training programs. **Keywords:** glass science, industry, guided research, sustainability, property control, workforce development

*Speaker
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Porous glass functionalization for Environmental Applications

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Glass foam, conventionally used for thermal and acoustic insulation, is now being studied for catalytic applications owing to its tunable porosity, stability, and durability, thus offering an alternative to ceramic and metallic foams. In this study, open-cell foams were synthesized by optimizing working conditions (e.g., temperature, dwell time, foaming agent) in addition to monitoring weight percentages of glass powder and additives. This study demonstrates the synthesis and composition modification of open-cell glass foams to enhance their functionality for environmental applications.

Glass foam functionalization was investigated through two distinct pathways. The first involved solid-state ion exchange, replacing Na by Ag using a $NaNO_3/AgNO_3$ mixture at 420 °C for 4–6 h [**?**]. Another route employed the use of an aqueous ion exchange process. 0.4 M and 0.2 M silver solutions were used to favor the silver–sodium ion exchange. The resulting Ag-functionalized foams exhibited potential for iodine adsorption.

Glass foams were fabricated using a powder sintering technique. Float glass with an average particle size of 40–60 μm was mixed with 3 wt.% of foaming agents (TiN, Mn_2O_3, AlN, $CaCO_3$, or SiC). Controlled heat treatments were carried out between 750–950 °C with a dwell time ranging from 30 to 90 minutes. Additional acidic and basic treatments were performed to induce extra porosity. The synthesized foams were evaluated using XRD, TGA, He pycnometer, and SEM techniques. Only TiN, Mn_2O_3, and AlN were selected for further experimentation because they prompted open porosities ranging between 60–75%.

[**?**] A. Nahal, *Journal of Materials Science*, 2020 **Keywords:** Glass Foam, Environmental Applications, Filtration

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Horizon Europe project H2GLASS: First campaigns of industrial scale H2 combustion trials in the oxy-fuel glass melting furnaces of Steklarna Hrastnik and Owens Corning

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Within the framework of the Horizon Europe H2GLASS Project, in preparation for the long-duration H_2 combustion trials with green H_2 produced in situ exploiting the project's electrolyzer that will take place starting Q1 of 2026, several short-duration (e.g., one week long) experimental campaigns of grey H_2 (delivered on site by trucks) combustion trials took place in the industrial demonstrator sites of Steklarna Hrastnik and Owens Corning.

The tests were carried out respectively in an oxy-fuel fired furnace producing high quality flint glass for the manufacture of premium beverage containers, and in an oxy-fuel fired furnace producing continuous filament boron-free E-glass fibres for composites reinforcement applications, in both cases retrofitting the existing burners and skids, without changes or tailored optimizations to the furnace design.

These preliminary testing campaigns were aimed at assessing the impact of the combustion of various H_2/Natural Gas blends on the gaseous emissions, on glass quality, and on the energy transfer by flames to the melt and raw materials.

The trials involved feeding different numbers of burners at a time with fuel mixtures ranging from 0% to 100% H_2, thus experimenting combustion configurations where H_2 accounted respectively for up to 60% (in Steklarna Hrastnik) and 100% in volume (in Owens Corning) of the total fuel input, thus contributing respectively up to 33% and 100% of the total combustion power required for glass melting, which translates into an approximately equivalent reduction in direct combustion CO_2 emissions.

During the trials, SSV carried out simultaneous multi-parametric measurements in several points of the furnace systems, deploying its MCM – Multipoint Continuous Monitoring approach

*Speaker

for glass furnace behavior characterization, also including endoscopic thermal imaging of furnaces and flames with a dedicated portable IR borescope.

This presentation will highlight the main results and evidences gathered from these on-site measurements, providing a first assessment of the impact of increasing H_2 concentrations in fuel on combustion, emissions, and production of the studied furnaces. **Keywords:** Hydrogen,

H2GLASS, Combustion, NOx, Furnace, Decarbonization, CO2

Innovated Self-Healing Glass Seal Composition for Electrochemical Cell

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A current main challenge in High Temperature Electrolyze and Solid Oxide Fuel Cells (HTE/SOFC) technologies is the glass / metal sealing to prevent any leakage. In the literature, various types of seals are studied including compressed, brazed and glass seals. Glass seals appear to be the most promising technologies, provided if the glass remains stable over time.
Two different types of glass seal can be differentiated, compliant and rigid seal. Compliant seals have a softening point lower than the working temperature, while rigid seals have a higher softening temperature. This fact gives to the seal different properties. A compliant seal has the advantage of easy to seal the capacity to self-repairing cracking but with a lower thermal and chemical stabilities, than rigid seals which require a higher sealing temperature, which can induce cell degradation.
In this present study, we propose a new way for obtaining a glass seal that combine characteristics of both compliant and rigid seal. Throughout this presentation, the amount of the compliant seal and its influence on various properties (such as densification and sealing temperatures) were studied. Crystallization at working temperature and diffusion were characterized by SEM-EDX, XRD and NMR. These results indicate that a diffusion occurs between the two glasses, inducing the crystallization of new phases. However, this type of seal shows a promising thermal and chemical stabilities for 960h at working temperature and an autonomous self-healing capacity at 800∘C.

Keywords: Glass seal, SOEC/SOFC seal, self healing materials

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In-situ Vitrification of Contaminated Soils Using Geomelt® ISV™ Process: Latest Results of the SOLVERIS Project

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This presentation describes the latest results of the Solveris project, which aims to radiologically and chemically stabilize soils and waste present in wells or pits, until ultimate storage, by developing an industrial in situ vitrification process called GeoMelt® ISV™.

The project involves five key partners: ASSYSTEM, BRGM, CEA, E.C.I. MECA, and VEOLIA. The main scientific challenge is to adapt and validate the GeoMelt® ISV™ technology, originally developed in the United States, to comply with French regulatory requirements for managing radioactive waste and contamination in subsoil.

The GeoMelt® ISV™ process works by inserting graphite electrodes into contaminated ground and heating the soil through the Joule effect to temperatures between 1200–1600 °C, causing the soil to melt. Off-gases produced during this process are collected and treated. Upon cooling, a glass-like monolith forms, with radionuclides integrated into a stable and durable vitreous matrix.

A contaminated site (in CEA Cadarache) was selected for pilot tests, using a multi-criteria analysis based on physicochemical properties, geological characteristics, and site accessibility.

With the soil of the selected site, extensive laboratory and small-scale pilot pre-tests were carried out, including a 200 kg pilot test at the Veolia GeoMelt® pilot facility in Limay, France. The structure and properties of the vitreous material were studied.

A pilot unit was then designed and built, and full-scale pilot testing was realized from October 2025 to March 2026. These tests examined various process configurations, the use of radionuclide spikes to study glass homogeneity and durability, and the off-gases composition.

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The project's ultimate goals include demonstrating that vitrified blocks can be safely stored immediately after production, preserving ANDRA storage capacities, and developing a comprehensive industrialization strategy, including life cycle analysis and multi-criteria sector evaluation covering environmental performance, socio-economic benefits, and social acceptability.

The French government and ANDRA, as part of the "France 2030" investment plan, support the Solveris project. **Keywords:** Soil, waste, in situ, vitrification, Geomelt, radioactive waste

Research and development of nuclear waste vitrification in China

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The total installed nuclear power capacity in China has reached 125 GW in 2025, where 53 units is under construction and will generate _˜0.6 GW electric power by 2030. With such rapid growth of nuclear power, huge amount of nuclear waste will be soon produced from nuclear power plants and reprocessing plant. The high-level waste in China is going to be immobilized in the borosilicate glass before the long-term geological disposal, while, vitrification of intermediate- and low-level wastes is an option. This talk will give an overview of recent research and development of nuclear waste vitrification in China. The main efforts are concentrating on (ii) development of the nuclear waste vitrification technology, including thermal plasma treatment furnace, cold crucible induction melter and Joule heating ceramic melter; (ii) development of glass formulation for kinds of wastes, including the high-level waste and the incineration ashes from dry active wastes; (iii) development of waste glass property study, including investigations of crystallization behavior and melt properties. Finally, opportunities and challenges for nuclear waste vitrification will be discussed.

Keywords: Nuclear waste, vitrification, waste glass.

*Speaker

Microwave-Plasma Furnace Melting of Recycled Green Container Glass: Effect of Melting Time and Atmosphere

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The global glass industry is facing growing pressure to adopt sustainable energy sources amid rising fossil fuel prices, stricter environmental regulations, and the urgent need to mitigate carbon emissions. As glass melting is one of the most energy-intensive processes in manufacturing, innovative approaches are essential to achieve decarbonization goals. This study focuses on the melting behavior of recycled green container glass using microwave-plasma furnace technology, emphasizing the effects of melting time and atmospheric conditions on process performance. Microwave plasma provides an efficient means of delivering high thermal energy with enhanced control of the melting environment. The research investigates how this technology affect key parameters such as melting efficiency, glass homogeneity, and color quality. Experimental results are presented to evaluate the feasibility, benefits, and challenges of integrating hydrogen and microwave plasma into industrial-scale glass furnaces. The findings contribute to advancing sustainable melting technologies and support the glass industry's transition toward carbon-neutral production.

*Speaker

Introduction of hydrogen during glass melting affect's structure and properties

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The use of hydrogen as a substitute for fossil fuels is a prominent focus in sustainable energy research, attracting significant attention from both academic groups and industrial entities. However, the impact of hydrogen-based fuel systems on the structure of green container glass remains largely unexplored. In this study, we investigate these effects through Raman and FTIR spectroscopy. Our analysis provides insights into structural modifications induced by hydrogen, contributing to a deeper understanding of its implications for green glass materials and their performance in practical applications

*Speaker

Trace heavy metal ions detection from β-Cyclodextrin Modified Gold-Core Silver-Shell Nanoparticles on glass substrate

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With heavy metal ions pollution becoming increasingly serious, trace detection methods have become particularly crucial. Lead ranks among the most toxic heavy metals to humans. In the current research, a surface-enhanced Raman scattering (SERS)-based detection method for lead ions is proposed. A β-cyclodextrin-modified gold-core-silver-shell nanoparticle (β-CD–Au@Ag NPs) material was synthesized via hydrothermal and ion-reduction methods, and coated on a glass substrate. Microscopic structure, elemental distribution, and morphological analyses confirmed the uniform spherical morphology with an average diameter of approximately 17 nm.

The Au@Ag NPs exhibited a minimum detection limit of 10^{-13} M for crystal violet (CV) dye analyte, with a 1.77×10^8 enhancement factor. Upon Pb^{2+} addition, β-CD on the Au@Ag NPs surface reduces Pb^{2+} to metallic Pb, which coats the signal molecule surface. This simultaneously diminishes the Au@Ag NPs LSPR effect and blocks direct contact between the analyte and Au@Ag NPs, causing a reduction in CV Raman signals. This achieves indirect Raman detection of Pb^{2+}.

The lowest detection limit for lead ions using Au@Ag NPs on a glass substrate was determined to be 10^{-10} M, significantly below the World Health Organization (WHO) maximum permissible level of 5×10^{-5} M for Pb^{2+} in drinking water. Furthermore, Au@Ag NPs-based fiber probes were applied for Pb^{2+} ion detection in drinking water. The detection also exhibited favorable repeatability and stability.

This research offers a potentially effective approach for the trace detection of lead ions in the environment. **Keywords:** Surface, enhanced Raman scattering, Noble metal nanoparticles, Optical fiber, LSPR

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Optimization of full cavity NiCr coating by cold spray on cast iron glass molds for glass industry

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Nickel-Chromium based coatings are well known for their excellent corrosion resistance, which makes them particularly suitable for demanding applications in the glass industry. This is particularly important when dealing with abrasive glass, as it is essential to protect the substrate from abrasion wear. In this context, manufacturers require a uniform coating that completely covers the glass mold cavities, presenting a well-controlled thickness without defects. Achieving such specifications relies on a high metallurgical quality, characterized by strong interfacial adhesion between the coating and the substrate, minimal porosity, and absence of cracks. Cold spray is an emerging additive manufacturing process used to deposit metallic particles on a substrate without melting. In this study, a nickel-based alloy was successfully deposited onto a cast iron substrate. The main challenge of this study was to obtain the required coating thickness without negatively affecting adhesion, considering the mold geometry complexity and the intrinsic limits of the cold spray technology. The effects of various process factors on the metallurgical properties of coatings, such as powder composition (NiCr 80/20, NiCr 50/50), spraying trajectory, and surface preparation (including surface roughness, blasting powders, laser surface texturing, and in-situ micro-forging), were investigated. Coating analyses were performed, including coating thickness measurements, microstructural characterization, adhesion testing, and glass/metal contact test. Microstructural examinations were carried out using optical microscopy, scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDX). Adhesion strength was evaluated through a bonded pin test. The results showed a significant influence of surface preparation and powder type on coating adhesion (reaching up to 80 MPa) and achievable thickness (up to 2 mm without loss of adhesion). Controlling adhesion and coating thickness is crucial to ensuring efficient heat transfer between mold and glass, thus improving the final glass quality.

Keywords: cold spray, additive manufacturing, NiCr coating, cast iron, microstructure, adhesion tests, micro, forging

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Effect of Process Parameters on the Production of Water Glass from Recycled Silica for CO_2 Laser-Assisted Additive Manufacturing

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Additive manufacturing of glass has emerged as an innovative alternative to conventional glass-production methods, enabling the fabrication of complex and high-precision components. Among the various approaches, CO_2 laser-based additive manufacturing using water glass (sodium silicate) as a precursor has shown strong potential for producing silica-rich structures with specific geometries. This study focuses on the sustainable synthesis of water glass from recycled fused silica waste to support environmentally responsible glass printing processes.
The process is based on the hydrothermal dissolution of amorphous silicon dioxide (SiO_2) in alkaline media, specifically sodium hydroxide solutions with pH values above 11. The objective was to investigate the influence of particle size, temperature, reaction time, SiO_2–Na_2O molar ratio, and solid content on the dissolution rate of silica and the rheological behavior of the resulting sodium silicate solutions. The results revealed that smaller particle sizes and higher temperatures significantly improved dissolution rate, while the SiO_2–Na_2O ratio and solid content strongly affected the viscosity and concentration of the produced solutions.
The results confirmed that fused silica waste can be efficiently dissolved and transformed into a chemically stable water glass with viscosity values within the suited range for precise deposition and layer formation in additive manufacturing processes.

Keywords: Waterglass, additive manufacturing, Viscosity, dissolution rate

*Speaker

Stabilization of Color and Batch Layer during Amber Glass Melting within All-Electric Furnaces (AEF)

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1

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Conventionally, the commercial production of amber glass (e. g. brown glass for beer bottles) is performed in regeneratively fired melting furnaces. However, the industrial implementation of amber glass production in all-electric melting furnaces (AEF) has not yet been realized due to process instabilities, particularly related to the batch coverage and final glass coloration.
Within a research project, supported within the framework of Industrial Collective Research (IGF) by AiF – Federation of Industrial Research Associations e.V. provided by the Federal Ministry for Economic Affairs and Energy, under the funding code (01IF22664N), the necessary technological conditions for producing amber (brown) container glass in an AEF were successfully demonstrated on a laboratory scale. This was achieved without adapting specific furnace design parameters, thereby enabling the consistent melting of amber glass in a lab-scale all-electric furnace. The experimental results confirmed that a stable and continuous melting process for amber glass can be realized in a lab-scale cold-top all-electric furnace. The key to this success was the combination of an optimized amber batch composition and the precise process control provided by the heating system.

Keywords: amber glass, ll, electric melting furnaces, Batch Layer, amber batch composition, Stabilization

*Speaker

Full-Electric Glass Melting Furnaces: From the Memory of the Borel Furnace to Recent Advancements Achieved at ARC Group

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Electric melting has undergone significant evolution over the past century. The first part of the talk aims to present a historical exploration of the Borel electric furnace (Romont, Switzerland). The Borel furnace has a distinctive full-electric design associated with the Fourcault vertical drawing process. Its specific configuration makes it a valuable case study for understanding the constraints of early electric melting, including electrode arrangement, glass ribbon conditioning, and the delicate thermal balance required to stabilize the vertical drawing operation. Drawing on technical archives and industrial testimonies, this first part aims to preserve and transmit the history of this unique technological heritage in flat glass production. The second part provides an overview of the fundamental principles of electric melting in cold-top furnaces for opal glass, and presents the recent advancements achieved at ARC for the production of soda-lime silicate glass in full-electric furnaces capable of meeting today's environmental and industrial performance requirements.

Keywords: Electric melting, Fourcault process, Cold top furnace, Tableware, ARC Group

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Lubricant free glass mold material

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In this work, we studied the use of new mold materials for pressed glass process. These materials were shaped to be adapted on an **automatic** and **monitored press** to allow real condition press tests. As speed and part of mold position can be calibrated, reproductive press cycles can be performed. **Custom programs** can be choosen and adapted to different kind of mold geometry or glass viscosity properties.
Data, as the **in situ mold temperature**, have been monitored and collected, and can be correlated with mold material evolution. In fact, the mold surface in contact with the glass was analyzed and compared with traditionnal metallic mold reference at different step of wear. Althrough, the glass pieces obtained with the mold at different steps of the mold life are also analyzed to determine the **impact of the material degradation on the glass surface**.
Comparative tests to determine the impact of using lubricant, to avoid glass adherence on hot mold, on the new mold material were also performed. The **new material solution** shown that the use of **lubricant is not mandatory**, helping to reduce the health impact of press process.

Keywords: Press, Material, Mold, Lubricant

*Speaker

The Pixel

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Keywords: glass facade ceramic print pixel curtain wall leed gold

*Speaker

The batch-to-melt conversion - batch chemistry, energetics and melting rate

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The present contribution focuses on the role of batch chemistry as well as on the energetics and overall reaction rate of the batch-to-melt conversion. During industrial batch melting, a heterogeneous particulate raw materials mixture at normal conditions (25 ∘C, 1 bar) is converted to a homogeneous melt made available for further manufacturing at some upper reference temperature T-ex (typically the temperature of the melt at furnace exit). The following aspects will be highlighted: (1) Energetics: Knowing the intrinsic heat demand of the batch-to-melt conversion is indispensable for any quantitative approach. A well-established approach via thermochemic calculations is briefly presented, (2) Reaction path calculation and melting kinetics: A general approach to the conversion kinetics is still missing. It is true, there are many experimental methods ranging from the *mg* to *kg* scale, like DTA-TG, DSC, hot stage microscopy, high-T XRD, batch-free time tests, tests in transparent reaction tubes etc. But these methods do not allow a systematic approach to the kinetics; they rather give empirical insights on a case-by-case basis only. A more systematic approach is proposed here: In fact, a batch mixture at normal conditions is stable for kinetic reasons only. The equilibrium state is the polycrystalline state corresponding to the glass composition, as read from the phase diagram, plus the batch gases. Upon heating, the system passes through a sequence of solid-liquid equilibria, eventually reaching a homogeneous melt above its liquidus temperature. This sequence marks – at any given temperature – the target towards which a given batch reacts. The temperatures of onset and maximum turnover are identified with the solidus and liquidus temperature of the system, respectively, and the termination of turnover with the viscosity level of 10 Pa·s of the rersulting melt. From these results, a dimensionless reaction variable a(T), $0 < a(T) < 1$, is derived which, in turn, yields a complete reaction path for any given batch composition. The transition from the reaction path variable a(T) to the reaction rate a(t) is achieved via a heat radiation model.

*Speaker

Highly porous 3D-printed 70S30C bioglass scaffolds from engineered silicone-based emulsions

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70S30C (70 mol% SiO2, 30 mol% CaO) bioglass is recognized as one of the most promising bioceramics for bone tissue engineering. It is often considered as a reference composition for sol-gel derived bioglasses, due to its simplicity; however, the controlled fabrication of amorphous structures, free from undesirable crystalline phases in oxidizing atmosphere, remains a critical challenge. In this work, a 'third way' between conventional glass melting and sol-gel processing is explored, enabling the coupling of synthesis and shaping, also through additive manufacturing. Specifically, commercial silicone resins mixed with photocurable acrylates form the basis for pastes processed by direct ink writing to obtain reticulated scaffolds, later stabilized by UV curing. Upon firing in air at 800∘C, the silicone component provides amorphous silica, while Ca ions are introduced from calcium nitrate tetrahydrate. A key aspect is the quasi-molecular distribution of the CaO precursor, enabled by dissolving the salt in water and dispersing the solution as an emulsion within the silicone/acrylate blend. The resulting scaffolds are fully amorphous, nearly crack-free, and exhibit a unique hierarchical architecture: macropores from printing are combined with pores in the struts, arising from salt decomposition, water release, and the polymer-to-ceramic transformation of the silicone. In addition, the strategy proves highly versatile allowing the fine tuning of composition, porosity, and architecture, paving the way for scalable and customizable scaffold manufacturing for bone regeneration and other biomedical applications.

Keywords: bioglass, silicone, emulsion, polymer, derived ceramics, additive manufacturing

*Speaker

Process development for lamination of functional inlays into curved glass panes

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Laminated glass, consisting of glass panes and polymer interlayers, has long been used as safety glass which offers several key advantages over ordinary glass, such as safety and injury prevention, security and impact resistance, structural integrity, optical clarity as well as design flexibility in respect to smart glass technologies. With reference to the last, the layered structure opens up the possibility of embedding functional elements such as solar cells, lighting elements, radiation-modifying films or displays while simultaneously protecting them from environmental influences. However, the integration of such inlays is challenging due to the relatively high processing temperatures and pressures involved in the lamination process, as sensitive elements can lose their functionality.
The production of curved laminated glass is particularly complex, as it also requires ensuring a homogeneous distribution of the interlayer and avoiding mechanical stress. New approaches for the targeted control of temperature and adhesion during the lamination process could pave the way for innovative, three-dimensionally shaped laminated glass that combines functional properties with the advantages of safety glass.
The poster illustrates the path to successfully laminated, bent glass panels with functional inlays, like solar cells or electrochrome films, via an optimized bending and lamination process. It will be discussed how to avoid common problems like pressure marks, air pockets, and delamination.

Keywords: Laminated glass, Polymer interlayer, Functional inlays, Glass lamination process, Delamination

*Speaker

Simultaneous measurement of gaseous NaOH and SO2 in industrial glass furnaces by means of an optical sensor

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The effects of fuel switching from natural gas to low carbon heating technologies (hydrogen, biofuels and hybrid heating) have been investigated in a confidential GFL (Glass Futures Ltd) membership project. The investigation was carried out on the Glass Futures' pilot furnace and had a focus on the reactive evaporation of (chemically aggressive) NaOH from the melt and on the release of SO_2 fining gas.

An optical sensor system further developed for simultaneously measuring gaseous NaOH and SO_2 in-situ in hot flue gases was applied. This sensor was installed and tested on the Glass Futures pilot furnace for a range of furnace scenarios. The advantages of this optical sensor over other, specifically extractive, measuring techniques include:

- In situ measurement, providing an average concentration of SO_2 and NaOH gases over an optical path, e.g., over the cross section of a flue gas channel or the width of a furnace chamber
- Continuous measurement
- Non-intrusive optical measurement without disturbance of the process

In this presentation, other important applications of the results obtained from the sensor are highlighted, including the use for (1) control of Na_2SO_4 particulate dust formation in the flue gases and (2) continuous monitoring of glass melt redox changes and the sulphur balance of a glass furnace.

The sensor enables the optimisation of the burner settings to minimise the (volatilisation of the gaseous precursors of the) dust.

By continuously measuring the SO_2 fining gas concentration in the hot flue gases, changes in the glass redox state can be predicted at an early stage. Furthermore, the sensor will enable

*Speaker

continuous monitoring of the progressing sulphur balance of the furnace. **Keywords:** In situ

optical sensor, Industrial melting furnace, hot flue gases, gaseous NaOH, SO2 fining gas, decarbonisation, redox

Challenges and Early Successes of running a 30 tonnes per day pilot line

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Glass Futures is a not-for-profit, membership-based, research organisation, based at its Global Centre of Excellence in St Helens, UK. The remit of the organisation is to enable its members from across the glass supply chain and beyond to collaborate in areas which affect all parties, with a particular focus on decarbonisation of the glass-making process and its upstream and downstream activities.

At the heart of the new Glass Futures' facility is a 30 tonnes/day pilot-scale glass furnace, due to start up in Summer 2025. The facility has been designed to enable the industry to develop and trial new technologies at an industrially relevant scale, without risk to their commercial manufacturing assets, thus providing increased confidence for manufacturers looking to invest in low-carbon technologies such as alternative fuels, CCUS technologies and new raw materials.

The operation of such a globally unique research asset is a journey into the unknown, with procedures and techniques which are common in the glass manufacturing sector having to be adapted to manage experimental programmes rather than manufacture for sale. In this paper, an overview of the facility is provided, the initial challenges and successes of operating such an asset are discussed and key learning points are highlighted. Keywords: R&D, sustainability, net zero, carbon neutral, collaboration

*Speaker

Heraeus' Innovative DPH Alloys: Revolutionizing Glass Production wit Enhanced Performance and Sustainability

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Glass plays a crucial role in various sectors, from construction to electronics and lifestyle applications.

Technical glasses require significant amounts of precious metals, primarily platinum and rhodium.

To address these challenges and improve efficiency, Heraeus has developed Oxide Dispersion Strengthened (ODS) precious metal alloys—advanced materials that combine a metal matrix with fine, insoluble oxide particles to deliver exceptional mechanical strength, particularly at high temperatures.

Heraeus's ODS alloys—marketed as DPH—offer significant advantages: enhanced heat resistance, extended tool lifespan, and improved process efficiency. Notably, modern Pt-DPH alloys can fully replace rhodium, which is both costly and incompatible with certain glass compositions. Additionally, the reduced precious metal content contributes to lower CO_2 emissions, as mining these materials is energy intensive.

Recent innovations include DPH Strong, which delivers unmatched creep resistance, and DPH Flex, which combines high creep resistance with superior ductility. These advancements position Heraeus at the forefront of sustainable and high-performance glass manufacturing. **Key-**

words: Platinum, Rhodium, Precious Metals, ODS, DPH, alloys, Heraeus, sustainabilty, special glass, technical glass

*Speaker

How Numerical Simulation Can Reveal the Underestimated Criticality of Refractory Block Thermo-Mechanical Behavior on Glass Furnace Lifetime

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The thermo-mechanical behavior of refractory materials has often been underestimated regarding corrosion evolution and glass tank expected duration.

The lifetime of soldier blocks is partially driven by their mechanical behavior during the heating-up phase—a critical period for the formation of stresses and cracks at early stages of furnace operation—and by the evolution of these stress patterns during block wear. Indeed, crack formation can significantly accelerate localized corrosion processes, such as upward-drilling corrosion.

SEFPRO has developed an original approach, thanks to FEM modeling, to assess strain and stress fields inside refractory blocks during these different periods using numerical simulation.

We developed a 3D model that integrates SEFPRO in-depth knowledge of refractory materials' thermal and mechanical properties as a function of temperature. This allows us to take into account the complex thermal expansion behavior linked to the zirconia crystallographic phase transformation in fused-cast AZS, as well as stress relaxation by visco-plastic behavior.

The impact of different parameters, such as heating-up conditions and block cooling methods used to limit corrosion, will be discussed in the presentation. Based on these results, SEFPRO can support glassmakers in their refractory lining design, cooling processes, and heating-up strategies to optimize glass furnace lifetime.

This new numerical tool opens very interesting perspectives for understanding and improving refractory material corrosion resistance in glass furnaces. **Keywords:** Fused cast AZS, corrosion, lifetime, thermo mechanics, strain, stresses, cracks, glass furnace, FEM model, simulation

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Towards Climate-Neutral Glass Production: Integrated High-Temperature Sensing, Renewable-Fuel Combustion, and Digital Twin Development at GlasLAB Torgau, Germany

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The GlasLAB – Ad vitam project (100704719, funded by the European Union within JTF and co-financed by tax revenue on the basis of the budget approved by the Saxon state parliament) aims to enable climate-neutral and energy-efficient glass production by preparing a state-of-the-art research melting furnace with advanced analytics, flexible renewable-fuel burner systems, and high-fidelity digital twins. The initiative is closely aligned with the emerging GlasLAB Torgau innovation hub and supports regional industrial transformation in North Saxony in Germany. Its work focuses on seamlessly integrating experimental research, process monitoring, and simulation-based optimization to accelerate technology readiness for sustainable glass melting.

One of the key objectives is the development of an integrated high-temperature data acquisition and monitoring framework. To support high-resolution online process observation, multiple optical sensor systems are being evaluated for *in situ* operation in glass furnace environments at the example of the considered small-scale research melting tank.

Process modeling advances complement experimental work. Computational fluid dynamics (CFD) models of initial furnace geometries showed inadequate temperature levels at the ports; redesign efforts moved burner and exhaust openings to lateral positions, yielding more homogeneous heating and improved target temperature distribution. Simulations were performed using RANS (Reynolds-Averaged Navier-Stokes) turbulence closures and non-premixed combustion, with future work targeting hydrogen combustion and large-eddy simulation (LES) for enhanced resolution of flame dynamics and radiation coupling. To support rapid scenario exploration

*Speaker

and real-time process prediction, digital-twin workflows employing machine learning have been initiated. The project will also generate a research and technology roadmap, supported by close engagement with industrial furnace manufacturers and academic partners.

Overall, results to date demonstrate strong feasibility of integrated sensing, hydrogen-capable combustion, and AI-assisted modeling approaches for sustainable glass melting. The project establishes a knowledge and infrastructure foundation for high-impact decarbonization research, preparing the glass industry for a flexible, data-driven, and renewable energy future. **Keywords:**

sensing, hydrogen combustion, furnace simulation

Optimizing High Boosting Furnaces: A Modeling Approach towards Innovative Solutions

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In the context of the glass industry's transition to decarbonized glass production, the adaptation of melting technologies is critical. This study emphasizes the role of advanced modeling techniques in understanding and optimizing electric melting processes in highly boosted furnaces.

We begin by modeling the effects of high electrical power on fused cast refractories, identifying key challenges that glass producers face in this transition. Our modeling closely replicates a series of test campaigns, allowing for a detailed analysis of critical parameters of glass as well as refractory materials. Operating parameters, such as the amount of electrical power and the impact of the electrode heights, are also investigated.

Through our expertise in numerical simulation and experimental testing, we aim to provide valuable insights that will guide our customers in selecting the most suitable solutions for their high boosting furnaces. This research not only addresses immediate operational challenges, but also anticipates future demands and complexities associated with sustainable glass manufacturing. **Keywords:** Electric, Boosting, Modeling, Refractory

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Microstructural analysis of ultra-short pulse laser welded glass-metal joints

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Ultra-short pulse (USP) laser technology has revolutionized glass manufacturing by enabling processes often referred to as "cold" machining. Operating on timescales far shorter than those dictated by classical thermodynamics, USP laser–glass interactions minimize heat diffusion and significantly reduce thermal effects within the bulk material. This capability allows precise material modification without compromising structural integrity and opens a broad range of applications, from micrometer-scale structuring and functionalization to waveguide writing and glass-to-glass or glass-to-metal welding. The highly localized energy deposition ensures that only a minimal surrounding volume is affected, which, in welding processes, promotes stable bonding while preserving the intrinsic properties of the glass. The present study focuses on the analysis of the glass in and around the glass-metal weld seam to gain a deeper understanding of the fundamental mechanisms governing the USP laser welding process. A comprehensive investigation is conducted into various glass-metal and crystal-metal combinations, encompassing borosilicate glass, sapphire, and fused silica, along with aluminum, copper, and stainless steel. An analysis of the morphology is performed using electron microscopy techniques. Furthermore, the residual stresses are mapped, providing a detailed insight into the structural integrity and deformation mechanisms of the materials. The results obtained demonstrate the influence of laser parameters on stress distribution, and consequently, the mechanical performance of the weld. With this understanding, it becomes possible to achieve mechanically stable joints exhibiting shear resistance exceeding 50 MPa. These findings provide a robust foundation for the development of miniaturized devices for advanced applications in optics, medicine and electronics.

Keywords: Ultrashort pulse laser, welding, glass, metal

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CO2 savings in furnace heating and effects on downstream equipment

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One of the most discussed issues when selecting a new furnace is the way of heating.Recuperative, regenerative or Oxy fuel and all this with maximum electric boosting? Any decision will influence the choice and the possibilities for downstream equipment.
So the view should be widened as it influences more parts than expected in the beginning. So a decision for energy saving in the furnace could lead to energy spoiling in other areas. Mostly this appears at a later stage and astonishes decision makers.
The paper will show the effects of the decision for the type of heating for the downstream equipment. Starting from energy recovery till flue gas treatment. Different solutions will be compared and key questions will be outlined on the basis of realized plants.

Keywords: CO2 saving, Oxyfuel, regenerative furnace, flue gas treatment, energy recovery, ORC

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Laser irradiation to alkali ion conducting glass for all-solid-state battery

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In oxide-based all-solid-state batteries, grain boundaries impede ion conduction, necessitating materials and processes that facilitate interface formation for developing high-performance batteries. We have proposed an oxide solid battery composing the glass-ceramics and the solid electrolyte ceramics. The cathode precursor glass exhibits softening flow during heating at the interface with solid-electrolyte and then crystallizes to form a close interface between them. And it is well recognized that the spatially selective heating of oxide glasses by laser irradiation is an innovative technique to form melts, micro-crystal architecture due to hyper thermal field. In this study, we have applied tin-iron-sodium-silicate glass as the anode electrode to a solid electrolyte consisting of Na3Zr2Si2PO12 (NZSP) by screen printing and irradiated with a laser beam at a wavelength of 1064 nm and indicated melting of the anode layer and formation of a hetero interface with the solid electrolyte.
The target compositions of the glasses were 55SnO-15Na2O-yFe2O3-(30–y)SiO2 (y = 0, 2.25, 4.5, 6.75, 9 mol%) (yFe-SNS) prepared by melt-quenching method followed by mechanochemical method. The anode electrode ink was prepared by mixing 6.75Fe-SNS glass powders, including polyimide binders (a weight ratio of 85:15), with N-methyl-2-pyrrolidone (NMP). The anode electrode ink obtained was then painted to NASICON-type solid electrolytes using a screen-printing method. The fiber laser oscillating a pulsed laser with a wavelength of l=1064 nm was used as a light source. The laser spot diameter was about 60 μm, the laser power was fixed at P=3 W, and the scanning speed was changed to S=100 mm/s and higher. The anode coated-solid electrolytes were placed, and laser irradiations were performed on an area of 20 mm ' 20 mm and a laser hatch of 40 μm.
In correlation with the energy density of the laser beam, the melt-solidified layer of the anode active material formed a droplet-like or good wetted interface with NZSP as shown in Figure 1. An all-solid-state sodium-ion battery was operated with the hetero-interface formed by laser irradiation at a laser power of 3 W and a scanning speed of 100 mm/s.

Keywords: Laser, induced melting, additive manufacturing, all, solid, state batteries

*Speaker

Continuous glass melting method under the controlled atmosphere

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The chalcogenide glass with infrared-transparent is applied for the optical element of IR optical system. The telluride glass is watched with interest due to its prominent transmission characteristics. This glass must not be molten and formed in the air to obtain high transparency. It is because oxygen atoms in the glass structure make the absorption of far infrared rays. Such air-sensitive molten glass is generally produced in a sealed ampule tube or a glove box. This method has less productivity. Therefore, the industrial process with high productivity is required to spread the glass throughout the market. In this study, we propose a continuous melting method to produce the glass with high infrared-transparency under the controlled atmosphere. This method can achieve the large amount industrial production of the infrared-transparent glass with high optical homogeneity.

Keywords: Continuous process, Chalcogenide

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Impact of melting conditions on viscous behavior and crystallization tendencies in iron-bearing aluminum silicate glasses

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Lab-scale melting experiments can provide deeper insights into the properties and dynamic behaviors of glass. Within the mineral wool industry, lab-scale melt experiments have previously been used to study the effects of chemical composition, particle size distribution, and heating rates on the viscous shrinkage and crystallisation behavior of iron-bearing aluminum silicate glasses (1). In this work, we investigate the impact of glass melt preparation conditions, specifically melting temperature and duration, on the shrinkage and crystallisation behavior of the produced glass. We find that these variables lead to a significant change in the shrinkage behavior of particle pellets produced from the crushed glasses. We attribute this change in shrinkage behavior to the incomplete homogenization of the amorphous glass melt, resulting in a compositionally inhomogeneous glass that, in turn, alters its shrinkage and crystallisation behaviors. More attention to the melting conditions at the lab scale could lead to a better understanding of the industrial melting process and the properties of glass products, thereby increasing the value of lab-scale experiments.

Keywords: Shrinkage, viscous deformation, crystallization, homogeneity

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AI optimization for forming equipment's - Productivity, failure and safety aspects

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After having automated and digitalized our lines, the Artificial intelligence is the next step for the container industry to master the performances of the forming machines. The first target is to make more rapid and precise analysis on complex and extensive datasets. This can be done online for the standard parameters of the process. The second target is to have access to new parameters such as events (glass jams, fire...). The AI processing of these videos allows the detection and the classification all the events that occur in our facilities. The events are detected and classified automatically by AI tools and the root cause analyses are being conducted by the operators. The AI tools can interact with the equipment, particularly for the events related to safety. Less defects, less events, less risk and less downtimes, higher safety but and a new type of management for the forming machine.

Keywords: AI optimization, glass forming, productivity

*Speaker

Room-Temperature Bonding of Ultrathin Freestanding Glass Films for Optical and Biomedical Applications

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The conventional formation of thin glass films often requires high-temperature processing, leading to critical defects such as cracking, warping, and peeling due to a mismatch in coefficients of thermal expansion or damage to thermally sensitive substrates. To overcome these issues, we have developed a Room-Temperature Bonding (RTB) technique using ultrathin freestanding glass films (UTFG), typically less than a few micrometers thick, fabricated via glass blowing. This adhesive- and heat-free method is essential for constructing multilayer structures required in 3D integrated optical circuits and composite biomaterials.

For optical applications, tellurite glass, known for its wide optical transmission and high refractive index, was successfully bonded onto diverse optical materials, including silicate glass, Si, sapphire, and $LiNbO_3$, at room temperature. The achieved bonding strengths, measured by the Obreimoff-Metsik method, reached up to approximately 400 mJ/m^2 on the same tellurite glass substrate. This robust adhesion relies on the formation of strong interfacial chemical bonds, which are favored by reducing the surface hydroxyl group density.

For biomedical applications, we focused on integrating bioactive and antibacterial functionalities. Bioactive silicate glass (45S5) UTFG (1–2 μm thick) bonded strongly to polished titanium (Ti) substrates under wet conditions, with strength increasing to 900 mJ/m^2 after 9 hours. This strength increase is driven by the corrosion-reconstruction Bonding mechanism, initiated by the dissolution of a Na-rich surface layer on the UTFG, which increases local pH and promotes the dissolution and subsequent repolymerization of Si, Ca, and Ti components at the interface. The RTB method was extended to phosphate glasses to realize antibacterial/bioactive multilayer coatings. Unlike silicate UTFGs, phosphate UTFGs do not exhibit a surface Na-rich layer. They achieve strong, rapid bonding, even to Ti, due to their high solubility and uniform dissolution pattern. Furthermore, strong multilayer structures (e.g., Ag phosphate/45S5) can be designed by controlling the interaction between the acidic dissolution behavior of phosphate glass and the alkaline dissolution behavior of silicate glass. This universality demonstrates the potential of RTB for fabricating multi-functional composite materials.

Keywords: ultrathin glass, bonding, tellurite, bioactive glass, phosphate, silicate

*Speaker

Experimental and Mathematical Methods for Analysis of Dynamic Corrosion of Refractory Materials

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This work focuses on the development of new experimental and mathematical methods for analyzing the dynamic corrosion of refractory materials. These methods enable detailed investigation of subsurface and interfacial corrosion rates under conditions representative of real glass-melting furnace operation, while simultaneously providing data required for mathematical modeling of refractory corrosion in glass melts. The experimental setup for dynamic corrosion testing enables controlled laminar flow of molten glass around a flat refractory sample, thereby simulating actual furnace flow conditions and producing samples with a well-defined corrosion profile for subsequent analysis. After corrosion testing, refractory samples are examined using optical microscopy and SEM–EDS techniques, allowing determination of corrosion rates, assessment of component concentrations at the glass–refractory interface for the development and validation of mathematical corrosion models, and analysis of the phase composition and microstructure of corroded layers. The analysis of corroded layers also provides an opportunity to study thermomechanical damage in refractory materials, known as spalling-mechanical delamination caused by internal stresses arising from differences in thermal expansion between the original and corroded material. In parallel, models describing the formation of mechanical stresses and their relationship to crack density, as determined by experimental measurements, will be developed. The results of the corrosion experiments will be used to develop and validate mathematical models of both subsurface and interfacial corrosion. These models are based on diffusion-controlled dissolution of refractory components into the glass melt and account for flow dynamics, including the effect of Marangoni convection in the meniscus at the glass–refractory interface.

Keywords: refractory, corrosion, surface tension

*Speaker

Why has your float- or PV-glass tank trouble in fining low iron glass?

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Low iron glass is recognized as being heated in depth by the combustion radiation. This should avoid low temperature flow shortcuts in the fining zone and ensure low bubble and seed levels. In fact, the fining quality of low iron melts often degrades and forces for a reduction of the pull rate. A complex link between high melt transparency, melt recirculation and temperatures leads to a significant reduction of the fining times. Moreover, bottom temperatures increase, leading to a risk of glass infiltration. Finally, the increased recirculation intensity and higher temperatures accelerate the refractory corrosion with low iron glass.
The conventional countermeasures like increasing bottom losses or strengthening the return flow of cooler melt from the float working end or PV forehearth have serious drawbacks and do not solve the fining quality problem.
A modified float tank design allows us to overcome these low iron glass problems. Fining times stay conserved when switching from mid-iron to low iron melt. The bottom temperatures remain moderate with the low iron melts, allowing for a good level of insulation and low specific consumption. Tank pull rates remain conserved with low-iron production. The carbon footprint for low-iron PV-glass is reduced.

Keywords: Melting tank, Low iron, Fining, Design, Heat transfer, consumption, carbon footprint, float glass, PV glass

*Speaker

Oxidation resistance and thermal performance of copper-based coatings on cast iron for glass manufacturing moulds

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For manufacturing of glass containers, viscous glass gobs (700-1200∘C) are pressed or blown into metallic moulds. More than giving the final shape, the moulds role is to absorb calories from the hot glass to make it rigid. With good thermal conductivity and oxidation resistance, copper-nickel bronzes are efficient materials for making moulds parts. However, cost is not negligeable for this type of alloy. Cast iron is, so, largely used because it combines economic advantages and satisfying thermal properties. To improve cast iron moulds performance and glass products' quality, cold spray coatings of a copper-nickel and copper-based alloys onto cast iron are investigated. Cold spray is an additive manufacturing technique avoiding fusion of the feeding material, thus, reducing cracks defects when covering large surfaces. Cold Spray parameters (temperature, pressure and gun's travel speed) were optimised in this study, and coatings microstructure were analysed with Optical Microscope and Scanning Electron Microscope, before and after oxidation experiments. All the different combinations of CuNiAl/CuCrZr coatings led to dense ($<$ 3% porosity) and thick layers (up to 5 mm), providing high protection of the cast iron in hot environment. Also, temperature measurement in transient state experiment showed better heat exchange of coated samples in comparison with cast iron demonstrating the gain of performance that the glass container moulds can achieve.

Keywords: cold spray, additive manufacturing, Cu, based coating, cast iron, oxidation, thermal properties, moulds

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The secret face of hidden displays

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Hidden display technology is reshaping how information and aesthetics coexist within the vehicle interior. Unlike classic, fully transparent display systems, hidden displays employ decorated or partially transmissive cover glass that conceals underlying electronic components until activated. When dormant, the surface appears purely decorative—patterned and/or textured—blending seamlessly into the design language of the cockpit. Upon activation, light transmits through the decorated glass, revealing icons, symbols, ambient lighting and/or dynamic information. This subtle interplay between visibility and concealment represents a new paradigm in automotive human-machine interface design.

The development of such displays relies on the precise control of optical properties, such as transmission and reflection (for optimized ambient contrast ratio), combined with innovations in backlighting (local dimming) and sensor integration. Material engineering and advanced decoration techniques—such as multi-layer screen-printing, digital printing, coating, spraying and even decorated film lamination—enable designs that meet the dual requirements of aesthetic refinement and functional legibility. These advances allow displays to be fully integrated into complex 3D glass geometries used in center consoles, dashboards and door panels without compromising visual harmony or manufacturability.

Hidden displays support a minimalist and intuitive interior design, aligning with the industry's shift toward clean surfaces and ambient interaction. They fulfill the current trend of "Technology detox". They also contribute to safety by reducing visual clutter and focusing driver attention only when necessary. Moreover, their design flexibility supports brand differentiation through bespoke colors, finishes, textures and lighting behaviors.

This presentation will showcase current R&D and industrial applications that bridge decorative glass processing and display engineering. It will discuss material and decoration technology selection, optical performance and challenges in balancing aesthetic rendering with optical efficiency. Ultimately, hidden displays redefine the role of glass in mobility: no longer a passive surface or transparent medium, but an intelligent, expressive material that conceals technology until the precise moment it is needed. **Keywords:** Hidden displays, hidden, until, lit, decorated cover glasses, automotive interior, optical performance, seamless design, intelligent surfaces

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How to optimize your flue-gas energy-recovery cascade in hybrid tanks?

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In hybrid glass furnaces, electrical input improves flexibility and reduces CO_2 emissions, but the combustion section remains the main source of recoverable high-temperature energy. Optimizing flue-gas heat recovery is therefore essential to improve overall efficiency and operational flexibility.
This study examines the integration of a *Heat Recovery Area (HRA)* with recuperative combustion, in comparison with oxy-fired operation. The HRA is part of the furnace superstructure, where residual flue-gas energy is recovered by radiative and convective heat transfer to the glass and batch. A combined CFD and energy-balance approach was used to evaluate how these configurations affect heat-transfer distribution and overall furnace performance across different electrical boosting levels. The comparison between oxy and air-recuperative firing shows that an optimized HRA–recuperator cascade can sustain high combustion efficiency and stable operating temperatures over a wide hybridization range.
The first industrial hybrid furnaces equipped with HRAs are now under construction and will provide full-scale validation of these design principles. The expected trends offer clear guidance for flue-gas cascade optimization and hybrid furnace design. These results confirm that combining the HRA with an efficient recuperative system is a key step toward flexible and energy-efficient next-generation hybrid melting technologies.

Keywords: hybrid glass furnace, heat recovery area (HRA), recuperative, oxy, fuel, energy recovery and efficiency

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Improving wetting behaviour of copper on glass for multi material 3D printing

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3D printing techniques have become increasingly popular in industry and research in recent years. Additive manufacturing (AM) at industrial scale is already possible for numerous materials. As a result, additive manufacturing of multi-material compositions is getting more and more attention.

Although there are still challenges to be overcome in the additive manufacturing of glass, there is increasing interest in multi-material 3D printing (e.g. [1]). Within our research project *Coco*, funded by tax revenues on the basis of the budget decided by the Saxon state parliament under the project number 100688406 within M-ERA.NET, we are targeting a combined metal—copper—and glass material extrusion (MEX-TRB) process. For this, the adhesion between the individual materials and the temperature-dependent wetting of the substrate material by the printed layer are of crucial importance in order to ensure uniform material application and good stability of the final product.

The presentation will show experimental results of the wetting and adhesion behaviour between different low-melting glasses and copper. With respect to the AM process, their relevancy and observed challenges will be discussed.

*Speaker

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Keywords: Additive Manufacturing, wetting, 3D printing

Vitreous enamel as primer in metal-to-glass joints

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Metal-glass bonds are challenging due to the significant deviations in material properties. Huge differences in expansion coefficients and mechanical properties often result in fragile bonds with only low resistance to external stresses caused by mechanical loads or temperature differences. However, this material combination is highly relevant for sensors in medical technology or environmental analysis, for instance.
It has long been known that these poor bonding properties do not apply to all glass compositions. Vitreous enamels have been used for centuries to coat metals, whether in arts and crafts or as corrosion protection on metal objects. Customized enamel compositions have been developed for various metals and alloys to ensure optimal adhesion and durability of the material bond under specific conditions.
The poster will show experimental results on the use of vitreous enamel coatings on glass as a primer to improve the adhesion of copper drops deposited on the surface by material extrusion. Their relevancy and process challenges for 3D copper to glass printing will be presented.

Keywords: enamel, wetting, additive manufacturing, 3D printing

*Speaker

Radiative Heat Transfer in Nuclear Waste Glasses and Melts: Measurements, Modeling, and Key Compositional Effects

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Understanding heat transfer in nuclear waste vitrification melters requires knowledge of radiative properties of glass melts, which are semi-transparent at typical operating temperatures near 1150 °C. In this study, we present a model that quantitatively predicts near-infrared extinction and effective thermal conductivity as functions of glass composition, temperature, redox state, and the presence of solid and gaseous inclusions. The model is validated by high-temperature absorption spectra (0.7–3.8 μm) of representative borosilicate waste glasses, measured from 300 °C to 1150 °C with a custom-built high-temperature spectrophotometer.

The model resolves individual contributions from key chromophores such as Fe^{2+}–O–Fe^{3+}, V^{4+}, and hydroxyl groups, as well as scattering from crystalline or spinel particles. It accurately reproduces measured extinction spectra for multiple nuclear waste glass compositions and captures compositional and redox-dependent trends. From the measured and modeled spectra, Rosseland mean extinction coefficients, and radiation thermal conductivities were determined, enabling the estimation of effective thermal conductivity across a broad range of glass types. The results show that radiation dominates heat transfer in many nuclear waste melts and that variations in composition, oxidation state, and inclusion content can significantly affect thermal conductivity.

Given the difficulty of high-temperature measurements and the limited applicability of effective-conductivity concepts at small length scales, this experimentally validated model provides a practical framework for predicting heat transfer in vitrification melters directly from glass composition and processing parameters. The findings support advanced computational fluid dynamics simulations and improved design and control of large-scale nuclear waste vitrification systems. **Keywords:** Radiative heat transfer, Scattering, Absorption spectra, Borosilicate

*Speaker

glass, Radiation thermal conductivity, Nuclear waste

Alternative Fuels to Improve Sustainability in Glass Fiber Manufacturing

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In this paper, we cover the development of using hydrogen to decarbonize glass manufacturing operations. We will present an extensive effort focused on experiments, numerical modeling, lab testing and plant trials. As part of this initiative, flame behaviour, its impact on the burner and heat transfer were evaluated with new measurement methods. Those sensing techniques, along with simulations allowed us to understand the fundamentals of hydrogen combustion for glass fiber manufacturing. Those efforts were helping us develop confidence in further implementing the technology in furnaces.
We also present the results of implementing hydrogen combustion at one of our plant facilities and as part of the *H2Glass* European program. Two, one-week tests were carried out in 2024. Different sensing techniques were installed and provided measurements of the combustion characteristics and emissions. This included flame characteristics, temperatures in the combustion space, as well as NOx values. We will cover the results of those campaigns.
In late 2025, an electrolyzer was installed to provide hydrogen generation for an extended period. This allowed us to evaluate longer term effects of the technology on the furnace operations. This paper will describe the different efforts and challenges that helped us integrate green hydrogen in our facilities.

Keywords: Hydrogen combustion

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Glass as a binder material for additive manufacturing by Powder Bed Fusion

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Additive manufacturing refers to the process of creating 3D objects by successively adding layers of material to obtain the desired shape [1]. Among these methods, powder bed fusion (PBF) consists of selectively melting powder using either a laser or an electron beam. The process relies on the presence of a binder, typically a polymer, that absorbs the laser energy; it is referred to as an indirect process, in contrast to direct selective fusion, where the powder itself is melted. These two process categories correspond to Selective Laser Melting (SLM), generally employed for metals, and Selective Laser Sintering (SLS), commonly used for polymers, highlighting the suitability of PBF for producing both metallic and polymer components [2].

In this context, our study focuses on developing a glassy binder that efficiently absorbs laser energy, which is of particular interest for enabling additive manufacturing of complex glass-based objects. In the present work, we report the results obtained on borosilicate glasses containing additives such as iron oxide and other rare earths to make the glass absorbent in the laser wavelength range (1 μm). The glass must meet its ability to soften under the effect of the laser. The properties of these glasses were determined in particular by UV-Visible-NIR absorption spectroscopy, heating microscopy, XRD, Selective Laser Melting Tests, etc.

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Keywords: Glass, Powder Bed Fusion (PBF), Selective Laser Melting (SLM), Rare Earths, Binder Matrix

High-throughput glass synthesis by 3D-printing

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Conventional investigations into composition-structure-property relationships of glasses typically start from laboratory glass synthesis. This involves manual, time-intensive procedures, from selecting the approbriate crucibles to raw material batching, melting, casting, sample preparation and subsequent analysis. Thereby, even minor deviations in synthesis parameters, thermal histories or sample handling may result in inconsistent sample quality and limited reproducibility. Here, we demonstrate a high-throughput approach, wherein a machine-assisted 3D printing process allows us to fabricate cmˆ-3 glass specimens suitable for comprehensive characterization on the scale of 50 individual glasses per run. Using commercial reference materials in a representative case studies, we quantitatively describe compositional dependencies across a compositional range from 0 - 100% of admixture of from a silicate to a borosilicate glass. Detailed quantitative analysis confirms process viability in reference to conventional crucible melting. Raman spectroscopy is subsequently used as a high-throughput analytical tool for semi-quantitative assessment of glass meltability, overall sample quality, and further basic properties. In this way, champion materials are identified for further in-depth analysis and regular laboratory melting of larger samples.

Keywords: 3D, printing, Additive Manufacturing, High, throughput synthesis

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Fabrication of an alumina gradient doped silica fiber via additive manufacturing

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Data transmission, light generation, and amplification rely on the utilization of optical fibers. The variety of fiber cross sections, e.g., step index fiber (SIF), gradient index fiber (GRIN), photonic crystal fiber (PCF), and antiresonant fiber (ARF), enable the optimization of optical fibers for almost any application. High-performance optical fibers are usually based on silica (SiO_2) due to its high transparency, mechanical stability, and durability.

The production of a state-of-the-art optical fiber involves a multistep process spanning from doping of the silica core matrix with different cations for controlling the refractive index profile or enabling lasing and fluorescence, followed by elongation of the core preform into rods and finally drawing of a thin fiber. Nowadays, chemical vapor deposition is used for high-purity co-cationization of the silica core. Manual stacking procedures using canes and rods are employed for manufacturing of advanced core arrangements and well-defined core-to-cladding ratios. These processes consume a high amount of resources, both in terms of laboratory equipment and time, and the geometrical design of the fiber cross section that can be realized is restricted.

Arbitrary complex structures with a high spatial resolution can be created using additive manufacturing (AM) as a layer-by-layer approach from a digital 3D model. In recent years, different techniques for the 3D printing of silica have been developed, e.g., powder-based techniques, extrusion-based techniques, or vat-based techniques. Digital light processing (DLP) uses light-curable slurries for shaping. It combines high resolution with a moderate printing time. The use of additive manufacturing for the production of fiber preforms could improve current applications and enable new fields of use for optical fibers.

In this work, we demonstrate the successful production of a 3D-printed preform drawn to a fiber with a defined gradient index profile. We used a vat polymerization approach and dual-material printing to create a gradient by combining two different slurries of pure SiO_2 and Al_2O_3-doped SiO_2, respectively. The preform was vitrified and drawn into a 265 μm thick

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fiber with a radial parabolic refractive index profile. Our work paves the way to overcome limits of traditional GRIN fiber production techniques via ion exchange. **Keywords:** additive

manufacturing, 3, D printing, GRIN, optical fiber

Cooper extruding glasses for additive manufacturing

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Different classes of materials are combined to produce modern machines and technical components. For example, glasses are known for their strong chemical resistance, high hardness and low thermal expansion. In contrast, metals are noted for their high conductivity and ductility. A metal/glass composite could benefit from the hardness of glass while also exhibiting the ductility of metal. However, the contact between metal and glass is challenging due to their significant difference in thermal expansion coefficients. The resulting stresses from thermal fluctuations could lead to cracks and ultimately result in the loss of contact between the two materials. This issue is critical in the construction of cooling systems for high-power electronic devices.
Additive manufacturing provides greater design freedom compared to traditional production techniques. In recent years, various 3D printing methods have been used to produce glass or glass-ceramic structures, such as extrusion-based, powder bed-based, or vat-based approaches. Cooling systems require fine structural details to achieve a high surface-to-volume ratio. The use of additive manufacturing offers the potential to use novel materials for cooling systems with enhanced performance.
In our work, we present a novel approach for creating metal/glass composites. Copper oxide is added to the composition of traditional borosilicate glass. During a subsequent heat treatment, the glass matrix extrudes copper. Various structures using this copper-extruding glass were printed with a DLP printer. The structures underwent different heat treatments in nitrogen and normal atmospheres. Different measurement techniques were employed to analyze the copper-extruding properties.

Keywords: Additive manufacturing, metal glass composite, Cooper extruding glass

*Speaker

Fabrication of large-sized hybrid glasses: progress, challenges and opportunities

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Hybrid glasses refer to materials in which the structural units consist of metal nodes coordinated with organic ligands, linked together through coordination bonds or hydrogen bonds. In these systems, hybridization arises from the chemical bonding between metal atoms (or metal clusters) and organic molecules. Hybrid glasses encompass several categories, including metal-organic framework glasses [1, 2], coordination polymer glasses [3], and metal organic-inorganic complex glasses [4, 5]. Currently, rapid progress has been made in the development of hybrid glasses, and their functionalities are being uncovered [6], pointing to diverse potential applications. However, despite these advances, significant challenges remain, particularly in scaling up the fabrication of hybrid glasses and improving their mechanical robustness. In this talk, I will present several promising approaches for producing large-sized hybrid glasses and discuss the current challenges associated with upscaling. I will further analyze the underlying origins of these challenges and highlight opportunities and strategies for overcoming them.

*Speaker

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Keywords: Hybrid glass, Metal organic framework glass, Metal organic inorganic complex glass, Coordination bonded network, Hydrogen bonded network

Binary aluminate transparent ceramics and glass microspheres formation from plasma melting

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The fabrication of aluminate transparent ceramics and glass microspheres are still challenging due to high melting temperatures and poor glass forming ability. In this research, various binary aluminate microspheres were fabricated using radio frequency plasma melting technique. The morphologies, structure evolutions, and mechanical performances were investigated. For Al2O3-CaO microspheres, the average diameter is around 35 μm. The main crystal phases change from the combination of CaAl4O7 and Ca3Al10O18, to Ca3Al10O18 and CaAl2O4, then to CaAl2O4 and CaAl4O7 with decreasing Al2O3/CaO ratio. While glass microspheres were formed with 36Al2O3-64CaO component. The microspheres exhibit maximum 12.73 GPa microhardness and 133.16 GPa Young's modulus, from mixed crystal phases evolutions and decreasing 9.25 GPa microhardness and 96.64 Young's modulus for 36Al2O3-64CaO from amorphization. The effect of precursor diameters on the glass formation were studied. The glass formation can benefit from the smaller diameters, for the faster cooling speed. .Al2O3-ZrO2 binary microspheres present eutectic characteristics, containing α-Al2O3, t-ZrO2, m-ZrO2 crystals, with maximum 23.21GPa microhardness, and 211.80GPa Young's modulus. Moreover, other binary aluminate microspheres, such as Al2O3-Y2O3, Al2O3-Gd2O3, will be investigated Novel aluminate glass formation processes and structural evolutions also will be discussed.

Keywords: Plasma melting, Aluminate glass, transparent ceramics, mechannical performance, structure evolution

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Additive manufacturing of open porous glass foams using vat photopolymerization

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Glass foams are typically produced using a thermochemical approach by mixing glass powder with a foaming agent that produces gas upon heat-treatment. This is a cheap and efficient way to recycle glass into a new product; however, the method offers limited control over the pore geometry and connectivity. Overcoming these limitations may be possible through additive manufacturing. In this study, we utilize vat photopolymerization to design glass foams based on cathode ray tube (CRT) panel glass. CRT glass powder is suspended in an organic UV-curable matrix and printed to obtain tailored pore sizes in the range 4-7 mm. The printed samples are fired to remove the organic matrix and sinter the glass particles. The final structure of the fired glass foams is analyzed using X-ray tomography evaluating macrostructural features such as the actual pore size and the pore network connectivity. The application of glass foam as thermal insulator requires understanding of the heat transfer in porous materials. Therefore, the thermal conductivity is experimentally investigated and compared to that of computationally simulated values using the tomographic 3D images. This allows for evaluating the impact of pore size on thermal conductivity. Last, the open porous structure of the glass foam samples allows for investigating a potential convective contribution to the total thermal conductivity by fabricating a setup to control a forced convection through the porous structure providing insight to the impact of pore size on the convective contribution to the total thermal conductivity of porous materials.

Keywords: Glass foam, Thermal conductivity, Additive manufacturing

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ICG Montpellier Summer School – History, Concept, Outcomes

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We will review 20 years of the history of the development of the Montpellier Summer School starting from conversations within various ICG sub-committees and leading in 2006 to a major European grant (EFONGA). The philosophy behind its creation and the development of thinking arising from the early experiences of running such schools will be outlined. Side tracks and pitfalls uncovered during those early years will be addressed. Secondly, the pursuit of a curriculum will be presented – what did the audience and their fee payers expect, what could realistically be achieved in just a week? Finally, we will consider the creation of a structure that includes lectures, tutorials, and student projects and at its heart promotes teacher-teacher, student-teacher and student-student interactions. The outcomes have included several similar courses on other continents and the formation of a worldwide network of around a thousand young professionals throughout the world, treasuring their experiences in Montpellier and elsewhere, and many maintaining contact. **) K. Bange and B. Hehlen were not available to directly author the present abstract. Their invaluable and long-term dedication to the school will be gratefully acknowledged in the presentation.

Keywords: education, summer school, curriculum

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The glassworks of Portieux and the Atelier des Arts de Portieux (1982-1986). A creative utopia serving industrial renaissance.

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The Portieux crystal factory, founded in 1703 in the Vosges, offers a privileged observatory of the changes in the French hand-blown glass industry at the end of the 20th century. Heir to renowned expertise, from the 1970s onwards it faced a double pressure: the weakening of the economic model of art manufacturing and the need for industrial modernisation. The bankruptcy in 1981 of the Compagnie Française du Cristal (CFC), which it had joined in 1970 and which produced up to 40% of French artisan glass, illustrates this evolution.

In an attempt to recover, the Portieux glassworks took a gamble and created the Ateliers d'Art de Portieux (1982–1986), making creativity the spearhead of this revival. By bringing together contemporary glass artists—Jean-Paul Van Lith, Matéi Negreanu, Monica Damian—and the factory's glassmakers, Portieux sought to reconnect with the creative dimension of the work while opening up to a more modern visual language.

This initiative, inspired by Nordic models such as Kosta Boda in Sweden, where collaboration between designers and craftsmen has been institutionalised since the 1950s, nevertheless proved to be a short-lived adventure: poorly prepared economically and lacking in research and distribution infrastructure, it was met with indifference and incomprehension.

This communication proposes to read the case of Portieux as an illuminating example of the serious crisis in French hand-blown glass at the end of the 20th century. Between cultural utopia and structural failure, the Portieux experience questions the very possibility of artisan modernity, that is, a model capable of integrating innovation, craftsmanship, and creation into a globalised economy of luxury and design.

*Speaker

Fourteenth- and fifteenth-century stained glass in Barcelona: Cathedral; Reial Monestir de Santa Maria de Pedralbes; and Santa Maria del Mar.

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The medieval stained glass in Barcelona has been thoroughly studied by art historians, who have examined its artistic and formal qualities and traced its history, mostly in ecclesiastical archives. In the 14th century, Barcelona was the capital of the Catalan-Aragonese Crown, whose territory stretched across the Mediterranean Sea and to the northern side of the Pyrenees. Magnificent buildings such as Barcelona Cathedral, Pedralbes Abbey and Santa Maria del Mar were constructed in styles influenced by Italian and French international styles, with the promoters contracting the best international craftsmen.
Recent conservation campaigns on the stained glass in these buildings provided an opportunity to analyse samples of medieval glass dating from the early 14th to the late 15th century. Previously, only isolated analyses had been conducted, which did not allow for a general overview of the evolution of the medieval glass composition and origin in Barcelona to be drawn. This study reveals the presence of ancient potash glass, followed by a transition to soda-lime glass, which was prevalent in medieval production across the Mediterranean.
This current study presents the results of medieval glass from the aforementioned three buildings and contrasts them with archaeological glass preserved at the City Council Archaeological Deposit, which serves as a reliable dating reference. The results provide a clear framework for understanding the evolution of glass compositions, and enable us to interpret the data by comparing it with historical facts.

Keywords: mediterranean glass, Barcelona glass, medieval glass, stained glass, composition, production

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A study of Cu and Fe redox interaction: thermodynamic insight into the "medieval green glass" coloration type

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Color is one of the most striking properties that can be conferred to a glass matrix through doping with transition metals. The physicochemical origin of the coloration is linked to the speciation of the chromophores inside the glass. For instance, copper is a widely used dopant, which can produce blue (absorption of diluted Cu^{2+}) to red (surface plasmon resonant absorption of Cu^0 nanoparticles) colors [1]. However, doping with a single TM is rare, as both ancient and industrial glass often contain iron impurities (ranging from a percent to a few tens of ppm of Fe_2O_3), brought by the raw materials. These impurities can interact with Cu through the redox equilibrium $Fe^{2+} + Cu^{2+} \rightleftharpoons Fe^{3+} + Cu^{+}$ and therefore change the final shade of the glass, as Fe^{2+} and Fe^{3+} chromophores can also be present [1].

In this study, we characterized the redox interaction between copper and iron for potash-lime model glass matrix doped with different Cu/Fe ratios. Equilibrating temperatures of the glass were varied from 1200 °C to 1500 °C. The redox and speciation of Cu and Fe were determined quantitatively through XANES analyses at the Fe-K and Cu-K edges. Those measurements were compared to Optical Absorption Spectroscopy (OAS) measurements to link physicochemical parameters to the final color. Complementary Electron Paramagnetic Resonance (EPR) spectroscopy allowed probing the evolution of the local environment of Cu^{2+} and Fe^{3+} in the glass.

Finally, we propose a thermodynamic description of the Cu-Fe equilibrium in medieval-like potash-lime glass matrix, and we compare it to existing models for the corresponding isolated multivalent elements [2, 3, 4] as well as the few published results for the Cu/Fe couple in other matrices [5, 6].

*Speaker

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Keywords: green glass, redox, speciation of copper and iron, XANES, OAS, EPR

From Chemical Clusters to Provenance: Islamic Glass in al-Andalus

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This paper offers a review of analytical studies of glass in al-Andalus between the 9th and 13th centuries, and suggests a statistical approach to clarifying patterns of glass circulation and primary silica sources for "new" types of plant-ash glass. Late Antique and early medieval glass-making was separated into large-scale primary production on the Levantine coast and in Egypt, using local sands and natron (a mineral-soda flux), and small-scale secondary workshops across the Mediterranean and Europe. Between the 8th and 9th centuries, a gradual transition toward plant-ash fluxes and more regionally oriented practices took place. For the Islamic territory in the Iberian Peninsula (al-Andalus), however, the pace and local transitions of this shift remain unclear. The archaeometric record of glass across 9th–13th-century contexts shows the presence of both natron and soda-rich plant-ash glass, while the early Islamic contexts also witness the emergence of two types of lead glass. Newly defined soda-rich plant-ash groups are consistently different from Near Eastern plant-ash glass, and appear in Córdoba, Almería, Murcia and Toledo in Spain and in Silves and Mertola in Portugal. To obtain more information about these groups, we propose a framework for (1) comparability across studies and (2) a multivariate analysis to interpret the compositions using principal component analysis and model-based clustering (GMM) on compatible datasets. This approach helps distinguish plant-ash groups and subgroups, while biplots using silica-related proxies (Al, Ti, Zr, Th, etc., and their ratios) clarify links between "glass families" and sand mineralogy, suggesting quartz-rich sources with different heavy-minerals enrichment. The presence or absence of these groups can give us an idea of the types of glass circulation in each region. By integrating archaeological evidence, analytical datasets, and a statistical interpretation, this study turns isolated case studies into coherent narratives of production, circulation, and regional adaptation across al-Andalus.

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Keywords: islamic glass, plant, ash groups, al, Andalus, Iberian Peninsula

Studying the old to create the new: the example of the stained glass windows of Saint-Etienne-Du-Mont (17th century).

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Saint-Étienne-du-Mont is a church in Paris showing astonishing 17th-century stained glass windows painted in enamels with remarkable details. Unlike the restoration enamels applied in the 19th century, their stability in terms of both adhesion and color is impressive.

Taking advantage of their restoration, in agreement with the city of Paris (COARC) and the Ministry of Culture (DRAC Île-de-France), a team of researchers from IMPMC, IRAMAT, and the Vincent-Petit stained-glass workshop studied bay number 10 of this ensemble.

In this presentation, we will discuss the chemical composition of both the glass substrate and the enamels, using data acquired by LA-ICP-MS. The physical origins of the colors of these enamels will be characterized using optical absorption spectroscopy. Finally, we will try to bring some explanations to account for the great mechanical and color stability of these enamels.

This project received DIM PAMIR funding for the REVA Internship.

We would like to thank the curators of the panels (Louise Delbare, Véronique Milande, and Marie-Hélène Didier) for providing access to the stained-glass windows and for supporting this project. **Keywords:** Enamels, Stained Glass, Colors, Archaeometry

*Speaker

Glass Recycling from Antiquity to the early Middle Ages: The case of Tusculum (Italy)

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This paper presents new archaeometric and typological results from the exceptional glass assemblage from the ancient city of Tusculum near Rome, which was recovered from the context of the 12th-century church built on top of a 10th-century church, itself built within a Roman bath complex dating to the 2nd to 3rd century. The integration of typological studies and chemical data reveals a clear shift in glass consumption between the Roman and medieval phases, closely linked to the changing function of the building - from the predominance of tableware in the Roman period to the dominance of lighting devices in the medieval occupation. The glass from the medieval context proved to be of a base glass that had originally been produced about half a millennium earlier and had heavily been recycled in the meantime, as evidenced by impurities from vapor and furnace environment, as well as the accidental admixture of coloured cullet. Particularly striking is the recurrence of this recycled natron base glass (Foy 2) even in shapes generally associated with the Islamic world, such as so-called "mosque lamps". Because Islamic glass production had changed to plant-ash recipes by the 9th century, their presence at Tusculum could suggest regional or subregional reinterpretations of Islamic-derived models relying on recycled natron glass rather than imported products from Islamic regions. These results offer a rare and much-needed reference point for the Roman region, where the transition from natron glass to medieval plant ash glass production is still poorly documented. They also contribute to broader discussions on the circulation of objects and models, craft knowledge, and the socioeconomic strategies that shaped glass recycling across the medieval Mediterranean.

Keywords: recycling, Roman glass, medieval glass, Italy, glass recipes

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Drying the tears of ‘weeping‘ glass

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Some historic glasses, made with excessive alkali and insufficient stabiliser, are ‘sick’ showing white haze or drops on the surface and ‘crizzling’. Aerial humidity leads to the efflorescence of salts due to ion exchange which further attacks the glass network by the alkaline films formed and absorbs humidity. However, a dry atmosphere can cause cracks in the degraded silica gel layer on the glass surface. An optimal RH minimises damage. In 1992, Ulitzka recommended 33% for displaying the ducal glass collection at Veste Coburg achieved by the use of saturated solutions of magnesium chloride. After implementation and 30 years of experience, the glasses appeared to be in excellent condition, no new tears occurred. This method requires low maintenance (only one annual change of solutions) and is low-cost (no machines and no electricity needed, making it fail-safe). No problems with spilling or the creeping of salts were obsserved. The choice of RH (typically 35–38% in not completely tight cases) is now corroborated by research on the desorption of water from historic glasses. Depending on the glass type, desorption (and, therefore, the risk of cracking) increases considerably below 35-25% RH. Analyses of the ions on the glass surface found no significant increase of chloride values (no deposition of chloride via traces of HCl emitted from the solution). In 1996, the Fraunhofer Institute for Silicate Research conducted measurements with glass sensors that confirmed the excellent atmosphere in such a display case (low in VOC). As expected from Henry’s law and known for pure water, aqueous solutions absorb pollutants such as corrosive polar carbonyls (acetic and formic acids, formaldehyde). This was confirmed in model experiments using MOS gas sensors. For example, acetic acid from a continuous gas stream (up to 1000 ppb) was fully absorbed by the MgCl2 solution. This might be another hitherto neglected reason for the good condition of the glass collection. Compariing ion analyses from the surface with a corpus of other ‘sick’ glasses will show whether the occurrence of formate is reduced (proof of absorption) as well as that of potassium / sodium (deceleration of glass ‘sickness’.)

Keywords: glass ’sickness’, relative humidity, saturated salt solutions, magnesium chloride

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Stained glasses : from color to history

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Stained glass windows are one of the most striking characteristics of Gothic architecture. Their development in the 12th and 13th centuries is a response to the increasing size of windows in medieval monuments. Stained glasses serve as iconographic supports and fill the space with light and bright colors that make them one of the most well-known heritage objects. Determining the origin of color helps understanding the evolution of glass-making technologies since the Roman period. However, the scarcity of quantitative data on the color of stained glasses limits our knowledge of the control and choice of dyes used over the centuries. The richness of the color palette is a relevant testimony of the high mastery of ancient glassmakers. Because the obtained color depends on the elaboration conditions, (raw materials, colouring agents, glass composition and melting conditions), the determination of the subtle relations between chemistry and optical properties of the glasses helps understand the history of art and techniques by using the unique witnesses that are the stained glasses. During recent restoration campaigns, by using non-destructive and non-invasive original measurement devices and thanks to the coupling between spectroscopic measurements, chemical analyses and authenticity studies, we were able to obtain information on the way medieval artists managed the color of glasses and their production. The results revealed the extensive use of complex and high-technology glasses. The homogeneity of the chemical composition of the glasses and interpretations in terms of temporal and geographical origin will be discussed. This cooperative work between mineralogists, chemists and art historians illustrates the link between the color of stained glasses and manufacturing and restoration techniques over centuries, providing information on the evolution of glassmaking.

Keywords: Stained Glasses, spectroscopies, chemical analyses

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Archaeometric study of medieval glass coming a lost stained glass window from San Giacomo Maggiore church, Bologna (Italy)

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A set of 8 fragments of glass coming from a lost stained glass window (late 13th or early 14th century) decorated with black grisaille painting were analyzed using HR-ICP-MS-LAM and includes the 10 main components of glass, plus 49 trace elements.
Major components of glass show that all the glasses are medieval except one (SG7, a honey-colored glass with grisaille, with an excessively high SiO2 content. Medieval glasses correspond to two groups: an initial group (5) consisting mainly of soda-lime glass from the Mediterranean tradition, and two of a potassium-lime chemistry attributable to Central European production (a colorless and the second is red-plaqué; trace elements content confirms that the color of the red layer is due to the use of copper in the production of microcrystals embedded in the colorless glass. Regarding the major element composition of the K-Ca glass, it can be concluded that it comes from two different productions, a common occurrence in all medieval Mediterranean stained glass, both due to its imported nature and the greater susceptibility to the action of microorganisms (and consequent substitutions, even very premature ones) of these potassium glass fragments.
Regarding the soda-lime glasses, the two mauve-colored fragments are very similar compositionally, and their color is due to the intentional addition of MnO2, in contents over 1.5% more than the rest of the other glasses. The two blue glasses are quite different compositionally. The aquamarine receives its color from the well-known recipe of Cu and Fe (the latter in small proportion, justifiable by the desired color). The light blue, on the other hand, was obtained by using Co, also associated with the Cu-Fe recipe. As will be explained in detail, the combination of trace elements allows us to deduce the type of mineral salts used by the master glassmaker in each case to obtain the color. The colorant used in the honey-colored glass is not evident in the trace element spectrum of the metals present, so it can be assumed that they were obtained through skillful use of the furnace's redox conditions. The grisailles are Pb-rich (presence of Cu)

Keywords: archaeometric study, medieval stained glass, HR, ICP, MS, LAM, mediterranean and centreeuropean glass, color recipes

*Speaker

Archaeometric study of medieval glass coming from two medieval stained glass windows form Girona Cathedral, Catalonia, NE Spain

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We studied 15 medieval stained-glass fragments from at least two windows in Girona Cathedral, currently preserved in the cathedral archive. The archaeometric study included chemical analysis performed using HR-ICP-MS-LAM and includes the 10 main components of glass, plus 49 trace elements.

The cathedral was built in the 14th century on the previous Romanesque building. The stained-glass panels studied can be attributed to the Master of the Chancel (the oldest, dating from the early 14th century) and to the Norman Guillem de Letungard (working at the cathedral in 1357).

10 of the fragments correspond to soda-lime glass of Mediterranean tradition, comparable to those already studied by us in different Gothic sites in the Crown of Aragon and northern Italy, while the remaining 5 present the two potassium-lime compositions typical of medieval Central European glass. Four of these potassium-lime glasses are of the *plaqué* type (three red and one blue), a technology not yet developed by master glassmakers in Mediterranean southern Europe at that time, which is why they are interpreted (and have sometimes been documented) as the imported product.

The color in red-*plaqué* glass was obtained, as was common during that period, by sandwiching one or more very fine layers of glass containing copper microcrystals dispersed within the colorless glass between two layers. Blue-*plaqué* glass was obtained using cobalt as the chromophore, and cobalt is also the chromophore used in the blue-purple solid glass.

We have also been able to identify the color recipes in soda-lime glass. The four blue glasses also have cobalt as their chromophore; the green fragments have a composition of elemental copper and iron dispersed throughout the glass mass (a common recipe at that time in the Mediterranean environment); the amber and brown fragments were obtained using iron and a reducing environment in the kiln; and the silver yellow paints were obviously obtained by the well-known processes of second-firing glass with salts of this element dispersed in a charge or

*Speaker

paste. All these color recipes are consistent with those known in the medieval environment of the 14th century in the Crown of Aragon. **Keywords:** archaeometric study, medieval stained glass,

HR, ICP, MS, LAM, mediterranean and centreeuropean glass, color recipes

Chemical study of two coats of arms stained glass windows in the Chapel of St. Pietro Martire (early 15th century) of the Basilica of San Petronio, Bologna, Italy

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This work studies two small stained glass windows (they represent coats of arms) made around 1400 and restored in 2009. The windows come from the San Pietro Martire chapel of San Petronio Basilica of Bologna (Italy). The sampling performed includes 8 representative fragments of glass (blue and deep blue, red, green, amber and yellow glass) and 2 fragments from the framework constituted by the lead structure mixed with glass fragments. The chemical analyses were conducted by microablation craters with a HR-ICP-MS-LAM instrument.
The main chemical components of glass show a composition of lime-potassium silica glass of centeeuropean affinity (all except one in the 17-24% CaO range; while the K2O contents are more variable (most – 6 – range between 19-24%) and relatively low silica content (just over 50% in SiO2). These compositional characteristics are consistent with their state of preservation, which, although generally good, includes the presence of corrosion micropitting in the yellow samples, as well as widespread surface growths of sulfates in most of the fragments.
Also, the chemical study allows for understanding the color recipes used (Co with Ni-Cu fingerprint in blue, Fe-Cu for green, Cu for red-plaqué). REE elements content (attributable to the silica content in the glass formulation) is homogeneous for most glass fragments coinciding with the main group, which is relatively homogeneous in terms of its major element components. Trace element metals allow to explain the color recipe used, providing information on the characteristic geochemical composition of the metallic salts used in each case. The chemistry and the stylistic analysis confirms for the use of medieval glass, and the existence of an early restoration of the windows in the medieval period including important substitution of glass.

Keywords: archaeometric study, medieval stained glass, HR, ICP, MS, LAM, Ca, K centreeuropean glass, color recipes

*Speaker

Photoluminescence-Based Identification of Roman Colorless Glass groups in Reims

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Colorless glass was widely produced during the Roman period, particularly from the late 1st to the 2nd century AD, primarily for high-quality tableware. Its use declined by the late 3rd century AD. Decolorization was typically achieved using antimony or manganese compounds, and four main categories are recognized in the literature: naturally decolorized glass, glass decolorized with antimony, with manganese, or with both—indicating recycled material.

We present a new method based on photoluminescence spectroscopy to rapidly identify the type of decolorizing agent in Roman colorless glass. Under 266 nm excitation, Sb^{3+}, Mn^{2+}, and Fe^{3+} ions exhibit characteristic emissions between 400 and 700 nm. Time-resolved conditions were optimized to isolate each species, allowing us to classify glass samples accordingly.

This method was validated using uncolored Roman glass previously analyzed by LA-ICP-MS [3], alongside synthetic silicate glasses containing Pb, Sb, and Mn, more than 70 glasses in total. Particular attention was paid to Sb-decolorized glasses. Emission lineshape and Sb^{3+} excited-state lifetimes revealed several compositional subgroups. We applied this approach to over 80 Roman glass samples from Reims workshops (France), mostly from the 3rd century AD. Our results indicate the production of recycled Sb/Mn glass in Reims, suggesting the use of a rectangular furnace and supporting evidence for local manufacturing of Sb-decolorized glass.

*Speaker

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Keywords: Roman glass, photoluminescence, uncolored

The bicentennial of the Verrerie de Saint-Just: history and innovation in the art of mouth-blown glass.

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Our Glassworks owes its foundation to a ruling from King Charles X, but is not merely a custodian of past gestures. Following the days of the monarch, the nuances of our mouth-blown glass quickly hit the mark.

Our place within this lovely manufacturing town imparts the obligation: the Saint-Just Glassworks does everything in its power to protect its prestige and reputation. It has remained faithful to its address since 1826, while demonstrating mobility. As you know, ingenuity has marked its history, from the era when coal was transported from Saint-Étienne by lighter, when glass was shaped from the sands of the Loire River.

To ensure its continuity, the very first artisans of Saint-Just never ceased reinventing the manufactory. They questioned strategies, blazed into new markets, made important pivots. The Glassworks sought out opportunities uncorked by champagne bottles; it threw itself into the color revolution. Today, it is the oldest manufacturer of mouth-blown flat glass still in operation, with more than 160 years of expertise and glassmaking techniques passed down through the generations.

The potentials of glass are as numerous as its lives; with the right energy, its infinite application thrives. It had been fifteen years since the Saint-Just Glassworks last offered its famous gold-based flashed rose. The recipe seemed to have slipped into dormancy. Our teams are delighted to innovate and have reconnected with this emblematic technique, a tint elaborated identically.

Our creative commitment is total. It marks the return to our core craft, to our first love: enchanting our partners and clients with what emerges from our furnaces. **Keywords:** Saint Just,

mouth blown glass, stained glass, know how, handcrafted, glass art, colored glass, artwork, glassworks

*Speaker

Ashes to Art: The Glassmaking Traditions of Königsfelden's Medieval Windows

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The chemical composition and optical properties of the stained-glass windows in the Königsfelden Abbey church (Aargau, Switzerland), which are among the oldest and best-preserved examples from the 14th century in the region, were analysed on site using portable X-ray fluorescence (pXRF) and optical absorption spectroscopy. A subset of loose fragments was further characterised by Raman spectroscopy and LA-ICP-MS, and these data were used to improve the calibration of the results obtained with *in situ* pXRF. A machine-learning classifier (GLORIA) was applied to assess the variability of the glasses and their provenance relative to a reference database of European stained-glass windows. The results demonstrate that the Königsfelden corpus consists of potash-based forest glasses, mostly attributed to Central Europe (59%), with additional inputs from the Rhine region (32%) and Northwestern France (9%). While the colouring mechanisms for cobalt blue, copper red, manganese purple, silver yellow and iron sulphide amber are relatively well understood, the colouring techniques of a distinctive bluish grey and rare Pb-rich green glass (_˜10 wt% PbO) are unusual and have no clear published parallels. One hypothesis for the high PbO contents in green glass is that a CuO-PbO frit was deliberately employed to facilitate the dissolution of metallic copper in the silicate melt. The blue-grey glass, unique in hue and composition, appears to result from the combination of a manganese–cobalt glass with an additional, yet unidentified, contribution. Our study thus provides new insights into medieval glass recipes, trade networks, and workshop practices, while also validating the potential of calibrated pXRF combined with reference standards and machine learning for heritage science applications.

Keywords: Stained glass, Switzerland, pXRF, LA, ICP, MS, Optical spectroscopy, Machine learning, Provenance

*Speaker

Unstable glasses of the Cultural Heritage: A collaboration between glass chemists and curators to tackle the issue of their ongoing degradation

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Many glass objects produced from the end of the Middle Ages to the 19th century in Europe show signs of ongoing chemical degradation, even though the conditions of their conservation are deemed good. These glasses are known as "unstable". Their conservation is a matter of concern for curators, who seek reversible, safe, and simple ways to slow down the degradation [1, 2]. Among unstable compositions, those having a low content of alkaline earths (Ca^{2+}, Mg^{2+}) with respect to alkalis (Na^{+}, K^{+}) are the focus of this work.

Two PhD works have been recently devoted to the mechanisms of the alteration and possible conservation practices to mitigate its progress [3, 4]. This oral presentation will be giving a comprehensive view of this work. The first part summarizes the additional understanding of the effects of glass composition (alkali/alkaline earth ratio) and atmospheric composition (CO_2 and formic acid) that has been gained from these experimental studies, based on controlled ageing experiments of model glasses. The stability and basicity of the salts that precipitate in the water film are key influencing factors of the degradation kinetics. They are determined by both the glass and atmospheric composition. The second part presents current results about the impact of cleaning the degraded glass surface with water, following a common practice of curators to remove surface salts. This simple treatment, by removing the basic salts and favouring the polymerization in the alteration layer, improved the durability of the model low-lime glass of the study. The results of another treatment consisting in spraying a tiny amount of zinc salts on the glass surface will also be summarized. These treatments are currently under test on model

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samples and on a few unstable glass objects exhibited in Parisian museums. The methodology of these tests and the perspectives drawn from this work for the future conservation practices will be discussed.

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Keywords: Soda lime silicate glasses, degradation, alteration, chemical durability, Cultural Heritage, conservation

Glass Professions and Knowledge Transmission: Between Pedagogy, Technique, and Technology

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The arts of fire—and glassworking in particular—cover a wide range of applications. From industry to aerospace, from engraving to traditional cane blowing, this material embodies both innovation and tradition, cutting-edge technology as much as ancestral skills.

For more than 60 years, the National School of Glass has offered training programs to the French community, ranging from 9th grade through CAP, BEP, vocational baccalaureates, BTS, DNMADe (+3), and DSAA (+5). Over the past six decades, the number of graduates in glassmaking has remained steady at around 60 per year. The teaching staff is composed of former factory workers, craftspeople, and artists, and trains both future industrial glassworkers and renowned artists.

Teaching physical chemistry, art, design, as well as glassblowing, cutting, and polishing to students aged 14 to 23 is an ongoing challenge.

In my presentation, I will show several examples of successful pedagogical approaches.

I will also discuss how, over the past four years, we have developed a partnership with USTV (part of CNRS) around "Glass Week," which brings together academic, industrial, and artistic contributors through lectures in the morning and workshops in the afternoon. **Keywords:**

teaching glass, technology, art and craft

*Speaker

The Royal Glass Factory of La Granja: From the recipes to the pieces

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The Spanish glass industry has a prestigious international reputation, dating back to the foundation of the Royal Glass Factory of La Granja in 1727. This center, directly supported by the Crown, stimulated the national glass industry in the 18th century thanks to the artistic quality of the pieces manufactured there. Despite producing a significant amount of high-quality glass, the lack of studies on glass from this period in Spain is notable, creating a gap in understanding the impact of Spanish glassmaking in Europe. Therefore, the objective of this research is to address this information gap through the analysis of the production in the Royal Glass Factory of La Granja from different perspectives.

Different documents with recipes and production techniques related to the Royal Glass Factory have been analyzed and compared with the most renowned documentary sources, such as "Art de la Verrerie, de Neri, Merret et Kunckel," demonstrating that knowledge traveled together with the foreign glassmakers, giving rise to industrial globalization.

From a practical point of view, the Royal Glass Factory was divided into different sub-factories to produce flat glass (windows and mirrors), pharmacy containers, glassware, chandeliers, cornucopias, etc., many of them with enameled, gilded, carved, or engraved decoration. The chemical analysis of the original pieces was a challenge because complete pieces were analyzed directly at the museum. The results indicated the use of different glass batches for objects of varying quality, as well as the use of calcium phosphate and lead arsenate as opacifiers. The most common chromophores (Co2+, Cu2+, Mn3+...) were identified in the enamels. This is the first step in understanding the Royal Glass Factory production.

Keywords: Royal Glass Factory of La Granja, 18th and 19th centuries, glass production, archaeometry.

*Speaker

Coloured glass and mosaics in the medieval world

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Medieval glass mosaics were a costly and important status symbol across the Mediterranean world. Over 360 wall mosaics survive from the Roman and Byzantine Empires, the medieval Italian states and Carolingian Europe, as well as the Islamic Caliphates. However, relatively little is known about how they came to be. To appreciate the aesthetic and cultural value of mosaics, we need to understand the artistic choices and the material constraints in making them. Raw glass was produced in only a few places during the first millennium CE and depended on long-distance trade, while the production of coloured glass required even more specialised technological know-how and access to rare colorants. This means that the glass tesserae, the small coloured glass cubes from which the mosaics were made, contain information about global issues such as human mobility, cross-cultural exchange and power relations as well as economic and aesthetic considerations. Based on the chemical composition of mosaic tesserae from some of the most important medieval monuments (e.g. Hagia Sophia in Constantinople, the Great Umayyad Mosques in Damascus and Cordoba), I will illustrate what medieval wall mosaics can tell us about coloured glass technology as well as artistic, cultural and economic networks in the Mediterranean world.

Keywords: archaeometry, glass mosaics, colours, medieval glass

*Speaker

Identification of coloring agents of 19th and 20th century African glass beads using XRF and XAS spectroscopy

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The cultural anthropology collections of the Musée de l'Homme (MH), part of the Muséum National d'Histoire Naturelle (MNHN), intend to document the impacts of environmental changes on creativity and evolution of material productions and know-how. This study focuses on African glass beads, which appeared from the 7th century AD on the continent and were used as currency for several centuries. At the end of the 19th century, colored European glass beads, mainly from Venice and Murano, have been massively imported to Africa due to strong economic opportunities. Their color palette with new manufacturing and coloring techniques was adapted to the observed African tastes. This led to the development of a local craft industry, today emblematic of countries such as Ghana, Nigeria or South Africa [1].

The corpus studied includes about 60 African glass beads preserved at the MH, dated approximately from the end of the 19th and 20th centuries. Some are important trade beads manufactured in Europe while others may have been locally made from recycled glass. The mixture of stylistic and technical influences makes the provenance of the majority of them difficult to establish by a simple visual examination [2]. Moreover, the details of the manufacturing techniques both in Europe and in Africa remain unclear.

For these reasons, these beads were characterized using non-invasive and non-destructive

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techniques in search of chemical markers to distinguish them. X-ray fluorescence (XRF) and X-ray absorption (XAS) spectroscopy measurements were carried out at the PUMA beamline in the synchrotron SOLEIL. This allowed us to conduct a first qualitative study of the composition of the glasses, especially of the different colors. The results enable us to discuss the provenance of several beads of the studied corpus and also to specify the date or the manufacturing technique thanks to the trace elements detected in the glass matrix, to the identified coloring agents and to glass heterogeneities.

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Keywords: colored glass beads, coloring agents, synchrotron X, ray fluorescence, X, ray absorption spectroscopy, cultural anthropology

Education in Glass Art and Science – challenges of transdisciplinarity

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Education in glass art and science offers a unique opportunity to explore the intersection of artistic creativity and scientific inquiry. At VICARTE, students engage with glass as a material that connects historical production practices, contemporary innovations, and experimental research. The educational programs in Art and Science of Glass and Glass Conservation emphasise transdisciplinary approaches, enabling participants to develop both practical and theoretical skills while exploring how artistic intuition and scientific reasoning inform one another.

Through hands-on experimentation, material analysis, and historical study, students investigate the relationships between craft, design, and technology. They explore glass production, degradation, conservation, and sustainable practices, while reflecting on the cultural, scientific, and societal significance of the material. By engaging across disciplines, students cultivate critical thinking, teamwork, and effective communication, translating knowledge into meaningful artistic and scientific outcomes.

VICARTE's approach brings together diverse expertise: artists, designers, scientists, conservators, and engineers, allowing students to observe and participate in the convergence of tacit and explicit knowledge. This collaborative environment fosters innovation and supports the creation of original works and research, connecting past traditions with contemporary developments in glass and ceramic materials.

By integrating historical knowledge, scientific methods, and creative practice, education in glass equips students with the skills to produce high-quality research and artwork, engage in sustainable material practices, and contribute to the preservation and appreciation of cultural heritage. It demonstrates the potential of transdisciplinary learning to foster innovation, critical reflection, and human-centered impact in both art and science.

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