

ISSN 1753-3562

2026 Volume 67 Number 4

PHYSICS AND CHEMISTRY OF GLASSES

European Journal of Glass Science and Technology Part B



***Society of Glass Technology Annual Meeting
7–9 September 2026
Programme and Abstracts***



Volume 67 Number 4

2026

Physics and Chemistry of Glasses

European Journal of Glass Science and Technology B

SOCIETY OF GLASS TECHNOLOGY ANNUAL MEETING
i SGT ANNUAL MEETING PROGRAMME
101 Abstracts
to 172

Manuscript submissions to the European Journal of Glass Science and Technology can be made through Editorial Manager, see the inside back cover for more details.

Editor-in-Chief

Professor Gin Jose

Deputy Editor

Dr A. C. Hannon

Regional Editors

Professor J. M. Parker

Professor M. Liška

Professor Y. Yue

Professor R. J. Hand

Managing Editor

D. Moore

Assistant Editor

S. Lindley

Society of Glass Technology
9 Churchill Way
Chapeltown
Sheffield S35 2PY, UK
Tel +44(0)114 263 4455
Email info@sgt.org
Web <https://www.sgt.org>

The Society of Glass Technology is a registered charity no. 237438.

Advertising

Requests for display rates, space orders or editorial can be obtained from the above address.

Physics and Chemistry of Glasses:
European Journal of Glass Science and
Technology, Part B
ISSN 1753-3562 (Print)
ISSN 1750-6689 (Online)

The journal is published six times a year
at the beginning of alternate months from
February.

Electronic journals: peer reviewed papers
can be viewed by subscribers through
Ingenta Select
<https://www.ingentaconnect.com>

The editorial contents are the copyright ©
of the Society.

Claims for free replacement of missing
journals will not be considered unless
they are received within six months of the
publication date.

This publication is brought to you in part by support from
Darshana and Arun Varshneya (Hon.FSGT)

of

Saxon Glass Technologies, Inc., Alfred NY

*"To promote the R&D in glass science, engineering, and technology
across the globe"*

"To disseminate such knowledge to human society-at-large"



SOCIETY OF GLASS TECHNOLOGY

Annual Meeting 2026

Murray Edwards College, Cambridge

7–9 September 2026

PROGRAMME AND ABSTRACTS

Sponsored by

AGC

and

ŞİŞECAM



CONTENTS

101	The science and technology of our transparent world Angela B. Seddon
103	The role of modifiers in oxide glasses Grant S Henderson
104	Bioactive glasses – is there still more to discover from simple compositions? Delia S. Brauer
105	Structure of mixed valence copper sodium borate biocidal glasses from combined neutron and x-ray diffraction Oliver L. G. Alderman
106	Strengthened glass by residual stress: depth of compression and surface flaws stability conditions Guglielmo Macrelli
107	Mechanical properties of Cu–Zr metallic glasses under sub- T_g thermal cycling: insights from molecular dynamics C. Fusco
108	Structure of lithium titano-phosphate $\text{Li}_2\text{O}-\text{TiO}_2-\text{P}_2\text{O}_5$ glasses including Ti K-edge x-ray absorption spectroscopy study of Ti sites Gavin Mountjoy
109	From structural modification to functionality in metal–organic framework glasses Morten M. Smedskjaer
110	Multimodal and multiscale interrogation of a glass forming copper-based metal organic framework Mounir El Skafi
111	Structural transitions in amorphous phase-change materials Shuai Wei
112	Investigation of a liquid–liquid transition through Peierls-like distortions in $(\text{GeTe})_x(\text{GeSe})_{100-x}$ David Vu Bui
113	Determining the kinetics of an amorphous phase change material through flash calorimetry Jens Moesgaard
114	Radioactive iridescence: understanding the evolution of alteration layers on nuclear waste glass Clare L. Thorpe
115	Developing opportunities for vitrification of complex radioactive wastes from the Sellafield site Rachel Crawford
116	Expansion of viscosity models for us hanford site radioactive waste glass melts Casey Walsh
117	Vitrification of radiological asbestos-containing wastes (ACW) Hannah E. Blystra
118	Glass positive electrodes for Li-ion batteries: from nickel phosphate glass synthesis to electrochemical properties Alexis Delanoë
119	AGC–Professor Michael Cable Memorial Lecture: The technology and science advanced by Michael Cable Arun Varshneya
120	Glass bottle lightweighting Olivier de Lataulade, L'Oréal, Clichy, France
121	Glass representation at the UK Parliament Stuart Hakes
122	Femtosecond laser induced plasma modification of silicate glass Gin Jose
123	Ultrashort pulse laser welding of dissimilar materials: glasses, metals and crystals Richard M. Carter
124	New mid-wave infrared (MWIR) fibre lasers Thomas Readyoof
125	Unravelling the formation pathway of CsPbBr_3 quantum dots in glass under modifier-ion regulation Kejie Huang
126	Photoluminescence and scintillation properties of co-doped phosphate glasses for x-ray imaging applications Falak Zaman
127	Tuning properties of oxynitride glass-ceramics through Na_2O -induced structural evolution Karolina Milewska
128	The bond angle distribution in silica glass, studied by analytical calculations and neutron diffraction Alex C. Hannon
129	Competition and connectivity in borogermanate glass networks Reuben M. Tosh
130	Structure of alkaline-earth aluminosilicate glass from molecular dynamic simulation and neutron diffraction Hikaru Ikeda
131	On the mixed alkali effect in silica-rich lithium-sodium silicates Alastair N. Cormack
132	Effect of melting conditions on $50\text{Na}_2\text{O}-50\text{P}_2\text{O}_5$ glass structure Lenorah Haight-Stott
133	Early- and Mid-Career Committee Workshop: academic and industrial career pathways Owen McGann, Stuart Hakes, Paul Bingham and Arun Varshneya
134	Glass Futures: a review of Furnace Campaign 1 and a preview of Furnace Campaign 2 Daniel J. Backhouse
135	Ammonia combustion technology for glass melting furnaces Hideyuki Imai
136	Vitrification of industrial wastes: a case study of air pollution control residues (APCr) Giulia Tameni

- 137 Greener glass melting with spent foundry sand
Robert Werner
- 138 Development of silicate glasses for agriculture
Martyn Marshall
- 139 Aluminosilicates for thermal treatment of intermediate level nuclear wastes
Russell J Hand
- 140 Beyond traditional process control: Hybrid-AI Digital Twins in hollow glass hot-end manufacturing
Federico Monegaglia
- 141 Reusable container glass: economics and technology
Owen McGann
- 142 Decarbonisation, the reality
Stuart Hakes
- 143 Multiphysics simulation for tin bath design and operation in float glass production
Adnan Karadag
- 144 **Plenary Lecture:** Tracing the invisible: reconstructing technological narratives to empower the conservation of cultural heritage
Inês Coutinho
- 145 Unravelling the correlation between populated site energies, activation energies and saddle point energies in solid ion conductors
K.-M. Weitzel
- 146 Configurational contribution to the thermodynamic driving force of crystallisation
Joshua Sena
- 147 Analysing thermodynamic and kinetic nucleation pathways through experimental and computational methods
River Pao
- 148 Intermediate-range order in the structure of borate glasses
Natalia M. Vedishcheva
- 149 **Invited Lecture:** Incorporation of chlorides in oxide glasses and glassy wasteforms
Paul A. Bingham
- 150 Low-temperature vitrification strategies for enhanced chloride retention in pyroprocessing waste
Luke Cooper
- 151 An XRD and XRF study of the incorporation of SnO₂ into soda–lime–silica glasses
Anthony M. T. Bell
- 152 Structural effects on the high temperature density of sodium borosilicate glasses doped with aluminium
Miu Onaru
- 153 **Invited Lecture:** Glass corrosion mechanisms alteration in long term tests
Michael I. Ojovan
- 154 The use of isotopic tracing to study the formation of the alteration layer on corroded glass
Eperke A. Rencz
- 155 Effects of high-temperature water vapour treatments on hydration and aqueous durability of float glass
Wei Deng
- 156 See page 144
- 157 Critically endangered: traditional glass making skills teetering on the edge of extinction within the UK
Jessamy Kelly
- 158 Venetian style filigree glass: initial results of a typological and technological investigation
Jerzy J. Kunicki-Goldfinger
- 159 Stuck expressions: fusing, hot sculpting and animating facial expressions for glassmation with ceramic slide transfer decals
Mark Hursty
- 160 From graphic translation to structural generation: a practice-led investigation of abrasive waterjet in glass art
Dian Shi
- 161 'I learnt about our 17th century Glass Heritage from this'
Colin Brain
- 162 Economically driven sustainability: modernisation in the glass industry, 1870–1920
Rahel Gugelmann
- 163 Research on the historical origin, craftsmanship and folk culture of Boshan Bulldong glass toys
Jianyong Guo
- 164 The full force of the law: how a Stourbridge glassmaker used nineteenth century IP law to take advantage of a fashion trend
D. C. Manison
- 165 Tracing the origins of early Iron Age glass in south east Europe
Ana Franjić
- 166 Conditions for the safe storage of early glass
Antanas Melinis
- 167 Ultraviolet-vis spectroscopy in cultural heritage: case studies on historical glass and ceramic glazes
Andreia Ruivo
- 168 Fragile infrastructures: interdisciplinary glass work and the decline of expertise in art and craft education
Goshka Bialek
- 169 Colour and corrosion in English medieval stained glass windows
Ian C. Freestone
- 170 A window into the medieval world: the consumption of English window glass at high status monastic sites in England, 12th to 16th Century
Bronwen Stone
- 171 Stained glass roof lantern: fragile heritage
Oksana Kondratyeva
- 172 The Lycurgus Project – a modern take on an ancient artifact
Lisa Hollands

CAMBRIDGE 2026 : MONDAY 7 SEPTEMBER : SCIENCE

The Long Room

- | | |
|-------|---|
| 09.00 | Welcome
Alex Hannon FSQT, Conference Chair |
| 09.10 | The science and technology of our transparent world
Angela B. Seddon, Mid-Infrared Photonics Group, University of Nottingham, UK |
| 09.50 | The role of modifiers in oxide glasses
Grant S Henderson, Dept. of Earth Sciences, University of Toronto, Toronto, Ontario, Canada |
| 10.30 | COFFEE |
| 11.00 | Bioactive glasses – is there still more to discover from simple compositions?
Delia S. Brauer, Otto Schott Institute of Materials Research, Friedrich Schiller University Jena, Jena, Germany |
| 11.40 | Structure of mixed valence copper sodium borate biocidal glasses from combined neutron and x-ray diffraction
Oliver L. G. Alderman, ISIS Neutron and Muon Source, Rutherford Appleton Laboratory, Didcot, UK |
| 12.00 | Strengthened glass by residual stress: depth of compression and surface flaws stability conditions
Guglielmo Macrelli, Isoclima SpA, R&D Department, Este (PD), Italy |
| 12.20 | Mechanical properties of Cu–Zr metallic glasses under sub- T_g thermal cycling: insights from molecular dynamics
C. Fusco, University of Lyon, INSA Lyon, UCBL, CNRS, Villeurbanne, France |
| 12.40 | Structure of lithium titano-phosphate $\text{Li}_2\text{O}-\text{TiO}_2-\text{P}_2\text{O}_5$ glasses including Ti K-edge x-ray absorption spectroscopy study of Ti sites
Gavin Mountjoy, University of Kent, Canterbury, UK |
| 13.00 | Lunch |

CAMBRIDGE 2026 : MONDAY 7 SEPTEMBER : SCIENCE

- | | |
|-------|---|
| 14.00 | From structural modification to functionality in metal–organic framework glasses
Morten M. Smedskjaer, Aalborg University, Denmark |
| 14.40 | Multimodal and multiscale interrogation of a glass forming copper-based metal organic framework
Mounir El Skafi, University of Oxford, UK |
| 15.00 | Structural transitions in amorphous phase-change materials
Shuai Wei, Aarhus University, Aarhus, Denmark |
| 15.20 | Investigation of a liquid–liquid transition through Peierls-like distortions in $(\text{GeTe})_x(\text{GeSe})_{100-x}$
David Vu Bui, Interdisciplinary Nanoscience Center, Aarhus, Denmark |
| 15.40 | Determining the kinetics of an amorphous phase change material through flash calorimetry
Jens Moesgaard, Aarhus University, Denmark |
| 16.00 | Coffee |
| 16.20 | Radioactive iridescence: understanding the evolution of alteration layers on nuclear waste glass
Clare L. Thorpe, University of Sheffield, UK |
| 17.00 | Developing opportunities for vitrification of complex radioactive wastes from the Sellafield site
Rachel Crawford, Sheffield Hallam University, UK |
| 17.20 | Expansion of viscosity models for us hanford site radioactive waste glass melts
Casey Walsh, School of Engineering and Built Environment, Sheffield Hallam University, UK |
| 17.40 | Vitrification of radiological asbestos-containing wastes (ACW)
Hannah E. Blystra, Sheffield Hallam University, UK |
| 18.00 | Glass positive electrodes for Li-ion batteries: from nickel phosphate glass synthesis to electrochemical properties
Alexis Delanoë, Université Grenoble Alpes, France |
| 18.20 | Close |

CAMBRIDGE 2026 : TUESDAY 8 SEPTEMBER : SCIENCE

The Long Room

- 09.00 **AGC–Professor Michael Cable Memorial Lecture:**
The technology and science advanced by Michael Cable
Arun Varshneya, Saxon Glass Technologies Inc. & Alfred University, Alfred, NY, USA
- 09.40 Glass bottle lightweighting
Olivier de Lataulade, L'Oréal, Clichy, France
- 10.20 Glass representation at the UK Parliament
Stuart Hakes HonFSGT, F.I.C. UK, Penzance, Cornwall, UK
- 10.40 **Coffee**
- 11.00 Femtosecond laser induced plasma modification of silicate glass
Gin Jose, University of Leeds
- 11.20 Ultrashort pulse laser welding of dissimilar materials: glasses, metals and crystals
Richard M. Carter, Heriot-Watt University, Edinburgh, UK
- 11.40 New mid-wave infrared (MWIR) fibre lasers
Thomas Readyoof, University of Nottingham, UK
- 12.00 Unravelling the formation pathway of CsPbBr₃ quantum dots in glass under modifier-ion regulation
Kejie Huang, Kyoto University, Japan
- 12.20 Photoluminescence and scintillation properties of co-doped phosphate glasses for x-ray imaging applications
Falak Zaman, University of Leeds, UK
- 12.40 Tuning properties of oxynitride glass-ceramics through Na₂O-induced structural evolution
Karolina Milewska, Linnæus University, Växjö, Sweden
- 13.00 **Lunch**

CAMBRIDGE 2026 : TUESDAY 8 SEPTEMBER : SCIENCE

The Long Room

- 14.00 The bond angle distribution in silica glass, studied by analytical calculations and neutron diffraction
Alex C. Hannon, ISIS Facility Rutherford Appleton Laboratory, UK
- 14.20 Competition and connectivity in borogermanate glass networks
Reuben M. Tosh, University of Nottingham, UK
- 14.40 Structure of alkaline-earth aluminosilicate glass from molecular dynamic simulation and neutron diffraction
Hikaru Ikeda, Nippon Electric Glass., Otsu, Shiga, Japan
- 15.00 On the mixed alkali effect in silica-rich lithium-sodium silicates
Alastair N. Cormack, Alfred University, USA
- 15.20 Effect of melting conditions on 50Na₂O–50P₂O₅ glass structure
Lenorah Haight-Stott, Alfred University, USA
- 15.40 **Coffee**
- 16.00 **Early- and Mid-Career Committee Workshop: academic and industrial career pathways**
Owen McGann, Stuart Hakes, Paul Bingham and Arun Varshneya
- 16.30 Discussion
- 17.30 **End**
– Followed by Reception (18.45) and Conference Banquet (19.30) at Clare College

Vivien Stewart Room

- 11.00 Glass Futures: a review of Furnace Campaign 1 and a preview of Furnace Campaign 2
Daniel J. Backhouse, Glass Futures, St Helens, UK
- 11.40 Ammonia combustion technology for glass melting furnaces
Hideyuki Imai AGC Inc., Yokohama Technical Center, Kanagawa, Japan
- 12.00 Vitrification of industrial wastes: a case study of air pollution control residues (APCr)
Giulia Tameni, Sheffield Hallam University, UK
- 12.20 Greener glass melting with spent foundry sand
Robert Werner, Glass Technology Services, Sheffield, UK
- 12.40 Development of silicate glasses for agriculture
Martyn Marshall, Glass Technology Services, Sheffield, UK
- 13.00 **Lunch**

CAMBRIDGE 2026 : TUESDAY 8 SEPTEMBER : INDUSTRY

Vivien Stewart Room

- 14.00 Aluminosilicates for thermal treatment of intermediate level nuclear wastes
Russell J Hand ISL, University of Sheffield, UK
- 14.20 Beyond traditional process control: Hybrid-AI Digital Twins in hollow glass hot-end manufacturing
Federico Monegaglia GlassFORM.ai, Rovereto, Italy
- 14.40 Reusable container glass: economics and technology
Owen McGann, Glass Technology Services, Sheffield, UK
- 15.00 Decarbonisation, the reality
Stuart Hakes HonFSGT, F.I.C. UK, Penzance, Cornwall, UK
- 15.20 Multiphysics simulation for tin bath design and operation in float glass production
Adnan Karadag, Aderis Engineering & Consultancy, Istanbul, Turkey
- 15.40 **Coffee**



Şişecam, the world's leading glass and chemicals manufacturer, is proud to announce its Diamond Sponsorship of the Society of Glass Technology (SGT). This sponsorship is a testament to Şişecam's commitment to innovation and technological advancement in the glass industry.

Şişecam is a global pioneer in the development and application of glass technology. The company has a long history of innovation, dating back to its founding in 1935. Şişecam continues to invest in research and development and has a team of scientists and engineers who are constantly pushing the boundaries of glass technology.

Şişecam's Diamond Sponsorship of SGT will support the Society's mission to advance the science and technology of glass.

Şişecam will contribute to and benefit from SGT's activities in a number of ways, including:

- Collaborating on research projects that will lead to new and innovative glass technologies.
- Providing and receiving educational opportunities for the next generation of glass scientists and engineers
- Promoting the exchange of knowledge and ideas among glass professionals

Şişecam is committed to working with SGT to advance the glass industry and to make a positive impact on the world.

To learn more about Şişecam and its passion to innovation, please visit our website at www.sisecam.com

CAMBRIDGE 2026 : WEDNESDAY 9 SEPTEMBER : SCIENCE

The Long Room

- 09.00 **Plenary Lecture:** Tracing the invisible: reconstructing technological narratives to empower the conservation of cultural heritage
Inês Coutinho, VICARTE, Portugal
- 09.40 Unravelling the correlation between populated site energies, activation energies and saddle point energies in solid ion conductors
K.-M. Weitzel, Philipps-Universität Marburg, Germany
- 10.00 Configurational contribution to the thermodynamic driving force of crystallisation
Joshua Sena, Alfred University, USA
- 10.20 Analysing thermodynamic and kinetic nucleation pathways through experimental and computational methods
River Pao, Alfred University, USA
- 10.40 Intermediate-range order in the structure of borate glasses
Natalia M. Vedishcheva, Institute of Silicate Chemistry, St. Petersburg, Russia
- 11.00 Coffee**
- 11.20 **Invited Lecture:** Incorporation of chlorides in oxide glasses and glassy wasteforms
Paul A. Bingham, Sheffield Hallam University, UK
- 12.00 Low-temperature vitrification strategies for enhanced chloride retention in pyroprocessing waste
Luke Cooper, Sheffield Hallam University, UK
- 12.20 An XRD and XRF study of the incorporation of SnO₂ into soda–lime–silica glasses
Anthony M. T. Bell, Sheffield Hallam University, UK
- 12.40 Structural effects on the high temperature density of sodium borosilicate glasses doped with aluminium
Miu Onaru, Sheffield Hallam University, UK
- 13.00 **Lunch**

CAMBRIDGE 2026 : WEDNESDAY 9 SEPTEMBER : SCIENCE

The Long Room

- 14.00 **Invited Lecture:** Glass corrosion mechanisms alteration in long term tests
Michael I. Ojovan, Wuhan University of Technology, Wuhan, P.R. China and University of Sheffield, UK
- 14.40 The use of isotopic tracing to study the formation of the alteration layer on corroded glass
Eperke A. Rencz, University of Sheffield, UK
- 15.00 Effects of high-temperature water vapour treatments on hydration and aqueous durability of float glass
Wei Deng, Sheffield Hallam University, UK
- 15.20 Coffee**
- 17.00 Close**

CAMBRIDGE 2026 : WEDNESDAY 9 SEPTEMBER : HERITAGE & HISTORY

The Long Room then from 09.40 Vivien Stewart Room 1

- 09.00 **Plenary Lecture:** Tracing the invisible: reconstructing technological narratives to empower the conservation of cultural heritage
Inês Coutinho, VICARTE, Portugal
- 09.40 Critically endangered: traditional glass making skills teetering on the edge of extinction within the UK
Jessamy Kelly, Edinburgh College of Art, University of Edinburgh, Scotland
- 10.00 Venetian style filigree glass: initial results of a typological and technological investigation
Jerzy J. Kunicki-Goldfinger, Institute of Nuclear Chemistry and Technology, Warsaw, Poland
- 10.20 Stuck expressions: fusing, hot sculpting and animating facial expressions for glassmation with ceramic slide transfer decals
Mark Hursty, University of North Carolina at Asheville, USA
- 10.40 From graphic translation to structural generation: a practice-led investigation of abrasive waterjet in glass art
Dian Shi, Tianjin Academy of Fine Art, PR China
- 11.00 Coffee**
- 11.20 'I learnt about our 17th century Glass Heritage from this'
Colin Brain
- 12.00 Economically driven sustainability: modernisation in the glass industry, 1870–1920
Rahel Gugelmann, Vitrocentre Romont, Switzerland
- 12.20 Research on the historical origin, craftsmanship and folk culture of Boshan Bulldong glass toys
Jianyong Guo, Shandong University of Art and Design, PR China
- 12.40 The full force of the law: how a Stourbridge glassmaker used nineteenth century IP law to take advantage of a fashion trend
D. C. Manison
- 13.00 Lunch**

CAMBRIDGE 2026 : WEDNESDAY 9 SEPTEMBER : HERITAGE & HISTORY

Vivien Stewart Room 1

- 14.00 Tracing the origins of early Iron Age glass in south east Europe
Ana Franjić, KU Leuven, Belgium
- 14.20 Conditions for the safe storage of early glass
Antanas Melinis, English Heritage Trust, London, UK
- 14.40 Ultraviolet-vis spectroscopy in cultural heritage: case studies on historical glass and ceramic glazes
Andreia Ruivo, VICARTE: Vidro e Cerâmica para as Artes, Portugal
- 15.00 Fragile infrastructures: interdisciplinary glass work and the decline of expertise in art and craft education
Dr Goshka Bialek
- 15.20 Colour and corrosion in English medieval stained glass windows
Ian C. Freestone, UCL Institute of Archaeology, London, UK
- 15.40 Coffee**
- 16.00 A window into the medieval world: the consumption of English window glass at high status monastic sites in England, 12th to 16th Century
Bronwen Stone, University of Sheffield, UK
- 16.20 Stained glass roof lantern: fragile heritage
Oksana Kondratyeva, Gerda Henkel Stiftung, Düsseldorf, Germany
- 16.40 The Lycurgus Project – a modern take on an ancient artifact
Lisa Hollands, University of Sheffield
- 17.00 Close**

The science and technology of our transparent world

Angela B Seddon

Mid-Infrared Photonics Group, University of Nottingham, Nottingham NG7 2RD, UK

Author email: angela.seddon@nottingham.ac.uk

A major reason for exploitation of glasses, and for their importance in the modern World, is transparency. But what contributes to transparency? In what part of the electromagnetic spectrum of light do we want transparency? How do we design glass compositions and glass-making processes to achieve transparency? Figure 1 shows the increase in visible transparency of inorganic glasses with time;⁽¹⁾ so progress from Phoenician/Egyptian glasses from 5000 years ago up to the late 1950s (and advent of float-glass), equals progress in the 13 years from 1966 to 1979, i.e. from Kao & Hockam first mooting transparent glass fibres for telecoms.⁽²⁾ to lab. realisation of the actual theoretical transparency of silica glass fibres (Figure 2,⁽³⁾), catalysing the boom of fibreoptic wiring-up of the City of London, trans-Atlantic telecom. glass cables and now a World Wide Web of glass fibre underpinning the Internet, social media, and streaming of videos and music on-demand. Announced first at the last Society of Glass Technology Cambridge Conference, 2025,⁽⁴⁾ by Polletti, University of Southampton UK, is a new transmission record in hollow-core silica glass fibre. The intricate anti-resonant, fragile silica glass structure guides light in an empty core, and smashes prior records for glass fibreoptic transparency. From there this paper will discuss transparency of heavy metal oxide glass fibres, fluoride⁽⁵⁾ and chalcogenide glass fibres⁽⁶⁾ and their importance as light-transmitting 'light pipes' and as light-emitting fibre-lasers.⁽⁷⁾ for new fibreoptic 'dipsticks and fishing lines'.

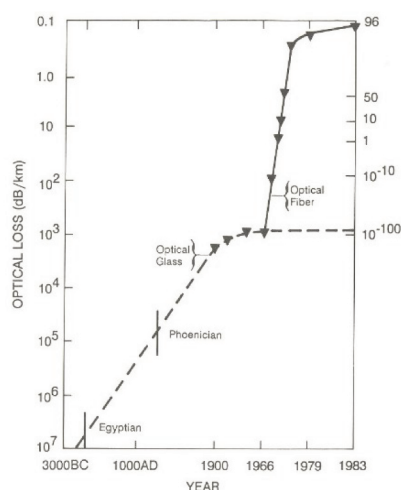


Figure 1. Inorganic glass transparency over time⁽¹⁾

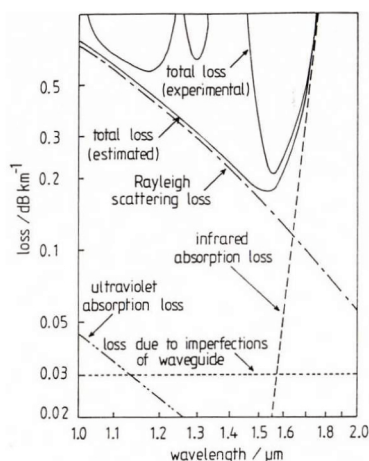


Figure 2. Record transparency, 1979, silica glass fibre underpinning Internet⁽²⁾

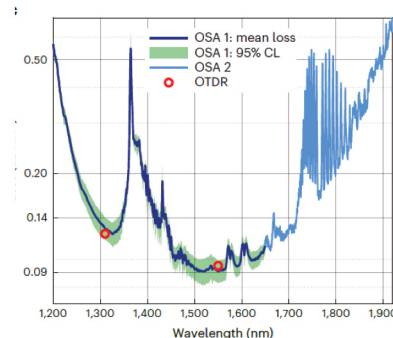


Figure 3. Recent breakthrough record silica glass fibre transparency⁽⁴⁾

References

1. *Materials Science and Engineering for 1990s: Maintaining Competitiveness in the Age of Materials* NRC, National Academic Press, 1989. ISBN-10: 0309039282
2. Kao, K. C. & Hockham, G. A. *Proc. IEE*, 1966, 113 (7), 1151–8.
3. Miya, T. et al. *Electron. Lett.*, 1979, 15, 106–8.
4. Poletti, F. et al., *Nature Photon.*, 2025, pub online
5. *Fluoride Glass Optical Fibers*. P. W. France, et al., Blackie, 2000.
6. Tang, Z. et al. *Opt. Mater. Expr.*, 2015, 5 (8), 1722–37.
7. Seddon, A. B. et al. *Eur. Phys. J. Plus*, 2024, 139 (2), 2024.

Angela Seddon graduated in Chemistry from the University of Nottingham, read for a PhD in Physical Chemistry, then was appointed British Telecom Research Fellow developing new mid-infrared fibreoptics at the University of Sheffield. Within the year, 1984, Seddon was appointed to a 'New Blood' Lectureship in Glass Fibreoptics at Sheffield. She was the first female Academic appointment since the Department's inception in 1937. In 2000, she became the



fibreoptics. Her research vision is to create a new paradigm in real-time mid-infrared endoscopy for early cancer diagnosis, based on chalcogenide glass fibre-optics. Towards this, her Group has made:

- record lowest optical loss chalcogenide glass fibre
- first in World, nonlinear chalcogenide glass fibre supercontinuum laser, and
- first in World, continuous wave fibre laser beyond 4 microns wavelength, using rare earth ion doped chalcogenide glass.

Author of over 300 publications and eight book chapters, Prof Seddon has delivered over 100 invited lectures. She is elected Fellow of: the Royal Society of Chemistry, the Institute of Materials, Minerals and Mining, Society of Glass Technology, and SPIE for distinguished contributions to optics and photonics using glass fibre-optics. Prof. Seddon served as an elected Trustee of the Royal Institution, London 2020 to 2026, and is currently President of the Society of Glass Technology.

The role of modifiers in oxide glasses

Grant S Henderson,¹ H. W. Nesbitt,² G. M. Bancroft³ & Philip A. W. Dean³

¹ Dept. of Earth Sciences, University of Toronto, Toronto, Ont. Canada M5S 3B1

² Dept. of Earth Sciences, University of Western Ontario, London, Ont. Canada N6A 5B7

³ Dept. of Chemistry, University of Western Ontario, London, Ont. Canada N6A 5B7

Corresponding author email: grant.henderson@utoronto.ca

The traditional approach to the role of modifiers, such as Na₂O, in oxide glasses (e.g. SiO₂) is that the modifiers break bridging oxygen (BOs) bonds to form nonbridging oxygens (NBOs). The alkalis then sit within rings of the glass network. As a result, there has generally been benign neglect of the role of modifiers in the physical and chemical behaviour of alkali-containing oxide (SiO₂, GeO₂) glasses. More recent work suggests that the modifiers initiate and control the physical and chemical behaviour of oxide glasses.

Some of the recent findings are:

- (a) The modifiers may bond to BOs, resulting in the BO coordination increasing from 2 to 3, 4, etc, with subsequent modification of the bonding characteristics of the BOs and NBOs
- (b) While the average coordination of Na in sodium silicate glasses appears to be around 5, there are several coordination environments from 4–8 with the Na atoms bonding to apical oxygens of a tetrahedron, tetrahedral edges and faces. Edge bonding appears to be the energetically stable configuration.
- (c) The Na–O distances are longer in glasses than crystals and increase with increasing Na₂O.
- (d) ‘free oxygen’ (an oxygen NOT bonded to a Si atom: Na₂O) is often present (at mol% levels at high alkali contents, e.g. above 30 mol% K₂O and above 40 mol% Na₂O) and is the most reactive species in the glass.
- (e) Collapse around the Na site due to a coulombic interaction (electrostriction) between the Na atoms and surrounding oxygens of the tetrahedra appears to initiate and control a number of physical properties such as partial molar volume (pMV), expansivity, etc. of both glasses and melts.

However, a number of questions remain:

- (a) What about the third dimension: cages, ribbons?
- (b) Why does there appear to be a dependence on the 20 mol% alkali composition for a number of oxides? For example, phase separation of sodium silicates, Ge–O bond length maximum in germanates
- (c) What are the effects of the different Na coordinations and bonding on ring statistics and shapes, Raman and NMR spectra, etc.

I shall present an overview of our understanding of the behaviour of alkali modifiers in silicate and germanate glasses (and melts) and make some suggestions for possible affects on glass structure and physical and chemical behaviour.

Bioactive glasses – is there still more to discover from simple compositions?

Meixin Su, Zhaorui Jin & Delia S. Brauer

Otto Schott Institute of Materials Research, Friedrich Schiller University Jena, Lessingstr. 12, 07743 Jena, Germany

Corresponding author email: delia.brauer@uni-jena.de

Bioactive glasses used as implant materials for bone regeneration are soda–lime silicate glasses containing small amounts of phosphate. In the past years, much of bioactive glass research has focused on incorporating various additional cations of potentially therapeutic use into the glass composition, covering many elements of the periodic table.⁽¹⁾ Does this mean that we already know everything there is to know about the compositions currently being used clinically or do open questions remain?

This talk looks into the molecular structure, thermal properties and reactions with aqueous media change if we vary either the SiO₂ to modifier oxide ratio or the CaO to Na₂O ratio in simple glass compositions. The results show that bioactive glasses are not particularly special in their composition – their characteristic properties (low viscosity of the melt, pronounced crystallisation tendency or fast ion release and surface mineralisation of apatite-like phases in contact with physiological solutions but also cell stimulation, bone formation or antibacterial properties) originate from their molecular structure containing large amounts of nonbridging oxygens and a low degree of silicate network polymerisation.^(2,3) This highlights how even moderate compositional changes can result in dramatic property changes, e.g. turning a bioinert material such as window glass into a highly bioactive materials suitable for regenerating bone, simply by lowering the silica content of the composition.

References

1. Brauer, D. S. & Hupa, L., Glass as a biomaterial: strategies for optimising bioactive glasses for clinical applications. *Compt. Rend. Géosci.*, 2022, **354**, 185–97.
2. Jin, Z., Neuville, D. R., Chartier, C., et al., From window panes to bone regeneration: structure, viscosity and bioactivity of soda lime silicate glasses. *J. Mater. Chem. B*, 2025, **13**, 3448–59.
3. Jin, Z., Neuville, D. R. & Brauer, D. S., Glasses for bone regeneration: structural features controlling physical properties and ion release of bioactive glasses 45S5, S53P4 and 13-93. *RSC Adv.*, 2025, **15**, 4997–5006.



Delia S. Brauer is a Professor of Bioactive Glasses at Friedrich Schiller University Jena, Germany. She studied chemistry with a focus on environmental chemistry in Jena and completed her PhD there in 2005, working on degradable phosphate glasses for biomedical applications. Following her doctorate, she conducted postdoctoral research at institutions including the University of California, San Francisco, Imperial College London, and Queen Mary University of London. In 2012, she returned to Jena as a junior professor and was appointed full professor in 2017. She held a four-month fellowship of the Japanese Society for the Promotion of Science at Nagoya Institute of Technology, Japan, in 2010 and was a Visiting Professor at the Institut de Physique du Globe de Paris, France, in 2022 and 2024. Her research focuses on the chemistry and structure–property relationships of bioactive glasses and related materials, particularly their interaction with water and their use in medical applications. Her work includes developing glass-based biomaterials for bone regeneration, dental applications, and controlled ion release. She is a Fellow of the Society of Glass Technology and

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

Oliver L. G. Alderman,^a Wesley Wall^b & Courtney Calahoo^b

^a ISIS Neutron and Muon Source, Rutherford Appleton Laboratory, Didcot, UK

^b Genics Inc., Alberta, Canada

Corresponding author email: oliver.alderman@stfc.ac.uk

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 the 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 synthesised, nominally $x\text{CuO} \cdot (20-x)\text{Na}_2\text{O} \cdot 80\text{B}_2\text{O}_3$ ($0 \leq x \leq 10$), $y\text{CuO} \cdot (40-y)\text{Na}_2\text{O} \cdot 60\text{B}_2\text{O}_3$ ($0 \leq y \leq 40$), and $z\text{CuO} \cdot (100-z)\text{B}_2\text{O}_3$ ($z=3, 6, 40, 50$). 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 15–60% 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% Fe_2O_3). 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 ^{11}B 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 2.14 Å, 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.



Oliver studies structure–property–function relationships in liquids, melts and glasses. He specialises in total scattering diffraction using x-rays and neutrons, and is currently a scientist within the Disordered Materials Group at the ISIS Neutron and Muon Source in the UK. Previously he worked at Materials Development, Inc. and the Advanced Photon Source in the US developing laser-heating levitation methods for the *in-situ* study of high-temperature molten materials, glasses and amorphous solids using synchrotron x-ray and pulsed neutron methods. Oliver obtained an MPhys degree and PhD in the elucidation of oxide glass structure from the University of Warwick. Oliver is a Fellow of the Society of Glass Technology and author or co-author of 60 scientific papers to date.

Strengthened glass by residual stress: depth of compression and surface flaws stability conditions

Guglielmo Macrelli

Isoclima SpA, R&D Department, via A.Volta 14, 35042, Este (PD), Italy

Author email: guglielmomacrelli@hotmail.com

To meet the demands of service loads and potential surface damage throughout its lifecycle, the structural performance of silicate glass must be enhanced through targeted strengthening processes.⁽¹⁾ The most effective method involves introducing a residual stress profile, characterised by near-surface compression balanced by internal tension. Typically, this is achieved through either thermal tempering via rapid quenching from temperatures above the glass transition or chemical strengthening, utilising ion exchange to replace native alkali ions with larger ones from an external source.⁽¹⁾ Surface compression (SC) and the depth of the compressive layer (DOL) are the defining parameters of these technological processes.⁽¹⁾ In this study, the reliability of these treatments under service conditions is evaluated by analysing the stress intensity factor K_I ($\text{MPa}\cdot\text{m}^{0.5}$) as a function of surface flaw length a (μm). The resulting $K_I(a)$ curves are compared against critical and threshold values to assess the risks of immediate fracture versus delayed failure driven by subcritical crack growth.⁽²⁾ Furthermore, the impact of service loads on compression depth is examined across three scenarios: thermally strengthened glass, standard chemically strengthened glass with a DOL of about $30\ \mu\text{m}$, and glass with an extended compressive layer $\text{DOL} > 100\ \mu\text{m}$. Finally, stability criteria for surface flaws are identified and compared across these distinct strengthening profiles.

References

1. Le Bourhis, E. Glass Mechanics and Technology. Second Edition, Weinheim, Wiley-VCH, 2014.
2. Macrelli, G. Flaws and cracks stability in strengthened glass by residual stress in Engineered Transparency 2018, Glass in Architecture and Structural Engineering, Edited by Schneider J. Weller B. Ernst & Sohn GmbH & Co. KG, 2028



Guglielmo Macrelli is presently Chief Scientific Advisor of Isoclima SpA (Este - PD Italy). Guglielmo was born in 1957, graduated in Physics in 1982 at the Università Degli Studi di Bologna (Italy). Guglielmo spent most part of his professional career in Isoclima SpA covering positions of R&D Responsible and Chief Technology Officer (CTO). He is a specialist in glass strength and strengthening processes mainly chemical strengthening by ion exchange, deposition of thin film coatings on glass by Magnetron Sputtering technologies, and smart glazing with variable optical properties (Electrochromics, SPD and PDLC technologies). Guglielmo has a scientific activity authoring several papers together with outstanding glass specialists (Arun K. Varshneya and John C. Mauro), participating as speaker in many international meetings and conferences and performing a peer review activity for the main journals (*Journal of Non-Crystalline Solids*, *Journal of the American Ceramic Society*, *International Journal of Applied Glass Science*, *Optical Materials*, *Ceramics International*).

Mechanical properties of Cu–Zr metallic glasses under sub- T_g thermal cycling: insights from molecular dynamics

A. Khan,¹ S.-J. Zhao,¹ J.-C. Qiao,¹ B. Wang,² L. Chazeau,³ C. Fusco,³ M. Liang⁴ & G.-J. Lyu¹

¹ School of Mechanics and Transportation Engineering, Northwestern Polytechnical University, Xi'an 710072, China

² School of Physical Science and Technology, Northwestern Polytechnical University, Xi'an 710072, China

³ Univ Lyon, INSA Lyon, UCBL, CNRS, MATEIS, UMR5510, 69621 Villeurbanne, France

⁴ State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing 100190, China

Corresponding author email: claudio.fusco@insa-lyon.fr

The long-term structural stability and mechanical reliability of metallic glasses (MGs) are critical for their application in high-performance engineering sectors. This study uses molecular dynamics (MD) simulations to investigate the synergistic effects of initial quenching rates and subsequent sub- T_g thermal-cycle treatments on the structural evolution and creep behaviour of a model $\text{Cu}_{64}\text{Zr}_{36}$ metallic glass.⁽¹⁾

While current literature often highlights thermal cycling as a method for structural rejuvenation, our findings demonstrate that cycling within specific sub- T_g temperature windows primarily drives structural relaxation and ordering, particularly in fast-quenched, highly disordered states. Specifically, it was observed that repeated thermal cycling between 100 and 600 K promotes a significant increase in the fraction of icosahedral (0, 0, 12, 0) clusters – the most stable local motifs in Cu–Zr systems. This leads to a more uniform and lower-energy state across samples, effectively reconciling the structural differences caused by varying thermal histories.

Crucially, we find that such induced structural stability translates to a marked enhancement in creep resistance. Post-cycling, fast-quenched samples that previously exhibited high creep susceptibility reached a stabilised state comparable to slowly quenched glasses, showing negligible strain even under elevated loads. This improvement is further supported by an observed shift in the activation energy distribution toward higher barriers, indicating a more robust energy landscape that resists atomic rearrangements. These results provide a predictive framework for using precise thermal protocols to 'erase' the detrimental effects of rapid processing, offering a pathway toward optimising the durability of amorphous alloys in load-bearing environments.

Reference

1. Khan, A., Zhao, S. J., Qiao, J. C., Wang, B., Chazeau, L., Fusco, C., Liang, M., & Lyu, G. J., Impact of sub- T_g thermal cycling on the mechanical properties of CuZr metallic glasses: a molecular dynamics study. *J. Non-Cryst. Solids*, 2025, 668, 123781.



Claudio Fusco is associate professor at the National Institute of Applied Sciences (INSA) in Lyon, France, where he is affiliated at the department of Materials Science and Engineering, and where he teaches for the undergraduate courses of general physics and mathematical and numerical methods. He is an expert on atomistic simulations, and his research interests cover different areas of condensed matter physics and materials science, with a particular focus on the mechanical properties of amorphous materials (oxide glasses, metallic glasses and glassy polymers), elastomers, semi-crystalline polymers, on fracture mechanics,

Structure of lithium titano-phosphate $\text{Li}_2\text{O}-\text{TiO}_2-\text{P}_2\text{O}_5$ glasses including Ti K-edge x-ray absorption spectroscopy study of Ti sites

Gavin Mountjoy,¹ Marie Naylor,^{1,2} Gregory Tricot,² Maria Alfredsson¹ & Sylvain Cristol²

¹ School of Engineering, Mathematics and Physics, University of Kent, Ingram Building, Canterbury CT27NH, UK

² LASIRE Unité Mixte de Recherche, Campus Cité Scientifique, Université de Lille, 59655 Villeneuve d'Ascq, France

Corresponding author email: g.mountjoy@kent.ac.uk

Li ion technology is the first choice for future battery technology, and several advances are being sought. Changing from liquid to solid electrolytes⁽¹⁾ improves safety and sustainability. Using glass as the electrolyte reduces energy expenditure and enables more applications. Lithium alumino-titano-phosphate (LATP) glasses have potential to be used as solid electrolytes for Li ion conductivity.^(2,3) Knowledge of LATP glasses can be built up from understanding the changes to a base lithium metaphosphate (LP) glass structure when making glasses with addition of Al (LAP) or Ti (LTP).

This talk will present initial work done that has been done to characterise the atomic structure of lithium titano-phosphate (LTP) glasses. Glass making has been done for compositions $50\text{Li}_2\text{O}-x\text{TiO}_2-(50-x)\text{P}_2\text{O}_5$ with $x=0$ to 20. Characterisation methods used are thermal analysis, infrared spectroscopy, 1D NMR spectroscopy of ^7Li and ^{31}P , and classical MD modelling. In addition, the oxidation state and coordination number of Ti sites has been studied using Ti K-edge x-ray absorption spectroscopy methods of XANES and EXAFS. The background, results, and interpretation, for LTP glass structures will be presented.

References

1. Zhai, H. et al. *Nano Lett.*, 2017, **17**, 3182.
2. Leo, C. J. *Mater. Res. Bull.*, 2002, **37**, 1419.
3. Manthiram, A. et al. *Nature Rev. Mater.*, 2017, **2**, 16103.

From structural modification to functionality in metal–organic framework glasses

Morten M. Smedskjaer

Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark

Author email: mos@bio.aau.dk

Metal–organic framework (MOF) glasses offer a unique combination of coordination-network chemistry and melt-processability, but their broader use requires processing strategies that can modify local bonding and thereby tune properties. In this talk, we present two examples of structural modification routes for zeolitic imidazolate framework (ZIF)-derived glasses, illustrating how traditional ‘glass chemistry’ concepts can be translated to hybrid networks. In the first case, co-melting ZIFs with halide salts provides a modifier-like approach that expands the set of accessible MOF glass formers and enables continuous adjustment of network connectivity through partial linker exchange.⁽¹⁾ Structural characterisation and simulations reveal systematic changes in local coordination environments consistent with controllable depolymerisation of the framework. In the second case, blending ZIF glasses with alkali phosphate glasses followed by targeted thermal and aqueous treatments yields glass composites, in which phosphate species are chemically grafted at interfaces while exchangeable ions are introduced.⁽²⁾ This processing route creates functional ion-exchangeable hybrid glasses, with potential to be used as either resins or membranes for mineral recovery and desalination. Together, these studies exemplify how processing-induced structural modification provides design pathways to enhance the functionality of MOF glasses.

References

1. Cao, F., Sørensen, S. S., Christensen, A. K. R., Mollick, S., Ge, X., Sun, D., Nielsen, A. B., Nielsen, N. C., Lock, N., Lu, R., Klemmt, R., Kristensen, P. K., Jensen, L. R., Dallari, F., Baglioni, J., Monaco, G., Karlsen, M. A., Baran, V., Smedskjaer, M. M. Continuous structure modification of metal-organic framework glasses via halide salts. *Nature Commun.*, 2025, **16**, 7001.
2. Mollick, S., Morgante, C., Christensen, A. K. R., Finkler, J. A., Youngman, R. E., Nielsen, A. B., Lu, R., Sørensen, S. S., Johansen, M., Karlsen, M. A., Stathopoulos, V. N., Lock, N., Nielsen, N. C., Boffa, V. & Smedskjaer, M. M. Selective mineral recovery from seawater by ion-exchangeable metal-organic framework glasses. *J. Am. Chem. Soc.*, 2026, **148**, 7450–9.

Multimodal and multiscale interrogation of a glass forming copper-based metal organic framework

Mounir El Skafi,¹ Gouqiang Li,² Sophie Thomas,³ James D. Taylor,⁴ Mark Frogley,⁵ Gianfelice Cinque,⁵ Michael Reithofer,³ Jia-Min Chin,³ Sebastian Henke² & Jin-Chong Tan¹

¹ Multifunctional Materials and Composites (MMC) Laboratory, Department of Engineering Science, Parks Road, Oxford, OX1 3PJ, University of Oxford, United Kingdom

² Anorganische Chemie, Fakultät für Chemie und Chemische Biologie, Technische Universität Dortmund, Otto-Hahn Straße 6, 44227, Dortmund, Germany

³ Faculty of Chemistry, University of Vienna, Währinger Str. 42, 1090 Vienna, Austria

⁴ ISIS Neutron and Muon Source, Science and Technology Facility Council, UKRI, Rutherford Appleton Laboratory, Chilton, Didcot OX11 0QX, United Kingdom

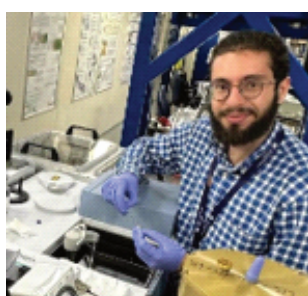
⁵ Diamond Light Source, Harwell Campus, Chilton, Oxford OX11 0DE, United Kingdom

Presenting author email: Mounir.elskafi@eng.ox.ac.uk

A copper-based metal-organic framework, Cu(Im)₂, was synthesised and subsequently melt-quenched into glass upon heating above 240°C. In this talk, we present a multimodal, multiscale characterisation of the MOF nanocrystals and the resulting glass. Structural characterisation using x-ray diffraction, atomic force microscopy, and electron microscopy was performed to understand the morphology and size of the synthesised nanocrystals. Thermogravimetric analysis and differential scanning calorimetry were employed to understand the melting process of the crystals to form the glass, synchrotron pair distribution function analysis was performed to verify that the framework structure is maintained upon melting, and infrared spectroscopy provided insight on the chemical structure of the materials. The mechanical characterisation via nanoindentation revealed that the resulting glasses exhibit remarkably high elastic modulus (~10 GPa) and the highest fracture toughness (>0.4 MPa m^{1/2}) compared to the reported values of ZIF-62 glass.^(1,2) Such development is important in the emerging field of processing and shaping MOFs while maintaining robust and fracture resistant material.

References

1. Bennett, T. D., *et al.*, Melt-quenched glasses of metal-organic frameworks. *J. Am. Chem. Soc.*, 2016. 138, 3484–92.
2. To, T., *et al.* Fracture toughness of a metal-organic framework glass. *Nat. Commun.*, 2020. 11.
3. El Skafi, M. & Tan, J. C. Manuscript under preparation, 2026.



Mounir El Skafi is a doctoral student in Engineering Science (Solid Mechanics and Materials) at the University of Oxford. He is a Stipendiary Lecturer at St Hugh's College and a retaining Lecturer at Somerville College teaching mechanics and engineering management. Mounir's work on metal organic framework materials (MOFs) aims at studying their mechanical properties in different forms such as monoliths, glasses, and composites at different length scales. Mounir's main focus is on processing MOFs for improving their fracture toughness and to design damage tolerant structures for energy absorption applications.

Structural transitions in amorphous phase-change materials

Shuai Wei

Department of Chemistry, Aarhus University, Aarhus, Denmark

Email: shuai.wei@chem.au.dk

Phase-change materials (PCMs), such as Ge–Sb–Te alloys, are functional materials, capable of rapid and reversible switching between amorphous and crystalline states, making them promising for novel electronic and photonic device applications. Here we show the structural evolutions in both the amorphous solid and liquid phases of PCMs as a function of temperatures and pressures. Using synchrotron x-ray scattering and advanced computational modelling, two local structural motifs such as octahedral motifs and Peierls-like distortions are identified and their transformation to each other have been investigated under controlled temperature and pressure conditions.⁽¹⁾ We highlight the hierarchical nature of the structural transition, involving both short and medium-range orders.⁽⁵⁾ By applying two-state models, we demonstrate a remarkable parallel to the structural transitions in supercooled water, underlying their high-to low-density, metal-to-semiconductor, and fragile-strong transitions.^(2,3) For the latter, we also demonstrate an experimental strategy, harnessing the fully coherent x-ray pulses of XFEL, to develop a femtosecond x-ray photon correlation spectroscopy (fs-XPCS),⁽⁴⁾ which enables us directly to probe the atomic-scale relaxations in the fragile liquid state above its crossover temperature.

References

1. Fujita, T., Chen, Y., Kono, Y., Takahashi, S., Kasai, H., Campi, D., Bernasconi, M., Ohara, K., Yumoto, H., Koyama, T., Yamazaki, H., Senba, Y., Ohashi, H., Inoue, I., Hayashi, Y., Yabashi, M., Nishibori, E., Mazzarello, R. & Wei, S. Pressure-induced reversal of Peierls-like distortions elicits the polyamorphic transition in GeTe and GeSe. *Nature. Commun.*, 2023, 14, 7851.
2. Wei, S., Lucas, P. & Angell, C. A. Phase-change materials: the view from the liquid phase and the metallicity parameter. *MRS Bull.*, 2019, 44, 691–8.
3. Wei, S., Lucas, P. & Angell, C. A. Phase change alloy viscosities down to T^* using Adam-Gibbs-equation fittings to excess entropy data: a fragile-to-strong transition. *J. Appl. Phys.*, 2015, 118, 034903.
4. Fujita, T., Sun, Y., Li, H., Albert, T. J., Song, S., Sato, T., Moesgaard, J., Cornet, A., Sun, P., Chen, Y., Mo, M., Amini, N., Yang, F., Lucas, P., Esposito, V., Vila-Comamala, J., Wang, N., Mamyrbayev, T., David, C., Hastings, J., Ruta, B., Fuoss, P., Sokolowski-Tinten, K., Zhu, D. & Wei, S. Femtosecond x-ray photon correlation spectroscopy enables direct observations of atomic-scale relaxations of glass forming liquids. *J. Chem. Phys.*, 2025, 162, 194201.
5. Fujita, T. *et al.* manuscript submitted, 2026.



Shuai Wei is an Associate Professor in the Department of Chemistry at Aarhus University, Denmark. He earned his Ph.D. from Saarland University in Germany and held postdoctoral research positions as a Humboldt Fellow at Arizona State University and at RWTH Aachen University before joining the faculty in Denmark. His research focuses on novel amorphous materials and liquids for advanced technologies, including phase-change materials for next-generation electronic and optical devices, as well as amorphous metals for structural and biomedical applications. His work explores the atomic-scale structure, relaxation dynamics, thermodynamics, and kinetics of amorphous states.

Investigation of a liquid–liquid transition through Peierls-like distortions in $(\text{GeTe})_x(\text{GeSe})_{100-x}$

David Vu Bui¹ & Shuai Wei²

¹ Interdisciplinary Nanoscience Center, Gustav Wieds Vej 14, 8000 Aarhus C, Denmark

² Department of Chemistry, Langelandsgade 130, 8000 Aarhus C, Denmark

Corresponding author email: dbui@inano.au.dk

Phase-change materials can be cycled between an amorphous and crystalline phase on a nanosecond timescale. Previous studies have shown that the ultrafast behaviour is linked to a supercooled liquid–liquid phase transition involving Peierls-like distortions.⁽¹⁾ A recent study on GeTe and GeSe has suggested that an overall transition line involving Peierls-like distortions exists in a pressure–temperature phase diagram.⁽²⁾ However, this hypothesis has yet to be investigated in further detail. In this work, high energy synchrotron x-ray diffraction experiments have been performed on a series of materials along the pseudo-binary line $(\text{GeTe})_x-(\text{GeSe})_{(100-x)}$ under heating to obtain reduced pair distribution functions. The results show that Peierls-like distortions become increasingly suppressed for compositions with a higher content of GeTe and the liquid–liquid transition eventually shifts below the melting temperature for a sufficiently high content of GeTe. Additionally, the results also suggest that the liquid–liquid transition temperature for phase-change materials may be estimated by extrapolation from liquid–liquid transition temperatures of non-phase-change materials along pseudo-binary lines. Finally, the behaviour of Peierls-like distortions with varying temperature shows a high degree of similarity to the behaviour with varying pressure, which supports the hypothesis of an overall phase transition line in the pressure–temperature diagram.

References

1. Zalden, P. *et al.* Femtosecond x-ray diffraction reveals a liquid-liquid phase transition in phase-change materials. *Science*, 2019, 364, 1062–7.
2. Fujita, T. *et al.* Pressure-induced reversal of Peierls-like distortions elicits the polyamorphic transition in GeTe and GeSe. *Nature Comm.*, 2023, 14, 7851.



David obtained his Master's degree in Nanoscience at Aarhus University in 2025 after his defense on the topic of phase-change materials. His supervisor, Shuai Wei, subsequently recommended David for the Oldfield Award, in which he received the second place. Since then, he has continued as a PhD student working on catalysis and decomposition of greenhouse gasses.

Determining the kinetics of an amorphous phase change material through flash calorimetry

Jens Moesgaard^{1,2} & Shuai Wei^{1,2}

¹ Department of Chemistry, Aarhus University, 8000 Aarhus, Denmark

² CENSEMAT Centre for energy materials, Aarhus University, 8000 Aarhus, Denmark

Corresponding author email: Jemo@chem.au.dk

Phase change materials (PCM) are promising candidates for applications in switchable non-volatile memory, devices due to their ultrafast phase switching between an ordered crystalline and disordered amorphous state, where these states possess a high electrical and optical contrast. The phase switching of PCMs functions by heating the glass into the supercooled liquid until crystallisation or heating the crystal into the liquid to melt quench into the glass. PCMs are categorised as poor glass-formers because of the amount of time it can remain in the supercooled liquid without crystallising, is too short for conventional methods to properly investigate the kinetics behind the PCMs' rapid crystallisation. However, flash calorimetry, e.g. flash differential scanning calorimetry (FDSC), has been shown to viable portray the temperature dependence of the crystallisation kinetics, through the Kissinger method.

Ge₁₅Te₂₄Sb₆₁ has been posited as a potential PCM, due to exhibiting structural and thermodynamic similarities to the known PCM Ge₁₅Sb₈₅. FDSC experiments were performed on the prospective PCM Ge₁₅Te₂₄Sb₆₁, to demonstrate its viability as a PCM, as well as elucidating its crystallisation kinetics through the Kissinger method. The analysis resulted in the determination of the fragility index and the temperature dependence of the crystal growth rate, with both being kinetic properties notoriously difficult to estimate by conventional methods. Furthermore, exploration of the temperature-dependent crystal growth rate revealed the appearance of a Fragile-to-Strong transition in the kinetic fragility of the supercooled liquid. Subsequent resistivity measurements of Ge₁₅Te₂₄Sb₆₁ also illustrated a high electrical contrast spanning several orders of magnitude between its crystalline and amorphous states, which further demonstrated the viability of Ge₁₅Te₂₄Sb₆₁ as an electrical PCM.

Radioactive iridescence: understanding the evolution of alteration layers on nuclear waste glass

Clare L. Thorpe, Garry Manifold, Eperke A Rencz & Russell J Hand

School of Chemical, Materials and Biological Engineering, Sir Robert Hadfield Building, University of Sheffield, Sheffield, S1 3JD, UK

Corresponding author email: clare.thorpe@sheffield.ac.uk

Glass dissolution mechanisms have been well described as far as they relate to nuclear waste type silicate or borosilicate glass exposed to simple solutions. However, with countries now engaged in site selection for near surface or deep geological disposal facilities, there is increased urgency to understand glass alteration mechanisms in more complex systems. Recent studies of glass alteration in dynamic, open, natural environments include those retrieved from shipwrecks (sea-water), caves (hyperalkaline water), terrestrial sediments (clay rich soils) and replica burial mounds (limestone). Across this range of natural systems common themes were observable: the important role that environmentally derived elements (e.g. Ca and P) play in secondary phase formation, evidence for continuing evolution of the alteration layer after formation resulting in banding/zoning and lamellae (Figure 1) and evidence of biological influence on alteration. Secondary mineral phase formation has implications for radionuclide retention and therefore is of relevance to the safety case for geological disposal of vitrified radioactive waste. Results from unique sites/field experiments are presented^(1–4) alongside experiments performed under controlled laboratory conditions. Differences in alteration layer chemistry demonstrate the importance of considering minor elements present at low concentrations that have the potential to sequester and have a major effect in the long-term.

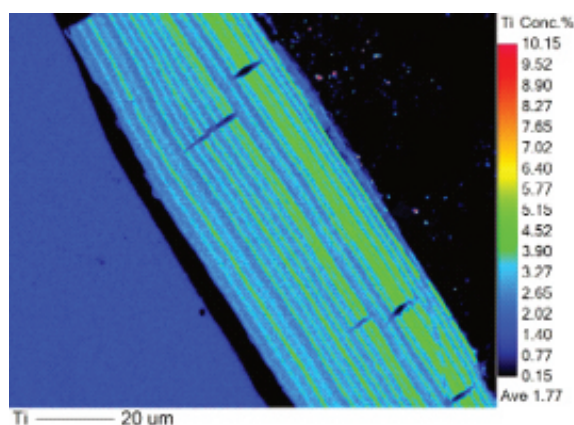


Figure 1. Lamellae formed on glass sample altered in sediment

References

1. Marcial, J., Chesnutt, J., Neeway, J. J., Gichon, E. et al. Alteration of archaeological and natural analogues for radioactive waste glass under different environmental conditions. *npj Materials Degradation*, 2025, 9, 102.
2. Thorpe, C. L., Aldred, N., Creasey-Gray, S., Stennett, M. C., et al. Comparison of naturally altered archaeological glasses from a marine environment with accelerated laboratory tests; implications for modelling long-term corrosion. *Appl. Geochem.*, 2025, 184, p.106363.
3. Thorpe, C. L., Fisher, A. J., Manifold, G., Creasey-Gray, S. et al. Insights into long term glass corrosion mechanisms from the Ballidon experiment. *npj Materials Degradation*, 2025, 9 (1), p.27.
4. Matthews, B. E., Neeway, J. J., Farias, L. N., Marcial, J., et al. Micro- and nanoscale surface analysis of late iron age glass from Broborg, a vitrified Swedish Hillfort. *Microsc. Microanal.*, 2023, 29 (1), 50–68.



Dr Clare Thorpe is a Senior Lecturer at the University of Sheffield and a Royal Society Dorothy Hodgkins Fellow. Her research aims to understand the interactions of glassy materials with complex aqueous environments, their durability and mechanisms of degradation. This is an interdisciplinary endeavour spanning the fields of geochemistry, mineralogy, microbiology and materials science. Her research group is an integral part of the Immobilisation Science Laboratory, with several current projects exploring the behaviour of materials developed to contain radioactive elements in glasses and ceramics to support their safe disposal.

Developing opportunities for vitrification of complex radioactive wastes from the Sellafield site

*Rachel Crawford*¹, *Adam Fisher*², *Alex Scrimshire*¹, *Jeremy Hastings*² & *Paul A. Bingham*¹

¹ School of Engineering and Built Environment, Sheffield Hallam University, City Campus, Howard Street, Sheffield, S1 1WB, UK

² Sellafield Ltd, Sellafield, Seascale, Cumbria, CA20 1PG

Corresponding author email: rachel.crawford@shu.ac.uk

Design and assessment of simulant radioactive wastes for investigation of immobilisation treatments that can support the development of a safety case is crucial for informing policy decisions surrounding the long-term disposal of nuclear waste. This work outlines the suitability of simplified simulants for poorly characterised radioactive wastes from the Sellafield site, such as legacy intermediate level wastes (ILW) including organic-rich storage tank sludges. This work is aiming to answer the questions: can we develop vitrified wasteforms for wastes that are not fully understood? If we can minimise the need for waste characterisation, can we improve the efficiency of disposal without compromising on wasteform suitability? Additionally, minimising the requirement for waste characterisation has greater benefits for site safety and increased retrieval rates. A waste treatment route that allows for swift retrieval and treatment without needing to fully characterise is a key driver.

Successful trials for thermal treatment technologies can feed into post operational clean out (POCO) activities and be implemented as a part of Sellafield's ongoing work, reducing the burden on future generations.

This work presents the development of proposed compositions to vitrify simulant wastes using historic Sellafield sampling data consisting of organic carbon content, activity, and partial ICP analysis, together with flowsheet information on input materials (i.e. 'what went in'). These analyses are used to produce a series of simulants, to feed into a full envelope of glass compositions for successful thermal treatment.

Expansion of viscosity models for US Hanford site radioactive waste glass melts

Casey Walsh,¹ Jaime L. George,² Pavel Ferkl,² Alex Scrimshire,¹ Pavel Hrma,³ Anthony M. T. Bell,¹ Robin Smith,¹ Albert A. Kruger⁴ & Paul A. Bingham¹

¹ School of Engineering and Built Environment, Sheffield Hallam University, City Campus, Howard Street, Sheffield S1 1WB, UK

² Pacific Northwest National Laboratory, Richland, Washington, USA

³ Attain X, General Services Contractor to the DOE Hanford Field Office, U.S. Department of Energy, Richland, Washington, USA

⁴ Department of Energy - Hanford Field Office, Richland, Washington, USA

Corresponding author email: casey.walsh@shu.ac.uk

Vitrification of nuclear wastes at the Hanford site requires accurate modelling of compositionally dependent properties such as the glass viscosity to maintain an efficient melting process. Despite the prevalence of alkali in the glass, interactions between alkali and the effects on viscosity has received relatively little attention. Further, multivalent oxides such as Bi, Cr and Mn are often assumed to occur in one oxidation state and/or are combined with other minor components into an 'others' category in many property models. Several series of simple alkali aluminoborosilicate glasses with varying contents of Bi₂O₃ (0–1 mol%), Cr₂O₃ (0–1.5 mol%), MnO (0–5.75 mol %), Li₂O and Na₂O (0–22 mol%) were fabricated, and viscosities measured across a wide range of temperatures. Viscosities will be compared relative to the ratio of alkali in the glasses and the effect the multivalent oxide has on the viscosity. Results will be presented and compared with existing models. Additional data to understand the thermal properties, crystallisation, oxidation, and composition will be presented.

Vitrification of radiological asbestos-containing wastes (ACW)

Hannah E. Blystra,¹ Anthony M. T. Bell,¹ Wei Deng,¹ James Stevens² & Paul A. Bingham¹

¹ Materials and Engineering Research Institute [Industry and Innovation], Sheffield Hallam University, Sheffield, UK

² United Kingdom National Nuclear Laboratory (UKNNL), Workington, UK

Corresponding author email: h.blystra@shu.ac.uk

This project aims to contribute to improvements in the following three key categories. One, exploring reductions in large volumes of the very low-level wastes (VLLW), low level wastes (LLW) and intermediate level wastes (ILW) further contaminated by asbestos.⁽¹⁾ Two, increase the availability of quality research into the management of radiological asbestos-containing wastes (Rad-ACW). Finally, three, assist evaluating alternative immobilisation methods for Rad-ACW with lower environmental impact. Vitrification of Rad-ACW seems a promising answer to all three of these categories, as vitrification creates a leach resistant product while lowering the volume of waste and immobilising radionuclides efficiently.⁽²⁾ This study further meets the needs of these three categories by establishing suitable chemical and morphological simulants for asbestos, allowing safer laboratory-based experiments, and utilising thermal treatment methods.

Two primary methods were used, method 1 was glass frit plus simulated waste loading melted at 1450°C, and method 2 explored lower temperature melts by using simulated waste plus flux and modifiers. Method 1 included using one of three glass frits (e-glass, soda-lime-silica (SLS), or Mixture Windscale (MW)) plus one simulated asbestos wastes, and radiological simulant doping at 0, 1 and 5% before heating. Method 2 included simulated asbestos wastes plus additives Na₂O, Li₂O, and B₂O₃ in a ratio to each other consistent with that of full lithium MW Frit.⁽³⁾ All materials were also evaluated for their suitability as immobilisation and denaturing hosts through characterisation of their composition-structure-property relationships.

By integrating materials science, process engineering, and regulatory frameworks, this study will aid in addressing critical waste management challenges in the nuclear sector, contributing to a safer, more sustainable approach to ACW management, aligning with industry objectives, enhancing long-term environmental stewardship and developing the foundation of a disposability toolbox.

References

1. NDA & BEIS UK Radioactive Waste Inventory 2022. Cumbria: Nuclear Decommissioning Authority. Available at: [UK Radioactive Waste Inventory 2022 - GOV.UK](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/115444/UK_Radioactive_Waste_Inventory_2022_-_GOV.UK) (Accessed: 27 Feb 2026).
2. Ojovan, M. I. & Lee, W. E. Immobilisation of radioactive waste in glass. In *An Introduction to Nuclear Waste Immobilisation*, 2014., Chapt. 17, pp. 245–82. doi: 10.1016/B978-0-08-099392-8.00017-6.
3. Short, R. Phase separation and crystallisation in UK HLW vitrified products'. *Proc. Mater. Sci.*, 2014, 7, 93–100. doi: 10.1016/j.mspro.2014.10.013.

Hannah Blystra is the Head of Quality and Glass Technology at Sina Medical Glass, a pharmaceutical glass start-up, and a full-time PhD student specialising in glass research and manufacturing. She brings more than eight years of experience in pharmaceutical glass development, fractography, root cause failure analysis (RCFA) and quality leadership. Hannah's glass journey began with ancient glass during her MSc at University of Sheffield, and historic telescopes and lenses at the Corning Museum of Glass, evolving into development work with some of the world's leading glass innovators including Corning Incorporated, Schott and Gerresheimer. Her current PhD is sponsored by the Nuclear Decommissioning Authority and titled 'Thermal Treatment of Radiological Asbestos Containing Wastes (ACW): a Disposability Toolbox'. Hannah is a lifelong learner and passionate advocate for accessibility and sharing of knowledge between industries and academia, she is also now working with PDA-UK as Student Engagement Officer and Deputy Treasurer for the local board.

Glass positive electrodes for Li-ion batteries: from nickel phosphate glass synthesis to electrochemical properties

Alexis Delanoë,¹ Julia Agullo,² Alexi Cardoso,² Maxime De Araujo,^{1,2} Laurent Gonon,³ Taos Guyot,^{1,2} Damien Perret,² Loïc Simonin,¹ Ambroise Van Rookeghem¹ & Sébastien Martinet¹

¹ Université Grenoble Alpes, CEA, Liten, DEHT, 38000 Grenoble, France

² CEA, DES, ISEC, DPME, Univ. Montpellier, Marcoule, France

³ Université Grenoble Alpes, CEA, CNRS, Grenoble SyMMES, Grenoble, France

Corresponding author email: alexis.delanoë@shu.ac.uk

Li-ion battery performances remain currently limited by the positive electrodes specific capacities. Commercial Li-ion batteries use crystalline materials (LFP, NMC, ...), but promising performances have been achieved with vanadium-containing glasses reaching up to 1000 Wh/kg at the material level after 10 cycles.^(1,2) Owing to their disordered network, glasses could theoretically incorporate high amounts of transition metals, resulting in high theoretical specific discharge capacities. Nevertheless, vanadium is a toxic critical element and the literature on vanadium-free glass positive electrodes remains scarce. Therefore, vanadium-free glasses as Li-ion positive electrode materials require further investigation.

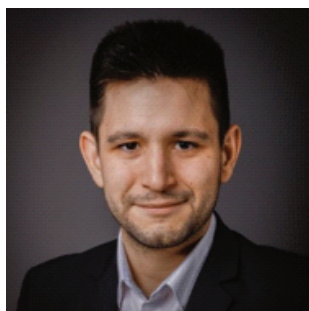
Nickel phosphate glass compositions were selected to maximise the theoretical specific discharge capacities of the glasses. The glasses were synthesised and characterised using different techniques (XRD, DTA-TGA, SEM, XRF). The ionic and electronic conductivities of the bulk glasses were also evaluated using electrochemical impedance spectroscopy and chronoamperometry.

Positive electrodes were prepared from glass powders, and the resulting electrodes were assembled into Li-metal coin cells. Their electrochemical performances were evaluated through galvanostatic cycling at a slow C/50 rate. Coin cells were disassembled at different states of charge, and post-mortem Ni K-edge XANES characterisations were performed on the positive electrodes to investigate the evolution of the Ni oxidation state during cycling.

Overall, the results of these characterisations provide structural, chemical, and electrochemical information on nickel phosphate glasses, helping to elucidate the mechanisms occurring during cycling and contributing to the understanding of this relatively underexplored topic.

References

1. Wang, Z., Luo, S., Zhang, X., Guo, S., Li, P. & Yan, S. *J. Non-Cryst. Solids*, 2023, 619.
2. Afyon, S., Krumeich, F., Mensing, C., Borgschulte, A. & Nesper, R. *Sci. Rep.*, 2014, 4, 7113.



Alexis Delanoë completed his PhD thesis at CEA Saclay (France), which defended in 2023, on the durability of nuclear glass in the presence of iron and clay-stone. He then conducted postdoctoral research at CEA Grenoble (France), working on glass positive electrodes for Li-ion and Na-ion battery applications. He is currently employed as a PDRA at Sheffield Hallam University (U.K.), working on topics related to nuclear waste immobilisation.

AGC-Professor Michael Cable Memorial Lecture: The technology and science advanced by Michael Cable

Arun Varshneya

*1*Saxon Glass Technologies Inc. & Alfred University, Alfred, NY, USA

Author email: varshneya@alfred.edu

This lecture is a homage by me, a former student, to my first "glass" mentor at Sheffield, Professor Michael Cable in 1964–65 at Sheffield, for the guidance and encouragement; it encapsulates some of Professor Cable's advanced thinking in the technology and science of glass making. Three topics will be presented: (i) his support to my development of the science of alkali migration in glass when bombarded by electrons, (ii) correction to Sir CV Raman's explanation of the science underlying glass inhomogeneity measurement using the Shelyubskii method, and subsequent advancement by me, and (iii) scientific understanding of fining of glass using arsenic which later developed into the understanding of redox equilibria in glass.



Arun Varshneya is a glass engineering scientist. He was educated at St. John's College, Agra, Sheffield University UK and Case Western Reserve University. In 1982, he joined Alfred University as a faculty, a position from which he retired in 2011. Arun made a world name for himself by writing, *Fundamentals of Inorganic Glasses*, which earned him much admiration and an affectionate nickname, "The Glass Guru". He is the founding president of Saxon Glass Technologies, Inc. of Alfred where, in 1997, he developed and marketed the chemically strengthened glass cartridge that contains epinephrine incorporated in the EpiPen autoinjector.

In 2019 at the International Congress on Glass, Boston MA, his former students and colleagues presented to him a "festschrift" – an honour symposium for four days.

He set up endowments at the American Ceramic Society to conduct two lectures annually on frontiers of glass science and technology, at Alfred University to fund "Varshneya-University Conference on Glass" which rotates among four institutions, and at Case to support a student tuition scholarship in memory of his own guru, Professor Alfred R. Cooper.

Glass bottle lightweighting

Olivier de Lataulade

L'Oréal, 9 rue Pierre Dreyfus 92110 CLICHY, France

Author email: Olivier.DELATAULADE@loreal.com

L'Oréal decided four years ago to open an R&D programme on glass bottle lightweighting. It means being able to achieve glass bottles with a lightweight ratio below 0.7 according to the Emahrt L value definition, and sufficiently resistant, with complex shapes (not only circular). Reduction in the weight of our packaging (by 20% at least in 2030), and reduction in CO₂ emissions (by 29% in 2030) are what triggered this initiative.

Based on our understanding of the glass industry and challenges analysis we have decided to divide this so-called 'Ultra-light glass bottle' programme into four sub-programmes: composition, processes, design and post-treatments. For each of them we have launched different projects with several partners: university, lab, converters, etc.

Now, we have achieved incredible results making the lightest/thinnest – complex shapes – cosmetics glass bottles in the world with a different process which is not the I/S process (30 ml 16 g; 330 ml 96 g; an average of less than 0.8 mm glass bottle wall thickness). This was accomplished with industrial lines including some modifications. It is now under patenting.

In terms of design we have started to learn how to predict resistance of such glass bottles.

For the compositions, with the objective to have a more resistant and less CO₂ glass, a first scientific publication was made on the ability to use AI and machine learning to well predict some mechanical properties starting from defined compositions. We are now achieving the opposite: predict composition based on targeted properties; some new glass compositions are under testing to evaluate differences between predictions and reality.

Finally we have already performed tests with post-treatments, chemical strengthening, mix of thermal/chemical strengthening and coating strengthening giving first amazing results on such thin glass wall thickness.



I am currently glass master scientist for L'Oréal group part of the Packaging Science Center which the packaging R&D department of L'Oréal. I also have in charge all about the colour, printing & finishing of our packaging. My role is to define what would be the R&D programmes and projects we have interest to conduct on these categories for the next 3–5 years.

Before this position, I was in charge on these categories too, of the expertise team with the mission of developing knowledge, support operational people and train the DevPack teams worldwide.

The other part of my career was dedicated to lead teams of Products Development or Packaging engineers, on an operational side directly in contact with our Brands (Biotherm Lancôme) and especially Designer Brands (Armani, YSL, Diesel, M Margiela, Viktor&Rolf), to put on the market the new skincare and perfumes products according to Marketing briefs.

Glass representation at the UK Parliament

Stuart Hakes HonFSGT

F.I.C. UK, Little Rock Industrial Estate, Penzance, Cornwall TR20 8HX, UK

Email address: s.hakes@fic-uk.com

The UK glass industries with Glass Futures, British Glass, the Glass and Glazing Federation and the Worshipful Company of Glass Sellers of London have formed an alliance representing all glass interests to the UK Parliament. They will be there again on Wednesday 9 September. Stuart will report on the progress so far and consult on any topics that need to be raised.

Femtosecond laser induced plasma modification of glass

Gin Jose

School of Chemical and Process Engineering, University of Leeds, Leeds, LS2 9JT, UK

Author email: g.jose@leeds.ac.uk

Surface modification of glasses by using femtosecond lasers have been proposed to strengthen, induce refractive index changes, and to manufacture active and passive waveguides. While most of the methods used are chemical in nature here we propose a laser induced plasma doping process using fs-lasers. The method was used to make waveguides in glasses with rare earth ions, to fabricate active functionalities. This ultrafast laser plasma doping (ULPD) method was used to modify the surface of silica, silicate glasses and silica-on-silicon.⁽¹⁾ ULPD can be used to introduce strength enhancement, colour and refractive index change in silicate glasses. The ability to dope rare earth ions such as Er^{3+} in record high concentrations and to depths of several micrometres has opened the opportunity to engineer high gain per unit length erbium doped waveguide amplifiers for the C-Band of fibre optics communication.⁽²⁻⁴⁾ The ULPD has been demonstrated with fs-lasers of different pulse durations and repetition rates. These include fs-lasers at 1 kHz, 10 kHz and higher repetition rate lasers (up to 1 MHz) with pulse durations of 100 fs, 45 fs and <290 fs using different laser systems. Er^{3+} -ion doping has also been demonstrated in silica-on-silicon substrates. The highest doping in silica is demonstrated with high calculated gain per unit length and low losses to fabricate waveguide amplifiers.⁽⁵⁾ In the talk an overview of the femtosecond laser induced changes in glass with emphasis on ULPD process will be presented.

References

1. Jose, G., Fernandez, T., Steenson, P. & Jha, A. Multi-ion diffusion in silica glass using femtosecond pulsed laser deposition. In *Conference on Lasers and Electro-Optics 2012*, OSA Technical Digest (online) (Optica Publishing Group, 2012), paper CM3L.6.
2. Chandrapan, J., *et al.* Target dependent femtosecond laser plasma implantation dynamics in enabling silica for high density erbium doping. *Sci. Rep.*, 2015, 5, 14037.
3. Ahmad Kamil, S., Chandrapan, J., Murray, M., Steenson, P., Krauss, T. F. & Jose, G. Ultrafast laser plasma doping of Er^{3+} ions in silica-on-silicon for optical waveguiding applications. *Opt. Lett.*, 2016, 41, 4684–4687.
4. Pal, P., Kumi-Barimah, E., Dawson, B. & Jose, G. Manufacturing of Er^{3+} -doped planar waveguides on silica-on-silicon using femtosecond laser-induced plasma. *Opt. Comm.*, 2022, 522, 128614.
5. Chandrapan, J., Murray, M., Petrik, P., Agocs, E., Zolnai, Z., Tempez, A., Legendre, S., Steenson, D. P., Jha, A. & Jose, G. Doping silica beyond limits with laser plasma for active photonic materials. *Opt. Mater. Expr.*, 2015, 5, 2849–2861.

Ultrashort pulse laser welding of dissimilar materials: glasses, metals and crystals

Richard M. Carter, Adrian Dzipalski, Tara van Abeelen, Ross Herbert, Paulina Morawska, Krystian Wlodarczyk & Duncan Hand

Institute of Photonics and Quantum Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, UK

Corresponding author email: r.m.carter@hw.ac.uk

Ultra-short pulsed laser welding has emerged as a powerful manufacturing technology for joining both transparent materials and creating robust bonds between highly dissimilar materials that are difficult or impossible to assemble using conventional techniques. The process works by focusing picosecond- or femtosecond- duration laser pulses at, or close to, the material interface, resulting in highly localized absorption and melting with minimal heat-affected zones.

This presentation will review more than a decade of research and development in ultra-short pulsed laser welding at Heriot-Watt. The fundamental principles of the process will be outlined, including the importance of interface quality, optical contact and laser-matter interaction mechanisms that govern weld formation. Particular attention will be given to the methods used to characterise weld performance, including mechanical strength testing, thermal cycling, stress birefringence measurements and environmental reliability assessments. Results demonstrate that appropriately engineered welds can achieve bond strengths comparable to, or exceeding, those of conventional adhesives while offering superior thermal stability and long-term durability provided that appropriate combinations of materials and processing are selected.

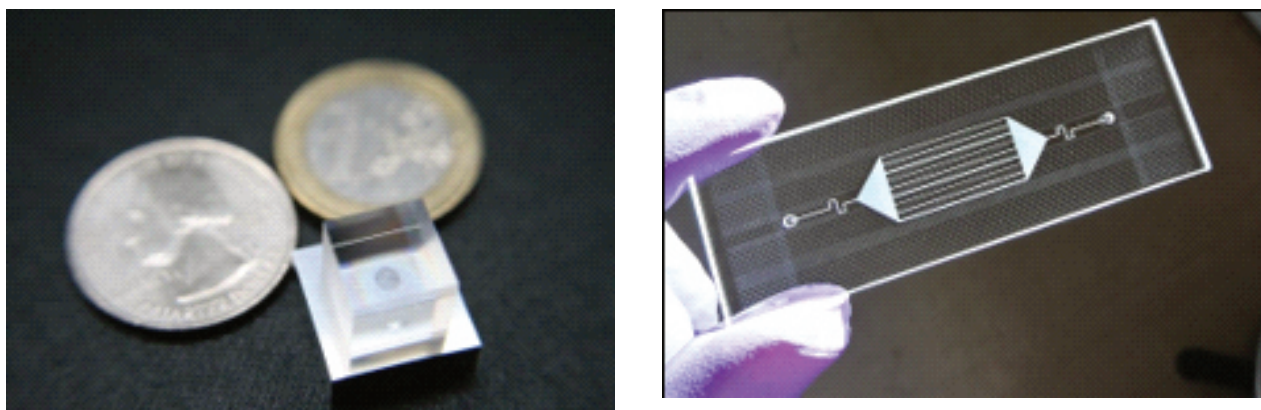


Figure 1. Exemplar glass/metal and glass/glass ultra-short pulse laser welded parts⁽¹⁾

Reference

1. Wlodarczyk, K.L., Hand, D. P. & Maroto-Valer, M. M. Maskless, rapid manufacturing of glass microfluidic devices using a picosecond pulsed laser. *Sci. Rep.*, 2019, 9, 20215. <https://doi.org/10.1038/s41598-019-56711-5>.



Richard graduated from the University of Edinburgh in 2005 with an MPhys, from the Universities of St-Andrews and Heriot-Watt with an MSc in photonics and opto-electronic devices in 2007 and in 2012 from Heriot-Watt with a PhD developing long period fibre gratings for environmental gas sensing. He then joined the high power laser applications group at Heriot-Watt as a research associate investigating laser based production processes becoming an Associate Professor in 2021 with teaching responsibilities in both Physics and Mechanical Engineering.

He is a member of the Applied Optics and Photonics Group, The Institute of Photonics and Quantum Sciences and the National Robotarium where he serves as the Academic Lead in Precision Laser Applications. Outside of the University he is a Vice President of the Association of Industrial Laser Users and chair of their External Engagement Board.

New mid-wave infrared (MWIR) fibre lasers

Thomas Readyhoof,¹ David Furniss, Mark Farries, Sendy Phang & Angela Seddon²

Mid-Infrared Photonics Group, George Green Institute for Electromagnetics Research, Faculty of Engineering, University of Nottingham, University Park, Nottingham, NG7 2RD, UK

Corresponding authors email: 1 thomas.readyhoof@nottingham.ac.uk and 2 angela.seddon@nottingham.ac.uk

The mid-infrared (MIR) wavelengths (3 to 50 μm) are of significant interest for photonic technologies, they have many applications in manufacturing, chemical sensing, environmental monitoring and healthcare. This is because the 3 to 50 μm span embraces the so called 'fingerprint region' of molecular absorption (~ 6 to 15 μm); absorption features in this region are both highly specific and highly sensitive to individual molecules, hence the name. Popular fibre materials such as silica glass and ZBLAN fluoride glass fibres are limited in this region, becoming opaque at ~ 3 and ~ 5 μm respectively. Hollow-core silica fibre and extruded polycrystalline halide fibre although mooted for transparency in the mid-infrared, suffer large optical bending losses and cannot be rare earth ion doped for emission. Chalcogenide glass fibres are much better suited, they exhibit low phonon energies, high refractive indices and non-linear optical properties and have a transparency to 12 μm in the MIR, can be doped and bending loss and robustness are acceptable. Chalcogenide glasses are composed of chalcogens, the elements found in Group 16 of the Periodic Table, selenide and sulphide-based chalcogenides are popular choices for MIR waveguides. Although transparent to MIR, chalcogenides are often hindered by impurities which introduce absorption and scattering centres that increase optical attenuation.

This PhD programme is building on the existing chalcogenide glass fibre work carried out at the University of Nottingham, working at wavelengths beyond 4 μm , extending the technology to include lanthanide ion doped ions for direct MIR fibre lasing working towards investigation of pulsed lasing behaviours. This involves high quality (low impurity) optical fibre fabrication and optical experimentation to produce fibre lasers working above 4 μm . Additionally, we are developing an embossing technique called Moth-Eye which bio-mimics compound eyes of insects onto optical fibres to increase their antireflection end-face properties.



Thomas Readyhoof is a PhD student at the University of Nottingham working in the George Green Institute for Electromagnetics Research. Their work focuses on Mid-IR optics, working with and fabricating chalcogenide glass optical fibres, testing and experimenting with fibres and investigating the effect of patterning to increase antireflection.

Unravelling the formation pathway of CsPbBr₃ quantum dots in glass under modifier-ion regulation

Kejie Huang,¹ Ruilin Zheng,² Jian Xu,^{1,3} & Setsuhisa Tanabe^{1,3}

¹ Graduate School of Human and Environmental Studies, Kyoto University, Kyoto 606-8316, Japan

² School of Science, Nanjing University of Posts and Telecommunications, Nanjing 210023, China

³ Graduate School of Global Environmental Studies (GSGES), Kyoto University, Kyoto 606-8501, Japan

Corresponding author email: huang.kejie.74w@st.kyoto-u.ac.jp

Halide perovskite nanocrystal embedded glasses combine the narrow-band, efficient emission of quantum dots, the continuously tunable visible-light emission of halide perovskites, and the high stability of glass, making them promising for various optoelectronic applications. In addition, the introduction of ions such as Zn²⁺ or S²⁻ into the glass system can further improve the performance of the quantum dots.⁽¹⁾ However, due to the structural complexity of these systems, it remains highly challenging to clarify how such ions influence the formation of the quantum dots.

In this work, we combined in situ transmission spectroscopy and in situ synchrotron x-ray total scattering with pair distribution (PDF) analysis to investigate the effect of different Zn²⁺ concentrations on the formation of CsPbBr₃ quantum dots in a fluorophosphate glass.⁽²⁾ The results show that Zn²⁺ can regulate both the phase separation of heavy-metal halides during heat treatment and the subsequent formation of quantum dots within the halide-rich phase, revealing that the formation of CsPbBr₃ quantum dots in glass is a process governed by both temperature and pressure.

References

1. Huang, K., Xu, J., Shimono, S., Shinozaki, K., Nakanishi, T., Zheng, R., Tanabe, S. *J. Non-Cryst. Solids*, 2026, 682, 124084.
2. Huang, K., Zheng, R., Shimono, S., Shinozaki, K., Nakanishi, T., Xu, J., Tanabe, S. *Chem. Commun.*, 2026, 62 (3), 855–9.

Photoluminescence and scintillation properties of co-doped phosphate glasses for x-ray imaging applications

Falak Zaman,^{*1,2} Gin Jose¹ & Jakrapong Kaewkhao^{#3, 4}

¹ School of Chemical and Process Engineering, Faculty of Engineering, University of Leeds, Leeds LS2 9JT, UK

² Department of Physics, University of Buner, Buner 19290, Pakistan.

³ Physics program, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Nakhon Pathom, 73000, Thailand.

⁴ Center of Excellence in Glass Technology and Materials Science (CEGM), Nakhon Pathom Rajabhat University, Nakhon Pathom, 73000, Thailand

Corresponding authors: *F.Naz1@leeds.ac.uk #jakrapong@webmail.npru.ac.th

The fabrication and synthesis of efficient luminescent and scintillating devices are important for advanced optical and x-ray imaging devices.⁽¹⁾ The present investigation is based on phosphate-based $\text{Ce}^{3+}/\text{Dy}^{3+}$ co-doped $\text{K}_2\text{O}-\text{Al}_2\text{O}_3-\text{P}_2\text{O}_5$ ⁽¹⁾ and $\text{Tb}^{3+}/\text{Eu}^{3+}$ co-doped $\text{K}_2\text{O}-\text{Al}_2\text{O}_3-\text{SrO}-\text{P}_2\text{O}_5$ glasses.⁽²⁾ The proposed samples were synthesised through conventional solid-state reaction and melt-quenching approach. The prepared glass samples were characterised using x-ray diffraction (XRD), optical absorption spectroscopy, Fourier-transform infrared spectroscopy (FTIR), photoluminescence (PL), radioluminescence (RL), decay lifetime measurements, photoluminescence quantum yield (PLQY) and scintillation imaging analyses. The amorphous nature of all prepared glass samples was confirmed by XRD analysis. The phosphate glass network was investigated via FTIR which contains both bridging and nonbridging oxygen units. The $\text{Ce}^{3+}-\text{Dy}^{3+}$ co-doped glasses exhibited strong emission at 484 nm blue and at 575 nm yellow under UV excitation, with efficient energy transfer from Ce^{3+} to Dy^{3+} ions. The highest photoluminescence quantum yield (PLQY) of 37-62% was obtained for the 0.5Ce:0.1Dy composition.⁽¹⁾ For the $\text{Tb}^{3+}/\text{Eu}^{3+}$ co-doped phosphate-based system, characteristic green emission from Tb^{3+} ($^5\text{D}_4 \rightarrow ^7\text{F}_5$, 544 nm) and red emission from Eu^{3+} ($^5\text{D}_0 \rightarrow ^7\text{F}_2$, 613 nm) were obtained, accompanied by efficient energy transfer from $\text{Tb}^{3+} \rightarrow \text{Eu}^{3+}$. The co-doped glasses exhibited orange-red chromaticity with correlated colour temperatures between 2000 and 3000 K. Importantly, scintillation imaging measurements demonstrated a spatial resolution of 11.6 LP mm⁻¹, approaching that of commercial BGO scintillators (13.2 LP mm⁻¹).⁽²⁾ The prepared $\text{Ce}^{3+}/\text{Dy}^{3+}$ and $\text{Tb}^{3+}/\text{Eu}^{3+}$ co-doped phosphate glasses provide efficient luminescence, effective energy-transfer mechanisms, and promising scintillation performance. These devices are good candidates for potential solid-state lighting (LEDs), radiation detection, and high-resolution x-ray imaging applications.

References

1. Abbasa, J. *Et al.* Spectroscopic properties and tunable color emission via $\text{Ce}^{3+}/\text{Dy}^{3+}$ energy transfer in $\text{K}_2\text{O}-\text{Al}_2\text{O}_3-\text{P}_2\text{O}_5$ glasses for solid-state lighting and scintillation applications. *J. Alloys Compounds*, 2025, **1044**, 184294.
2. Abbasa, J. *et al.* Photoluminescence and scintillation properties in $\text{Tb}^{3+}/\text{Eu}^{3+}$ co-doped phosphate glasses for X-ray imaging applications. *Vacuum*, 2026, **252**, 115504.



I am a research fellow at the School of Chemical and Processing Engineering at University of Leeds working in the field of Functional glass materials. My research focuses on the optical, photoluminescence, and x-ray luminescence properties of rare-earth-doped glasses for radiation detection and x-ray imaging applications. I have skills in fabrication of glass materials, structural characterisation, and spectroscopic analysis, including photoluminescence and radioluminescence studies. My work explores energy transfer mechanisms and the optimisation of glass compositions for optimisation performance. I am particularly interested in developing novel scintillator materials for high-resolution x-ray imaging, advanced photonic devices and Phosphate-based glass electrolytes for solid state batteries applications. My research contributes to the advancement of sustainable energy storage and high-performance optical devices. I actively contribute to scientific publications and conference presentations in the field of functional glass materials. Through my research, I aim to advance the understanding and application of luminescent materials for healthcare, and industrial imaging systems.

Tuning properties of oxynitride glass-ceramics through Na₂O-induced structural evolution

Karolina Milewska,¹ Natalia Wójcik,² Zuzanna Mielke,² Abbas Hakeem^{3,4} & Sharafat Ali¹

¹ School of Engineering, Department of Built Environment and Energy Technology, Linnæus University – SE-351 95, Växjö, Sweden

² Gdańsk University of Technology, Institute of Nanotechnology and Materials Engineering, Faculty of Applied Physics and Mathematics – Narutowicza 11/12, 80-952 Gdańsk, Poland

³ Interdisciplinary Research Centre for Hydrogen Technologies and Carbon Management (IRC-HTCM), King Fahd University & Petroleum & Minerals – Dhahran, 31261, Saudi Arabia

⁴ Department of Materials Science and Engineering, King Fahd University of Petroleum and Minerals – Dhahran 31261, Saudi Arabia

Corresponding author email: karolina.milewska@lnu.se

Oxynitride glass-ceramics combine advantages of amorphous and crystalline phases, offering thermal and chemical stability, making them attractive for applications in solid-state lighting and energy storage.⁽¹⁾ In this study, we synthesised two complementary series of Na₂O (0–12 wt%) oxynitride glass-ceramics in the Na–Mg–Ca–Al–Si–O–N system using spark plasma sintering (SPS): undoped⁽²⁾ and doped with 0.05 wt% Eu₂O₃.⁽³⁾ This approach allows isolating the Na₂O effect on structural evolution and, separately, correlate that evolution with thermal, electrical and luminescent properties.

XRD reveals Na₂O-induced amorphous-to-crystalline transition, the crystalline volume fraction increases from ~18% (0 wt% Na₂O) to ~60% (12 wt% Na₂O), with formation of silicate/aluminosilicate nanocrystals in an oxynitride glass matrix. FTIR confirms network depolymerisation with increasing Na₂O content. In undoped samples,⁽²⁾ higher Na₂O content reduces density (2.68→2.34 g/cm³) and thermal conductivity (1.448→1.428 W/m.K), while thermal expansion rises (5.65→10.24×10⁻⁶ K⁻¹). Impedance spectroscopy shows enhanced ionic conductivity ($E^a \sim 0.87$ eV) at ≥9 wt% Na₂O, indicating mixed Na⁺/K⁺ hopping. In Eu-doped samples,⁽²⁾ despite Eu being added as Eu₂O₃, the reducing SPS environment stabilises Eu²⁺ as the dominant emitter. Increasing Na₂O red-shifts emission from 481 to 499 (λ_{ex}=320 nm) and broadens FWHM from 113 to 138 nm, reflecting the emergence of distinct Eu²⁺ coordination environments. Emission intensity shows a non-monotonic behaviour, peaking at 3 wt% Na₂O (~31% crystallinity). CIE coordinates shift from blue to blue-green.

Thus, Na₂O enables simultaneously tuning of structural, thermal, electrical and luminescent properties, making these materials promising for ultraviolet-excited phosphors⁽³⁾ and as solid electrolytes.⁽²⁾

References

1. Ali, S., Hakeem, A., Eriksson, M. & Wójcik, N. A. A novel approach for processing CaAlSiON glass-ceramics by spark plasma sintering: mechanical and electrical properties. *J. Eur. Ceram. Soc.*, 2022, 42, 96–104.
2. Wójcik, N. A., Hakeem, A. S., Mielke, Z. & Ali, S. Investigation of structural, thermal, and electrical properties of sodium-doped oxynitride glass-ceramics. *Mater. Chem. Phys.*, 2025, 329, 30139, doi: 10.1016/j.matchemphys.2024.130139.
3. Milewska, K., Wójcik, N. A., Zaman, F., Hakeem, A. S. & Ali, S. Tuning Eu²⁺ emission in oxynitride glass-ceramics via Na₂O modification. *J. Non-Cryst. Solids*, 2026, 680, 124026, doi:10.1016/j.jnoncrysol.2026.124026.

The bond angle distribution in silica glass, studied by analytical calculations and neutron diffraction

Alex C. Hannon

ISIS Facility Rutherford Appleton Laboratory, Chilton, Didcot, Oxon OX11 0QX, UK

Author email: alex.hannon@stfc.ac.uk

Vitreous SiO_2 is the archetypal glass; it is often the example that is first considered in trying to understand the structure of network glasses. Its structure is formed by corner-sharing between $\text{SiO}_{4/2}$ tetrahedra, and the evidence is that these tetrahedra are very well ordered, much the same as in crystalline forms of SiO_2 . Thus the random nature of the glass structure does not arise from disorder within the tetrahedra, but instead from the way in which they connect together. Pairs of tetrahedra are connected to each other by a corner-shared bridging oxygen (i.e. a Si–O–Si bridge), and thus the most fundamental aspect of the random structure is the distribution of Si–O–Si bond angles.

Diffraction is an experimental technique that is sensitive to the structure of a glass, which might be expected to have played a key role in studies of the bond angle distribution (BAD) in glass, and the first attempt to measure the BAD in $v\text{-SiO}_2$ was based on x-ray diffraction results, see the famous 1969 paper by Mozzi & Warren (Journal of Applied Crystallography). However, there have been very few subsequent attempts to use more modern diffraction interpretation methods to study the BAD, and instead most reports have been based on NMR measurements. It may be that the relative lack of diffraction studies has arisen due to the mathematical complexity of deriving the BAD from the diffraction results.

This talk is based on new neutron diffraction results for $v\text{-SiO}_2$ with unparalleled resolution in real-space. The BAD is derived from the diffraction results using an analytical simulation method, that is applied numerically using a brute force method on a computer. Steric hindrance is taken into account by setting a minimum allowed distance between two oxygen atoms in different tetrahedra. A key feature of the method is the treatment of thermal vibrations of the atoms. For example, in the equilibrium structure of the quartz form of SiO_2 , there is only one single value for the bond angle, 143.64° . However, the effect of atomic vibrations is to broaden the instantaneous values of the bond angle, as observed by diffraction. We have used neutron diffraction results on $q\text{-SiO}_2$ to determine the effect of atomic vibrations on short interatomic distances, and these results have been incorporated in the calculations for the glass, so that the equilibrium BAD may be determined. It is found that the equilibrium BAD for $v\text{-SiO}_2$ has a mean angle of 149° , with a standard deviation of 14° . Despite the effective deconvolution of the effects of atomic vibrations, this result is relatively broad compared to typical literature results.

These results are important for a fundamental understanding of the disordered structure of vitreous SiO_2 .



I am an authority on the structure of glasses and other disordered materials, and an expert in the study of atomic structure by neutron diffraction, see <http://alexhannon.co.uk/>. I am employed at the ISIS Facility, which is a neutron source located in Oxfordshire in the UK. I work as an instrument scientist on the GEM (GEneral Materials) diffractometer, and I am responsible for its scientific programme in disordered materials.

Competition and connectivity in borogermanate glass networks

Reuben M. Tosh,¹ Emma Barney¹ & Oliver L.G. Alderman²

¹ Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham, Nottingham NG7 2RD, UK

² ISIS Neutron and Muon Source, Chilton, Didcot, Oxon OX11 0QX, UK

Corresponding author email: reuben.tosh@nottingham.ac.uk

Borogermanate glasses are an important class of optical materials due to their ability to incorporate rare-earth ions,⁽¹⁾ making them promising candidates for applications such as x-ray scintillators, lasers and optical communications technologies. Despite their technological relevance, the structural behaviour of these materials remains poorly understood, particularly the respective roles of boron and germanium as competing network formers within the glass network.

This work investigates a range of barium borogermanate ($\text{BaO-B}_2\text{O}_3\text{-GeO}_2$) glass compositions measured using neutron diffraction on the SANDALS instrument at the ISIS Neutron and Muon Source. Structural measurements were performed to probe the local atomic arrangements and network connectivity within the glass system. In particular, the study focuses on the competition between boron and germanium as coordination-changing network formers and how this influences the resulting glass structure.

Preliminary analysis of neutron diffraction data indicates that the B–O and Ge–O bond length distributions are clearly resolved from one another, as expected.⁽²⁾ In addition, changes in the broadening of the B–O and Ge–O coordination environments are observed as the glass composition varies. This behaviour, illustrated in Figure 1, is such that the principal tie-line compositions link the Ge–O coordination maxima to the B–O coordination maxima.^(3,4) Additional ¹¹B NMR measurements will accompany the neutron diffraction data to quantify the fraction of tetrahedral boron coordinated to oxygen (N_4).

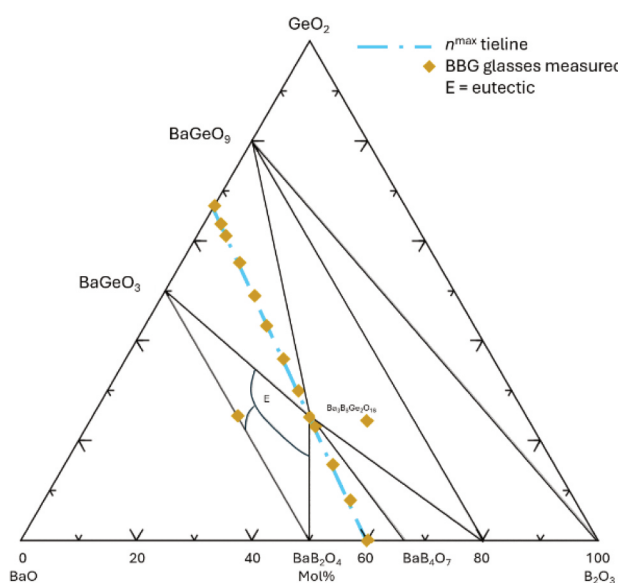
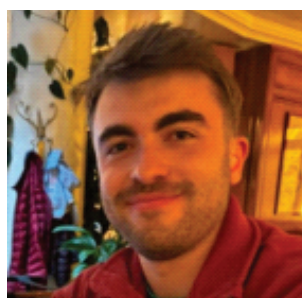


Figure 1. Ternary diagram of the $\text{BaO-B}_2\text{O}_3\text{-GeO}_2$ glass compositions. The blue tie-line connects the two coordination number maxima



Reuben Tosh is a first-year PhD student in Mechanical Engineering at the University of Nottingham, working in collaboration with the ISIS Neutron and Muon Source at the Rutherford Appleton Laboratory. His research focuses on understanding the structure of amorphous materials using neutron diffraction techniques. Currently, his work investigates the structural behaviour of borogermanate glasses and the evolution of amorphous networks in high-temperature melts. Alongside this, he will be developing new engineering approaches for probing the structure of disordered materials under extreme temperature conditions.

Reuben received a MPhys degree in Physics from Durham University in 2025, where he specialised in condensed matter physics. His broader interests include glass science, neutron scattering methods and the structural characterisation of complex disordered materials.

References

- Berno, A. E. *et al. Chem. – An Asian J.*, 2025, 20 e202401613. DOI: 10.1002/asia.202401613
- Paterson, A. L. *et al. J. Phys. Chem.*, 2018, C122 (36), 20963–80. DOI: 10.1021/acs.jpcc.8b05747
- Alderman, O. L. G. *et al. J. Phys. Chem.*, 2017, 121 (17), 9462–79. DOI: 10.1021/acs.jpcc.6b12372
- Alderman, O.L.G. *et al. Rep.n Progr. Phys.*, 2025, 88 (076501). DOI: 10.1088/1361-6633/ad69c

Structure of alkaline-earth aluminosilicate glass from molecular dynamic simulation and neutron diffraction

Hikaru Ikeda,¹ Gustavo Rosales-Sosa,¹ Yoshinari Kato,¹ Shingo Nakane¹ & Oliver Alderman²

¹ Fundamental Technology Division, Nippon Electric Glass Co., Ltd., Seiran, Otsu, Shiga, 520-8639, Japan

² ISIS Neutron and Muon Source, Rutherford Appleton Laboratory, Harwell, Didcot, Oxon OX11 0QX, UK

Corresponding author email: hkikeda@neg.co.jp

The physical and mechanical properties of aluminosilicate glasses are strongly affected by the network topology formed by alkaline earth cations (Mg, Ca, etc.). In recent work by NMR, the ternary $\text{SiO}_2\text{--Al}_2\text{O}_3\text{--MgO}$ system showed that Mg played a unique structural role, such as promoting to higher coordination numbers of Al, compared with other alkaline earth cations.⁽¹⁾ However, the effect of Mg on network topology of aluminosilicate glass is not clear.

In this study, we investigate a series of single and mixed alkaline-earth aluminosilicates $(80-x)\text{SiO}_2\text{--}x\text{Al}_2\text{O}_3\text{--}15(\text{Mg,Ca})\text{O}$ to reveal the roles of MgO and CaO on network structure by combining molecular dynamics (MD) simulations with neutron and x-ray diffraction experiments. Local structural environments (RDF, etc.) and the topology of the intermediate range order (ring size distribution) are investigated from MD simulations. The validity of the model was confirmed by comparing the calculated and experimental total correlation functions. Analysis of the validated structures revealed a clear difference in ring statistics between the MgO and CaO systems, and a clear change in the medium-range order network topology, such as an increase in the proportion of six- and seven-membered rings with increasing MgO content. In this presentation, we discuss how Mg and Ca individually and collectively influence the glass network structure.

Reference

1. Eckert, H., *et al*, Densification of sodium and magnesium aluminosilicate glasses at ambient temperature: structural investigations by solid-state nuclear magnetic resonance and molecular dynamics simulations, *Phys. Chem. Chem. Phys.*, 2024, **26**, 27348.

On the mixed alkali effect in silica-rich lithium-sodium silicates

Alastair N. Cormack

Inamori School of Engineering, NY State College of Ceramics, Alfred University, 1 Saxon Drive, Alfred, NY 14802 USA

Email: cormack@alfred.edu

Recently, there has been a renewed interest in the mixed alkali effect, in which there is a nonlinear 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.

In spite of a number of attempts to provide a theoretical explanation, none has received universal acceptance, although models based on the blocking of alkali migration pathways are gaining in popularity, as our understanding of the atomic scale structure of glasses increases.

It is known that the magnitude of the mixed alkali effect depends on the silica content in mixed alkali silicates; however, there have been little or no systematic studies of silica-rich compositions.

In this presentation, we will discuss the structure and related transport properties of a series of mixed Li,Na tetrasilicates and decasilicates, obtained from molecular dynamics. Comparisons will be drawn to the effect in mixed Li,Na disilicate glasses which we have previously described.

Effect of melting conditions on 50Na₂O–50P₂O₅ glass structure

Lenorah Haight-Stott¹, Andrew Parnapy², Lucas Greiner³, Randall E. Youngman⁴ & Doris Möncke¹

¹ New York State College of Ceramics, Alfred University, Alfred, NY, USA

² Friedrich Schiller University Jena, Jena, Germany

³ Missouri University of Science & Technology, Rolla, MO, USA

⁴ Corning Inc., Corning, NY, USA

Corresponding author email: lms19@alfred.edu

This study investigates the effects of melting temperature and duration on silica crucible dissolution and water retention in the sodium metaphosphate glass system. Glasses were melted at 650, 850, 1050 and 1150°C and aliquots of the melt were quenched at 15, 30, 60 and 120 min. High-performance liquid chromatography (HPLC) is used to monitor the evolution of phosphate chain length as a function of melting conditions. ³¹P and ²⁹Si NMR spectroscopies revealed the nature of silica incorporation into the phosphate network, such as the presence of six-fold-coordinated species. Additionally, UV-Vis-NIR spectroscopy was employed to quantify water content, demonstrating that higher melting temperatures and longer melting times reduce water retention, whereas lower temperature and shorter melt times yield more hydrated glasses. These structural changes are correlated with changes in T_g and physical properties.

Early & Mid-Career Committee Workshop 1: Academic and industrial career pathways

Paul A. Bingham,¹ Stuart Hakes,² Arun Varshneya³ & Owen McGann⁴

¹ Sheffield Hallam University, City Campus, Howard Street, Sheffield S1 1WB, UK

² FIC (UK) Ltd, Long Rock Industrial Estate, Penzance TR20 8HX, UK

³ Saxon Glass Technologies Inc, 200 N Main Street, Alfred, NY 14802, USA

⁴ Glass Technology Services, 9 Churchill Way, Chapeltown, Sheffield S35 2PY, UK

Corresponding author email: o.mcgann@glass-ts.com

The Early & Mid-Career (EMC) Committee are delighted to invite all conference attendees to the first workshop organised for members of the Society of Glass Technology. This workshop will provide an overview of the range of career pathways available to glass scientists pursuing academic and industrial careers. The session will feature three experienced members of the global glass community, with careers spanning academia and the glass industry across the UK and internationally.

Paul Bingham has a career in academia spanning nearly three decades, including roles at the University of Sheffield, Glass Technology Services and Sheffield Hallam University, where he is currently Professor of Glasses and Ceramics. His research has involved collaboration with academic, industrial, and national partners internationally. Paul will provide insights into career pathways within academia, as well as how skills developed through an academic career can contribute to and support work within the glass industry.

Stuart Hakes has an extensive career in the glass industry, with particular experience in industrial glass melting. He held several positions in the UK before taking up the role of Manufacturing Manager at Crown Crystal Glass in New Zealand, where he oversaw the electrification of the melters. Following further positions across Oceania and Southeast Asia, Stuart returned to the UK in 1999 to take up the position of CEO at FIC (UK) Ltd. He will discuss career pathways within the glass industry and the ways in which collaboration with academia can help address current skills gaps and challenges facing the sector.

Arun Varshneya began his career in glass science at the University of Sheffield before moving to the USA, where he completed a master's degree in Metallurgy and a doctoral degree in Materials Science at the Case School of Engineering. He subsequently developed a career spanning both academia, through teaching and research at Alfred University, and the glass industry, working across a range of glass applications. His industrial experience has included automotive glass and glass for lighting, as well as the development of strengthened glass components for EpiPens through the company he co-founded, Saxon Glass Technologies. Arun will draw on his experience across both sectors to illustrate how academic and industrial career pathways can complement one another rather than being mutually exclusive.

The workshop will feature a brief talk from each speaker, followed by an open forum discussion in which attendees will have the opportunity to ask questions and explore the different career pathways represented by the speakers.

The Early and Mid-Career Committee

The Early and Mid-Career Committee is a relatively new committee within the Society of Glass Technology. The primary aims of the committee are to provide support and resources to Early and Mid-Career glass scientists from the academic sector, through to the industrial sector and those involved in the arts and heritage of glass.



Glass Futures: a review of Furnace Campaign 1 and a preview of Furnace Campaign 2

Daniel J. Backhouse¹ Rob Ireson¹ & Dave Fordham

¹Glass Futures Ltd, James Roby Way, St Helens, Merseyside, WA9 5DT, UK

Corresponding author emails: Rob.Ireson@glass-futures.org & Dave.Fordham@glass-futures.org

Glass Futures (GF) 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 GF facility is a globally-unique 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, AI/Digital technologies and new raw materials.

The first campaign on the furnace, covering alternative energy sources (electric boost, liquid biofuels, hydrogen) and AI/digital technologies, was completed in April 2026. This presentation will review the key achievements and results from this campaign, highlighting the value of such industrial-scale research for the industry.

Planning for the second furnace campaign is underway with a targeted start date of Q4 '26–Q1 '27. This campaign will focus on further AI/digital technology developments as well as alternative raw materials innovation. The second part of this presentation will provide an overview of the planned work as well as highlighting wider opportunities for future collaboration.

Ammonia combustion technology for glass melting furnaces

Hideyuki Imai

AGC Inc., Yokohama Technical Center, Kanagawa, Japan

Author email: hideyuki.hi.imai@agc.com

Achieving carbon neutrality by 2050 requires decarbonisation across multiple sectors, including electricity, transportation, heat, and industrial processes. Ammonia is regarded as a promising fuel for power plants and industrial furnaces, as its combustion generates no CO₂ emissions. Against this background, a NEDO-commissioned project (JPNP21012) was initiated in 2021 to investigate the feasibility of direct ammonia combustion in industrial furnaces, carried out through industry-academia collaboration.

The project aimed to validate ammonia combustion technology in the glass melting process and to develop solutions adaptable to various industrial furnaces. Because the flame temperature of ammonia is lower than that of natural gas, radiation heat transfer performance is inherently reduced, and NO_x formation presents a further challenge. To address these issues, an ammonia-oxygen combustion approach was developed.

Demonstration tests were conducted in an industrial glass melting furnace, with a 200 kW-class burner from 2023 and a 1 MW-class burner in April 2025. NO_x concentrations in the exhaust gas remained below regulatory limits while the required operating temperature was maintained, with no adverse effects on glass quality or furnace materials. In addition, a UV camera successfully visualized ammonia combustion flames within the furnace at temperatures exceeding 1500°C.

These results indicate that the proposed technology can simultaneously achieve sufficient radiation heat transfer and low NO_x emissions under conditions representative of actual glass melting furnaces, suggesting strong potential to support decarbonization not only in the glass industry but also across other industrial furnace applications.



Hideyuki Imai joined AGC Inc. in 2011 as a manufacturing management engineer at a float glass plant, after receiving his master's degree in Micro Engineering from Kyoto University. He supported production operations across Asia, including Japan, China, Indonesia and Thailand. He then transitioned to the R&D team, where he worked on process development related to Tin Bath and Lehr for four years. Since 2021, he has been engaged in developing decarbonization technologies for melting processes. He has also led demonstration trials of ammonia combustion in glass melting furnaces as part of a NEDO project. Currently, he is focused on carbon neutrality and digital transformation of glass production processes.

Vitrification of industrial wastes: a case study of air pollution control residues (APCr)

Giulia Tameni,¹ Julie Padgett,² Ian Martin² & Paul A. Bingham¹

¹ School of Engineering and Built Environment, Sheffield Hallam University, City Campus, Howard Street, Sheffield, South Yorkshire, S1 1WB, UK

² FCC Environment, 3 Sidings Court, White Rose Way, Doncaster, Yorkshire, DN4 5NU, UK

Corresponding author email: giulia.tameni@shu.ac.uk

Thermal conversion of municipal solid waste in Energy-from-Waste plants enables energy recovery and landfill reduction, while generating hazardous air pollution control residues (APCr). These residues are classified as hazardous waste in the EU Waste Catalogue due to high alkalinity, concentrations of heavy metals and soluble salts. Current disposal options for APCr include landfilling and chemical stabilisation/immobilisation, while alternative treatment technologies developed worldwide, such as vitrification, thermal treatment and resource recovery, offer promising pathways for sustainable management. Vitrification provides the advantage of immobilisation of hazardous elements within a stable glass matrix, significantly reducing leachability and enabling the production of value-added materials.

In the first stage of this study, APCr samples have been characterised using x-ray fluorescence (XRF), x-ray diffraction (XRD), and thermogravimetric-mass spectrometry (TG-MS) analysis to assess elemental and phase composition, thermal decomposition behaviour, and evolved gas species. In the second stage, Na- and Ca-enriched APCr were mixed with other industrial residues, including incinerator bottom ash (IBA), foundry sands, dolomite, and biomass ash, to produce glasses fully derived from waste materials. The resulting glasses are prominently based on the CaO–SiO₂ and Na₂O–CaO–SiO₂ systems, and have been analysed using XRF, XRD, FT-IR, TGA-MS and EPR.



I was born in Brescia (IT) in 1997. I obtained a Bachelor degree in Chemical and Materials Engineering in 2019 and my Master's degree in Materials Engineering in 2022, both from the University of Padova. In 2025, I completed a PhD in Industrial Engineering at the same Institution. My research has focused on the development of innovative materials derived from unemployed glass fractions through the use of alkali activation technique, and the investigation of the molecular mechanisms underlying these materials. In June 2025, I moved to the United Kingdom to work at Sheffield Hallam University, joining the Glass, Ceramics and Soft Materials group led by Professor Paul Bingham. The project, carried out in collaboration with FCC Environment, aims to develop novel glass foams from alternative waste-derived materials.

Greener glass melting with spent foundry sand

Robert Werner & Chris Holcroft

Glass Technology Services, 9 Churchill Way, Chapeltown, Sheffield S35 2PY, UK

Corresponding author email: r.werner@glass-ts.com

This presentation will give an overview of recent work carried out by Glass Technology Services and partners to demonstrate feasibility of utilising spent foundry sand (SFS) as a secondary raw material for glass making. Analysis of sands from a range of metal casting processes with industry-standard recovery systems led to successful small scale melting trials with 100% sand replacement. Larger scale proof of concept was then established using the novel HTMOS furnace at GTS, producing ~40 kg each of flint and green glass.

This highlights an opportunity for glass manufacturers to increase levels of recycled content beyond the use of cullet. Adoption of these new materials would lead to a more sustainable glass industry by reducing reliance of virgin raw materials and associated energy and carbon emissions. Additionally, it encourages industrial symbiosis and promotes resource efficiency across other industries by reducing landfill and promoting a circular economy.



Senior Environmental Technologist at GTS, 20+ year experience in glass industry related issues. 20+ year experience of MCERTS industrial emissions monitoring before, and at, GTS.

Approx 10 years in project/R&D work mostly in environmental/sustainability field with academic/industrial partners alongside other aspects of testing work at GTS. Involved in projects covering emissions, recycling, alternative/secondary raw materials, circular economy, industrial symbiosis, energy/CO₂ reduction, waste heat recovery, coatings, glass strength, lightweighting, cement, nuclear waste etc.

Development of silicate glasses for agriculture

Roger Pauli,¹ Lee Rowley & Martyn Marshall²

¹ Apollo Furnaces, Greenforge Lane Dudley West Midlands, UK

² Glass Technology Services 9 Churchill Way, Chapeltown, Sheffield S35 2PY, UK

Corresponding author email: m.marshall@glass-ts.com

The paper explores a range of binary silicate glasses being used as carriers for nutritional and mineralogical elements essential in horticultural media.

There are three principal work streams;

- *Potassium Silicates as a plant health supplement.*
 - *Potassium Silicates enhanced with trace elements for specific plant issues, which is more early stage work)*
 - *Potassium Silicate as a gelling vehicle to mitigate the environmental impact or use of anaerobic digestates and agricultural waste streams/slurries as fertilisers.*
-

Aluminosilicates for thermal treatment of intermediate level nuclear wastes

Russell J Hand

ISL, School of Chemical, Materials & Biological Engineering, University of Sheffield, Sir Robert Hadfield Building, Mappin Street, Sheffield, S1 3JD, UK

Email: r.hand@sheffield.ac.uk

The UK has a wide variety of intermediate level wastes (ILWs) that will require treatment before disposal. Thermal treatment is an attractive route for treating at least some of these wastes, as it can result in highly durable wasteforms and a substantial volume reduction, which will save storage and repository costs. Despite the fact that thermal processes can lead to challenges for the retention of more volatile radio-isotopes, such as ^{137}C , relatively high processing temperature aluminosilicate compositions are attractive for a number of different ILWs, rather than the borosilicates used for HLWs. This presentation will review some of our work on the thermal treatment of ILWs, including the potential use of calcium aluminosilicate glasses (CAS) for ILW immobilization. CAS glasses can incorporate, relatively high levels of some problematic species, such as Cl,⁽¹⁾ the compositions of some ion exchange media are also essential CAS compositions. Both laboratory scale and trial scale melts will be considered. The fate of problematic species and the durability of the resultant wasteforms will be examined.

Reference

1. Schofield, J. M., Bingham, P. A. & Hand, R. J. The immobilisation of a chloride containing actinide waste surrogate in calcium aluminosilicate glasses, In *Environmental issues and waste management technologies in the materials and nuclear industries*. Edited by A. Cozzi & T. Ohji, John Wiley & Sons, Inc., 2009, pp. 69–80. <https://doi.org/10.1002/9780470538371.ch9>.



Russell Hand is a Professor of Glass Science and Engineering at the University of Sheffield with over 30 years experience in glass and ceramic research; during which time his primary focus has been on the mechanical properties of glass and aspects of nuclear waste immobilisation, especially vitrification. He has been involved with the SGT for many years, initially as a member of BSTC, becoming a Fellow in 2001. From 2014–17 he was President. He represents the SGT on the Council of the International Commission on Glass (ICG), is Secretary to the Coordinating Technical Committee of the ICG and a member of four ICG Technical Committees: TC05 Waste Vitrification, TC06 Glass Strength, TC23 Education and TC28 Glass Fibres for Reinforcement and Insulation.

Beyond traditional process control: Hybrid-AI Digital Twins in hollow glass hot-end manufacturing

Federico Monegaglia

GlassFORM.ai, Piazza Manifattura 1, Rovereto, 28068, Italy

Email: federico.monegaglia@glassform.ai

Glass manufacturing is increasingly challenged by energy costs, process variability and the need for higher production efficiency. However, hot-end process control is still often based on local and partially decoupled control strategies, relying on traditional approaches that struggle to capture the complexity of thermal and fluid interactions, operational constraints and process-wide dynamics.

This work presents an industrial approach based on Hybrid-AI Digital Twins for hot-end process control and supervision. By combining physics- and mathematics-based knowledge of the process, production data and learning algorithms, the proposed framework enables a more holistic and explainable representation of the manufacturing process, allowing real-time estimation and prediction of process conditions that are difficult or impossible to access through conventional sensing and control strategies alone.

Unlike purely data-driven approaches, the system does not rely exclusively on large quantities of production data or on sensor measurements alone, which may be noisy, incomplete or affected by misreads. Instead, Digital Twin models are built around structured physical and process knowledge and continuously refined through interaction with the real production environment, enabling increased robustness, improved interpretability and bidirectional consistency checks between models and field measurements.

Different industrial applications are presented, including forehearth thermal conditioning and energy consumption optimisation, gob-related process control such as forming and blowing, and the related model-based supervisory strategies. Particular focus is given to deployment in real manufacturing environments, highlighting practical challenges, operational constraints and the potential industrial impact in terms of process stability, energy efficiency, sustainability and production performance.



Federico Monegaglia is involved in the hollow glass industry since 2022 and is currently serving as R&D Manager at GlassFORM.ai, where he crafts Advanced Process Control Systems based on Physics-AI, a branch of Artificial Intelligence whose goal is to incorporate awareness on physical processes, such as thermodynamics, fluid dynamics, solid mechanics, into AI. Federico holds a PhD in Environmental Engineering, where he specialised in applied mathematics for CFD modelling of natural systems. Today, he is bridging his expertise in mathematical modelling to the glass conditioning and forming processes. He is author of tens of scientific publications encompassing glass, process control, mathematical modelling, environmental hazards and sustainability.

Reusable container glass: economics and technology

Owen McGann, Martyn Marshall & Chris Holcroft

Glass Technology Services Ltd, 9 Churchill Way, Chapeltown, Sheffield S35 2PY, UK

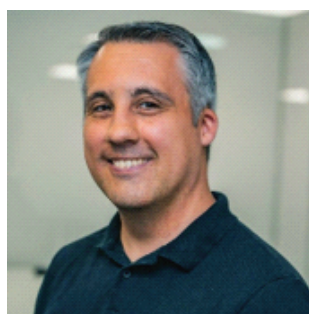
Corresponding author email: o.mcgann@glass-ts.com

The container glass industry is entering a period where rising and structurally persistent energy costs will challenge long established manufacturing and packaging models. This talk examines how long-term energy trends point to a future in which higher baseline energy costs become increasingly likely and explores the implications for container glass and reusable container glass. The presentation will highlight the technological challenges and opportunities associated with reusable container glass and will discuss several technologies currently being developed to address these challenges.

The baseline cost of energy is dictated by the return on investment for energy invested in its extraction, known as EROI. Historic data shows how changes in EROI for different energy sources have influenced the forms of energy used in glass production over time. Modelling of future EROI values for oil, gas and electricity indicates that industry will become more dependent on electrical energy, and that overall energy will become more expensive. The implications of this shift will be explored through cradle-to-cradle life cycle assessment of the various container options available to producers and consumers. This analysis highlights that, for glass, there is a growing economic incentive toward reuse, driven by the high energy cost of glass remelt.

Reuse of container glass bottles is widely practiced in many less developed economies where supply chains are shorter and labour costs lower. In contrast, it is less common in the developed world due to the demands of long supply chains, high product quality standards and the labour costs associated with cleaning and refilling. Addressing the challenges of transport cost and product performance requires technological solutions capable of enabling lightweight and robust reusable glass bottles. Three technologies, currently or historically used for this purpose, will be examined: thermal tempering, chemical toughening and the use of alternative glass compositions. The history, advantages and limitations of each method will be outlined.

This talk provides an insight into the future challenges facing the container glass industry and presents options through which some of these challenges may be addressed. GTS can support manufacturers, brand owners and customers in navigating this transition through life cycle assessment, materials development and technology innovation.



Dr Owen McGann is Principal Technologist and Innovation Development Lead at Glass Technology Services, where he oversees the development and commercial progression of new technologies and intellectual property.

He has more than 14 years of experience in materials science and glass technology, with expertise in photonic, vitrification and specialist glass materials and their production processes.

Owen manages the organisation's research and innovation pipeline, working across technical and commercial teams to deliver funded projects, build strategic partnerships and support collaborative programmes.

His career includes significant contributions to glass composition development, nuclear waste vitrification and advanced manufacturing processes. He is committed to advancing innovative applications of glass and fostering strong engagement between industry, academia and emerging technology communities. He is the chair of the SGT Early and Mid-Career committee.

Decarbonisation, the reality

Stuart Hakes HonFSGT

F.I.C. UK, Little Rock Industrial Estate, Penzance, Cornwall TR20 8HX, UK

Email address: s.hakes@fic-uk.com

The presentation will outline the options the glass industry has for decarbonisation and assess the likelihood of widescale adoption.

It will examine the speed bumps and opportunities that each option presents as well as what needs to happen to achieve decarbonisation.

Examples of some current decarbonisation pathways will be given as well as an assessment of future opportunities.

Multiphysics simulation for tin bath design and operation in float glass production

Adnan Karadag

Aderis Engineering & Consultancy, Sehit Yalcin Aydin Sk 8, 34330 Istanbul, TURKEY

Author email: adnan.karadag@aderisec.com

The tin bath has paramount importance in float glass production, yet coupled complex physical phenomena that are taking place are difficult to observe in detail and control directly. This work presents an integrated simulation framework developed to support the design and operation of industrial tin bath by computing the flow, heat transfer, free surfaces, species transport and electromagnetic effects. The model resolves the interaction between the molten glass, molten tin, top roll machines, cooling system and bath atmosphere enabling predictions of key process parameters such as temperature and velocity fields, forming stresses and thickness distribution in the glass ribbon as well as species concentrations in the bath atmosphere. Industrial case studies illustrate how the model supports optimal design and troubleshooting, energy management and mitigation of defects during production. The results highlight the value of simulation driven design and operation for securing product quality and process stability in float glass production.

Tracing the invisible: reconstructing technological narratives to empower the conservation of cultural heritage

Inês Coutinho

VICARTE Research Unit & Department of Conservation and Restoration NOVA FCT, 2829-516 Caparica, Portugal

Email: icoutinho@fct.unl.pt

Glass is more than a material artifact; it is a witness to human creativity and a mirror of evolving socio-economic networks. This lecture explores the technological and cultural biography of glass in Portugal (and beyond) from the medieval period to the dawn of industrial modernity. Historically positioned as a maritime hub, Portugal's archaeological record reveals a surprisingly heterogeneous glass landscape, yet the systematic study of these materials has long been overlooked.

Through an interdisciplinary framework combining archaeometry, historical reconstruction, and conservation science, this research challenges the narrative of Portugal as a mere passive consumer of European luxury. By integrating chemical analyses such as μ -PIXE and LA-ICP-MS with stylistic and documentary evidence, we identify clear patterns of technological transfer – from Mediterranean soda-ash traditions and *façon-de-Venise* sophistication to the 18th-century rise of potassium-rich and English lead crystal.

A central focus is placed on the intangible, embodied knowledge of the glassmaker. Through case studies of Iberian workshops and the experimental reproduction of historical arcana (batch books), this research reveals how local artisans selectively used and adapted foreign recipes – such as Venetian *lattimo* and English lead glass – to local raw materials and aesthetic preferences. These findings identify a dynamic regional production characterised by a unique high-alumina signature and sophisticated chromatic control, articulating an Iberian identity that transcends modern geographical boundaries and reconstructs the historical routes of (probable) itinerant craftsmen and materials.

Ultimately, this work positions glass as a primary material witness to the cross-cultural exchanges and technological innovations that shaped the early modern world. However, the narrative extends beyond the laboratory; from the study of glassmaking sands to the design of heritage in digital environments, this research seeks to illuminate how decoding the past can guide sustainable conservation and renewed significance for future generations.

Taken together, the research presented here stems from a singular interdisciplinary vision: to safeguard the continuity of human creativity. Whether analysing Roman luxury glass, medieval enamelling, or contemporary digital practices, the focus remains on the same fundamental questions: how knowledge moves, how materials shape meaning, and how craft mediates identity. By bridging the gap between historical craft and scientific inquiry, we find the tools to preserve the physical object, and the embodied, sensory, and social worlds it anchors – worlds that glass has carried from antiquity and continues to do so into the future.

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

M. Schäfer,¹ M. A. Badragheh,² M. Vogel,² & K.-M. Weitzel^{1,3}

¹ Philipps-Universität Marburg, Department of Chemistry, Marburg, Germany

² TU Darmstadt, Institute for Condensed Matter Physics, Darmstadt, Germany

³ University of Ulm, Institute of Electrochemistry, Ulm, Germany

Corresponding author email: karl-michael.weitzel@uni-ulm.de

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 local activation energies, $g(\text{Eact})$, and the saddle points (SPD) 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 obtained by Nernst–Planck–Poisson calculations.^(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 $\text{Li}_3\text{B}_7\text{O}_{12}$, the FWHM of the PSED is determined to be 250 meV.⁽³⁾ On the same material, the distribution of $g(\text{Eact})$ is probed through Nuclear Magnetic Resonance (NMR) measurements and a FWHM of 440 meV is found for the distribution of $g(\text{Eact})$.⁽⁴⁾ Rationalising $g(\text{Eact})$ as a convolution of the SPD and the PSED, we find that the width of the SPD is approximately 350 meV.⁽⁴⁾ Interestingly, the threshold for long range transport can be located in the high energy wing of the SPD. 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.

References

1. Schäfer, M. & Weitzel, K.-M. *Mater. Today Phys.*, 2018, 5, 12–19.
2. Schäfer, M. & Weitzel, K.-M. *Phys. Chem. Chem. Phys.*, 2025, 27, 18128.
3. Gunawan, V. H., Schäfer, M. & Weitzel, K.-M. *Phys. Chem. Chem. Phys.*, 2024, 26, 14430.
4. Weitzel, K.-M., Schäfer, M., Badragheh, M. A. & Vogel, M. to be published.



K.-M. Weitzel has studied chemistry. He obtained a PhD from the University of Göttingen. He did postdoctoral work at the UNC at Chapel Hill (USA). Later he obtained his Habilitation at the Freie Universität Berlin. From 2002 to 2026 he was Full Professor at the Universität Marburg. In mid-2026 he moves to the University of Ulm as the spokes person of the DFG research unit FOR_5065.

Configurational contribution to the thermodynamic driving force of crystallisation

Joshua Sena¹, River Pao¹, Ecem Akirmak-Yamac¹, Aubrey Fry¹, Maziar Montazerian², John C. Mauro² & Collin I. Wilkinson¹

¹ Department of Glass Science, Inamori School of Engineering, New York State College of Ceramics at Alfred University, New York, USA

² Department of Materials Science and Engineering, The Pennsylvania State University, University Park, Pennsylvania, USA

Corresponding author: wilkinsonc@alfred.edu

The thermodynamic driving force of crystallization, defined as the change in Gibbs Free energy between the liquid and crystal phase (ΔG), is vital to estimating nucleation and growth rates for the production of glass ceramics. Obtaining ΔG is difficult without precise knowledge of the change in heat capacity (ΔC_p) between the liquid and crystalline phase for the composition under study. This has prompted several approximations including the Turnbull, Hoffman, and Gutzow–Dobreva approaches which each make their own assumptions about ΔC_p . Heat capacity consists of both vibrational and configurational contributions. Here we assume that the vibrational component of ΔC_p is negligible, so we only consider the configurational contribution relevant in the study of crystallisation processes. We create a model to estimate the thermodynamic driving force of crystallisation solely from configurational thermodynamics and system dependent parameters of the glass-forming liquid. Our configurational model is compared to existing approximations for ΔG . A relationship between maximum entropy and liquid fragility is also investigated. This work presents a novel method for approximating the thermodynamic driving force of new compositions based only on configurational characteristics.

Analysing thermodynamic and kinetic nucleation pathways through experimental and computational methods

River Pao,¹ Jacob Wheaton² & Collin Wilkinson¹

¹ Alfred University, 1 Saxon Drive, Alfred, NY 14802, USA

² Coe College, 1220 First Avenue, Cedar Rapids, IA 52402, USA

Corresponding author email: rjp5@alfred.edu

Predicting nucleation in condensed matter systems remains an outstanding challenge. Despite decades of research the mechanisms behind crystal nucleation are not quantitatively understood. Recent advances have furthered our ability to estimate the temperature dependence but this requires fitting and obfuscates the compositional dependence. Here, we characterise the nucleation event as a function of composition through several different techniques to further understand nucleation mechanisms. Focus is given to the sodium disilicate to lithium disilicate tie-line. For each composition we test approximations for the kinetics and thermodynamics and make recommendations for what leads to practical predictability. Furthermore, the limitations of the in-situ approaches used here are discussed and a thorough review of the diffusion coefficient in nucleation theory is given.

Intermediate-range order in the structure of borate glasses

Natalia M. Vedishcheva

Institute of Silicate Chemistry, Nab. Makarova 2, St. Petersburg, 199034, Russia

Author email: ionatali386@gmail.com

The structure of borate glasses is characterised by two levels, which are the short-range order and the intermediate-range order. Basic structural units (boron–oxygen tetrahedra and triangles) determine the first level and superstructural units consisting of the basic units characterise the second level, which considers the structure beyond the first co-ordination sphere of boron atoms. From the results of high-temperature Raman studies available in the literature it follows that it is the intermediate-range order that determines glass properties. It will be shown (i) why the density of glass is always lower than that of the corresponding crystal, (ii) why, according to the available NMR studies, the spectra of $\text{Li}_2\text{O} \cdot 2\text{B}_2\text{O}_3$ in the vitreous and crystalline states are very similar, whereas those of $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3$ glass and crystal are noticeably different, (iii) why, over the extended glass-formation regions (0–40 Rb_2O and Cs_2O), only glasses with 17 mol% Rb_2O and 25 mol% Cs_2O are structurally very similar to the corresponding crystals $\text{Rb}_2\text{O} \cdot 5\text{B}_2\text{O}_3$ and $\text{Cs}_2\text{O} \cdot 3\text{B}_2\text{O}_3$, (iv) finally, it will be shown how much the structure of the intermediate depends on the chemical nature of the alkali oxide. None of the above facts can be explained at the level of the short-range order in the glass structure.

Incorporation of chlorides in oxide glasses and glassy wasteforms

Paul A. Bingham, Luke Cooper, Alex Scrimshire, Giulia Tameni, Sabrin Samad & Anthony M. T. Bell

School of Engineering and Built Environment, Sheffield Hallam University, City Campus, Howard Street, Sheffield S1 1WB, UK

Corresponding author email: p.a.bingham@shu.ac.uk

Chlorides, in different chemical forms and at different concentrations, occur somewhat ubiquitously throughout radioactive wastes, toxic wastes and other wastes that are destined for vitrification or thermal treatment. However, chlorides are challenging to incorporate safely within oxide glasses, with problems relating to chloride solubility and volatility requiring solutions. Wastes in which chloride is present include (i) non-radioactive slags, ashes and other wastes that could be valorised through thermal treatment; (ii) some high-level, intermediate level and low activity radioactive wastes (HLW, ILW and LAW, respectively), including decommissioning wastes, that are being (or may be) vitrified to reduce volumes and create passively-safe vitreous wasteforms; and (iii) a number of future wastes that may arise from new reactor types, new nuclear fuel cycles and future fuel pyroprocessing activities. In this presentation we will explore current understanding of chloride incorporation in oxide glasses, and the factors that govern it. We will summarise literature from a range of fields, from archaeological glasses to non-nuclear waste glasses, to examples from the nuclear arena. We will then present our recent work on developing new glass formulations that may be capable of incorporating alkali chloride-rich wastes arising from future molten salt pyroprocessing activities. The aim of this presentation will be to raise awareness of the issues surrounding chloride incorporation in oxide glasses, and to stimulate discussion and debate relating to development of new glass formulations and processing routes capable of generating increased levels of chloride incorporation in oxide glasses and vitreous wasteforms.

Low-temperature vitrification strategies for enhanced chloride retention in pyroprocessing waste

Luke Cooper, Alex Scrimshire, Anthony M.T. Bell & Paul A. Bingham

Sheffield Hallam University, Howard Street, Sheffield, S1 1WB, UK

Corresponding author email: Luke.A.Cooper@student.shu.ac.uk

PUREX (plutonium-uranium redox extraction) is the conventional aqueous reprocessing method for spent nuclear fuel, using nitric acid dissolution followed by solvent extraction to separate uranium and plutonium from fission products.⁽¹⁾ While PUREX remains the industrial standard, its reliance on aqueous chemistry and complex waste streams has motivated the development of alternative approaches such as pyroprocessing, a molten salt-based electrolysis technique. Pyroprocessing generates chloride-rich waste streams containing fission products and lanthanides, primarily within the LiCl–KCl eutectic (LKE) electrolytes.⁽²⁾ Zone refinement presents a potential route for partial separation and recovery of the electrolyte. However, a residual chlorine rich waste stream remains requiring safe disposal. Vitrification offers a well-established route for the long-term immobilisation of nuclear waste, but the high chloride content introduces significant challenges.

Incorporation of chloride species into glass matrices is problematic, often resulting in phase separation and reduced chemical durability. Conventional borosilicate glasses exhibit limited chloride solubility and suffer from volatilisation losses during melting. Consequently, low-melting glass systems present a promising alternative by processing at reduced temperatures.

To avoid the hazards associated with lead-based glasses, this work explores bismuth borate glass systems as a safer low-temperature alternative. The reduced melting temperatures of these compositions are expected to suppress chloride loss and enhance overfall retention.

Glass compositions will be systematically varied through adjustment of the $\text{Bi}_2\text{O}_3\text{:B}_2\text{O}_3$ ratio to help optimise network connectivity and melting behaviour. Additionally, the incorporation of network-modifying oxides such as ZnO will be explored to enhance structural stability and chemical durability. Structural and compositional characterisation will be conducted using x-ray powder diffraction (XRD) to confirm amorphous phase formation and identify phase separation, x-ray fluorescence (XRF) to quantify elemental composition and assess chloride retention, differential scanning calorimetry (DSC) to evaluate thermal behaviour, and Raman spectroscopy to probe glass network structure and bonding environments.

References

1. Rodríguez-Penalonga, L. & Moratilla Soria, B. Y. A review of the nuclear fuel cycle strategies and the spent nuclear fuel management technologies. *Energies*, 2017, 10 (8), 8.
2. Nagarajan, K. *et al.* Development of pyrochemical reprocessing for spent metal fuels. *Energy Proc.*, 2011, 7, 431–6. 1001.

An XRD and XRF study of the incorporation of SnO₂ into soda–lime–silica glasses

Anthony M. T. Bell,¹ Erhan Kilinc,^{1,2} Jack D. Cornwall¹ & Paul A. Bingham¹

¹ School of Engineering and Built Environment, Sheffield Hallam University, City Campus, Howard Street, Sheffield S1 1WB, UK

² Glass Futures Ltd, James Roby Way, Saint Helens WA9 5DT, UK

Corresponding author email: Anthony.Bell@shu.ac.uk

Comparatively little work has been done on the uptake of Sn into commercial soda lime silica glasses. Therefore, different amounts of SnO₂ have been added to these glasses to explore how the incorporation of Sn affects glass properties, and to quantify Sn solubility limits.

Two different x-ray techniques have been used here to characterise these Sn containing glasses. X-ray fluorescence (XRF) has been used to determine the elemental compositions of these glasses. X-ray powder diffraction (XRD) has been used to determine the solubility of SnO₂ in these glasses; and the secondary phases that form when the solubility limit is exceeded.



Dr Tony Bell is a Senior Technical Specialist at Sheffield Hallam University. He oversees the x-ray laboratory and works very closely with the research group of Professor Paul Bingham. He was educated at the Universities of Sheffield, Keele and Cambridge. He was a synchrotron scientist in x-ray powder diffraction on the Daresbury SRS in the UK, and on DORIS-III at the DESY laboratory in Hamburg, Germany.

He has worked at Sheffield Hallam University since 2015.

Structural effects on the high temperature density of sodium borosilicate glasses doped with aluminium

Miu Onaru,¹ Alex Scrimshire,¹ Anthony M. T. Bell,¹ Robin Smith,¹ Albert A. Kruger² & Paul A. Bingham¹

¹ School of Engineering and Built Environment, Sheffield Hallam University, Sheffield S1 1WB, UK

² U.S. Department of Energy, Hanford Field Office, Richland, WA, USA.

Corresponding author email: Miu.Onaru@student.shu.ac.uk

Boron is an essential component in most nuclear waste glasses, since it enhances chemical durability while reducing the thermal expansivity of the final product and reducing melt viscosity.⁽¹⁾ Its unique characteristic to transition from trigonal to tetrahedral coordination with increasing temperature governs certain structure-property relationships in borosilicate glass systems.⁽²⁾ However, the effects of boron coordination on the high-temperature density of molten glass remain largely unexplored, despite high temperature density being a key physical parameter affecting glass melt behaviour in melter furnaces.⁽³⁾

This presentation will discuss the motivation for investigating high-temperature density of simplified simulated Hanford nuclear waste glasses, present high temperature density data for borosilicate glasses, broadly representative of Hanford nuclear waste glass matrices, with varying Al₂O₃ contents, and the limitations in current high temperature density experiments. The presentation will also discuss high-temperature Raman spectroscopy results aimed at investigating how temperature-driven structural changes, particularly boron coordination, influence melt density.

References

1. Ojovan, M. I., Lee, W. E. & Kalmykov, S. N. Immobilisation of radioactive wastes in glass. *An Introduction to Nuclear Waste Immobilisation*, 2019, pp. 319–68. doi: 10.1016/B978-0-08-102702-8.00019-4.
2. Majerus, O., Cormier, L., Calas, G. & Beuneu, B. Temperature-induced boron coordination change in alkali borate glasses and melts. *Phys Rev B*, 2003, 67 (2), 024210, doi: 10.1103/PhysRevB.67.024210.
3. Sugawara, T. *et al.* High-temperature heat capacity and density of simulated high-level waste glass. *J. Nucl. Mater.*, 2014, 454 (1–3), 298–307, doi: 10.1016/j.jnucmat.2014.07.055.

Glass corrosion mechanisms alteration in long term tests

Michael I. Ojovan,^{1,2} Kai Xu¹ & Ruixin Guo¹

¹ State Key Laboratory of Silicate Materials for Architectures, Wuhan University of Technology, Wuhan, P.R. China

² School of Chemical, Materials and Biological Engineering, The University of Sheffield, Sheffield S1 3JD, UK

Corresponding author email: m.ojovan@sheffield.ac.uk

Corrosion of glasses is a complex process evolving with time which is mainly dependent on glass composition and environmental conditions. We analyse the alterations of glass corrosion mechanisms during the long-term tests focusing on an idealised model situation of a perfect homogeneous glass surface in contact with water solutions and revealing dominant contributions from either ion exchange or hydrolysis with progressing of corrosion process. Long term tests of vitreous nuclear wasteforms are of high importance in nuclear waste management and envisage field testing of glasses during which the governing mechanisms of glass corrosion can alternate.

At the beginning of contact of glass with water after the instantaneous surface dissolution (ISD) of weakly bonded species on glass surface the dominant mechanism of corrosion is the diffusion-controlled ion exchange (IEX) which gradually decreases its contribution yielding the glass network hydrolysis (HL) to become dominant. The transition time from the IEX to the HL can last from minutes to many decades and even millennia depending on glass composition and environment, with laboratory and field tests^(1,2) explicitly supporting the occurrence of transition. The corrosion process has an Arrhenius type temperature dependence with at least three activation energies which contribute to the apparent (effective) activation energy – namely that from the ISD, IEX and HL mechanisms.

The two long-lasting corrosion mechanisms – ion exchange (IEX) and hydrolysis (HL) – control the overall release of radionuclides from the nuclear waste glasses in contact with water with typical effective diffusion coefficients for ¹³⁷Cs via IEX of about $5 \times 10^{-21} \text{ m}^2/\text{s}$ ($4.5 \times 10^{-12} \text{ cm}^2/\text{day}$) and rates for HL of about 100 nm/y in field test conditions.⁽¹⁾

The intrinsic self-irradiation of nuclear waste glasses results in an enhanced role of IEX although not significantly increasing its overall contribution into released inventory of radionuclides.

References

1. Ojovan, M. I., Hand, R. J., Ojovan, N. V. & Lee, W. E. Corrosion of alkali-borosilicate waste glass K-26 in non-saturated conditions. *J. Nucl. Mater.*, 2005, **340**, 12–24.
2. Thorpe, C. L., Fisher, A. J., Manifold, G. *et al.* Insights into long term glass corrosion mechanisms from the Ballidon experiment. *npj Mater Degrad.*, 2025, **9**, 27.
3. Guo, R., Zhao, Z., Deng, W. *et al.* Dissolution behavior of Ag-doped antibacterial borosilicate glass powders blended into polypropylene. *J. Non-Cryst. Solids*, 2025, **669**, 123806.

The use of isotopic tracing to study the formation of the alteration layer on corroded glass

Eperke A. Rencz,^{a,1} Russell J. Hand,^a Jim J. Neeway,^b Carolyn I. Pearce,^b Zihua Zhu,^b Mike T. Harrison,^c Clare L. Thorpe^a

^a Department of Materials Science and Engineering, University of Sheffield, S1 3JD, UK

^b Pacific Northwest National Laboratory, Richland, WA, USA

^c United Kingdom National Nuclear Laboratory, Central Laboratory, Sellafield, Seascale, Cumbria, CA20 1PG, UK

¹Corresponding author email: eakoppany1@sheffield.ac.uk

Vitrification is used in the UK, US, France and other countries to immobilise radioactive elements from spent fuel re-processing and is increasingly considered for other waste streams.⁽¹⁾ In the UK, the intention with this vitrified waste is to place it into a geological disposal facility (GDF) with multi-barrier protection.⁽²⁾ Following the operational period of the GDF, it is expected that groundwater will eventually contact the vitrified waste.⁽³⁾ When water comes into contact with glass it begins a dissolution process that forms an altered layer on the surface that can be likened to a gel.⁽⁴⁾ There are several processes involved in the formation of this alteration layer that can be dependent on a myriad of factors including pH, temperature and solution composition.⁽⁴⁾

An experiment was designed to determine the effect that the level of silica saturation has on the formation of the alteration layer on two simple glasses ISG and SON68 glasses with the specific focus being to determine to what extent the formed layer is a legacy structure or a new formation comprised of Si from solution. The glass samples were placed into a single-pass flowthrough (SPFT) system where six different concentrations of silica were maintained ranging from 1–34 ppm Si. The glasses were left to corrode for three months at 90°C with a constant flow rate of 6ml per day. The silica used to create the solutions had a consistent ²⁹Si isotope ratio. Time-of-flight secondary ion mass spectrometry was then used to compare the ²⁹Si to total Si ratio of the alteration layers and ascertain the contribution from solution derived silica, and it was found that the silica from the solution does enter the glass in all systems and increasingly with increasing Si-concentration. This experimental set-up could, in future, be used to analyse the effects of other elements on gel chemistry.

References

1. Ojovan, M. I. & Lee, W. E. An Introduction to Nuclear Waste Immobilisation. Elsevier, Chantilly, UK, 2013. Accessed: Mar. 06, 2025. [Online]. <http://ebookcentral.proquest.com/lib/sheffield/detail.action?docID=1576655>
2. The Multi-barrier Approach. Radioactive Waste Management. GDF Science Files 3. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/654537/3_The_multi-barrier_approach_Proof_6_1_.pdf
3. Geological Disposal - Waste Packages and the Assessment of their Disposability. Radioactive Waste Management, DSSC/441/01, 2016. https://assets.publishing.service.gov.uk/media/5a82d7afed915d74e3403d8a/NDA_Report_no_DSSC-441-01_-_Geological_Disposal_-_Waste_packages_and_the_assessment_of_their_disposability.pdf
4. Doremus, R. H. Glass Science. Second Edition. Wiley, New York, USA and Chichester, UK, 1994.



Eperke Rencz is a PhD student at the University of Sheffield, working in the Immobilisation Science Laboratory. She is studying the alteration layer on corroded glasses primarily using laboratory-based experiments. After moving to the UK from Hungary, she gained her first class Master's in Physics from the University of Sheffield in 2024. Her MPhys dissertation concerned low-level programming used in axion detection, a dark matter candidate. She has recently begun doing more outreach work related to the nuclear industry.

Effects of high-temperature water vapour treatments on hydration and aqueous durability of float glass

Wei Deng,¹ Amy Young,¹ William Pinc,² William Perry³ & Paul A. Bingham¹

¹ School of Engineering and Built Environment, College of Business, Technology and Engineering, Sheffield Hallam University, City Campus, Howard Street, Sheffield, S1 1WB, UK

² Guardian Glass Science and Technology Center, 14511 Romine Rd, Carleton, MI 48117, United States

³ Guardian Industries, Tom Pudding Way, Goole DN14 8GA, UK

Corresponding author email: wei.deng@shu.ac.uk

The transition toward low-carbon combustion technologies, such as hydrogen-assisted firing, is expected to significantly increase water vapour partial pressures in glass manufacturing furnaces. This shift necessitates a comprehensive understanding of how enhanced water incorporation affects the structural and chemical integrity of float glass. This study investigates the hydration behaviour and aqueous durability of soda–lime–silica float glass produced under distinct industrial furnace conditions, including oxy-fuel fired and conventional regenerative systems. Glass samples were subjected to controlled high-temperature heat treatments in dry N₂ and humid N₂–H₂O atmospheres. Subsequent quantitative analyses of bulk water concentration and near-surface hydroxylation were performed using UV–Vis–NIR and ATR–FTIR spectroscopy, respectively. Furthermore, aqueous corrosion behaviour was evaluated through a static leaching protocol in deionised water at 55°C. By enabling a direct correlation between the hydration state and degradation kinetics, this study highlights that while adopting decarbonisation strategies, careful consideration must be given to the altered corrosion resistance and surface friability of the resulting high-water-content glass.

Tracing the invisible: reconstructing technological narratives to empower the conservation of cultural heritage

Inês Coutinho

VICARTE Research Unit & Department of Conservation and Restoration NOVA FCT, 2829-516 Caparica, Portugal

Email: icoutinho@fct.unl.pt

Critically endangered: traditional glass making skills teetering on the edge of extinction within the UK

Jessamy Kelly

Edinburgh College of Art University of Edinburgh, Scotland

Email address: Jessamy.kelly@ed.ac.uk

Recent research by Heritage Crafts, a leading national advocacy organisation dedicated to the preservation of traditional heritage crafts in the UK, have highlighted a disturbing trend. Numerous traditional crafts are on the brink of extinction across the UK. This alarming development is detailed in the Red List of Endangered Crafts, an initiative aimed at identifying crafts at risk of vanishing. The 2025 update from Heritage Crafts brought to light the severe decline in cut crystal glassmaking, newly listed as critically endangered. Additionally, in 2023, the organisation listed for the first time key glass-related skills such as stained-glass window making (specifically historic windows), the glass working of scientific glassware, brilliant cutting, and copper wheel engraving. This categorisation placed both brilliant cutting and the glass working of scientific glassware as endangered and the preservation and creation of historic stained-glass windows and copper wheel engraving as critically endangered. Tragically, by 2022, the art of mouth-blown flat glass was declared extinct, as it is no longer practiced in the UK. These crafts face the imminent risk of disappearing due to a range of factors, most notably the significant reduction in educational programmes specialising in glass at universities across the UK. This concern is particularly acute in regions with a deep cultural heritage connected to glassmaking. Notably, institutions such as the University of Wolverhampton and the University of Sunderland, which have historically contributed to this rich heritage, have recently ceased to run glass programmes and have closed their studios. Other contributing factors, include the labour-intensive nature of learning these crafts, as mastering these skills requires significant dedication and a considerable investment of time. The current visual and material culture of these traditional glass skills are at risk of disappearing as these practices diminish and the networks that have sustained these skills across generations begin to break down, with new students or recent graduates finding it challenging to connect with a dwindling generation of now older, skilled makers and the closure of the traditional studios that once nurtured these crafts. There is a real threat of these skills disappearing or not being transmitted to future generations.

This troubling situation highlights an acute need for targeted educational and policy interventions to sustain these traditional craft skills. This paper concludes with a call out for the revitalisation of glass craftsmanship in the UK. It seeks to galvanise support and funding to safeguard and perpetuate these invaluable heritage crafts, which hold a distinguished place in the UK's cultural history. These crafts are of cultural importance to a wide range of groups in the UK, but they hold particular significance for regional communities where these skills have been practiced for generations. Moreover, these crafts play a vital role in preserving the aesthetic and historical integrity of the UK's cultural heritage, particularly in the restoration and preservation of stained-glass windows within historic buildings and in the production of scientific glassware or cut and engraved glass. As an educator specialised in glass making, I recognise the crucial role I play in preserving these crafts and ensuring their transmission to future generations. This responsibility involves not only teaching the technical skills but also instilling an appreciation of the craft's cultural and historical significance. However, the viability of continuing to offer this kind of specialised education is increasingly precarious due to potential closures and the financial pressures facing the wider university sector. Compounded further by a contemporary marketplace that often undervalues the time and expertise required for such intricate crafts. The need for targeted support from both educational policy makers and financial bodies is critical. Such support could help secure the required resources and infrastructure to continue offering these programmes, thereby ensuring that these vital skills do not vanish but thrive through transmission to future generations.

Venetian style filigree glass: initial results of a typological and technological investigation

Jerzy J. Kunicki-Goldfinger,¹ Paweł Duma,² Beata Marciniak-Maliszewska,³ Petras Jakubauskas,³ Grażyna Z. Żukowska,⁴ Wojciech Starosta,¹ Jakub Kotowski,³ Beata Miazga,² Paweł Kalbarczyk,¹ Zbigniew Rogulski,⁵ Barbara Żelazko⁵ & Barbara Wagner⁵

¹ Institute of Nuclear Chemistry and Technology, Dorodna 16, 03-195 Warsaw, Poland

² Institute of Archaeology, University of Wrocław, Szewska 48, 50-139 Wrocław, Poland

³ Faculty of Geology, University of Warsaw, Żwirki i Wigury 93, 02-089 Warsaw, Poland

⁴ Faculty of Chemistry, Warsaw University of Technology, Noakowskiego 3, 00-664 Warsaw, Poland

⁵ Faculty of Chemistry, University of Warsaw, Pasteura 1, 02-093 Warsaw, Poland

Corresponding author email: j.kunicki@wp.pl

Among the many glassmaking techniques invented in the early modern era, ‘vetro a filigrana’ occupies a unique place. ‘Filigrana’, appearing in many different variants, is certainly one of the most beautiful glass techniques invented in Murano. The oldest known written record of this glass comes from 1527. With the dissemination of ‘façon de Venise’ vessels in Europe, ‘vetro a filigrana’ also became increasingly popular outside of Italy. ‘Vetro a filigrana’ is under-investigated and its materials science seems to have been particularly neglected.

This paper presents preliminary results of a project focusing on filigree glass recovered during archaeological excavations carried out in recent decades in the old town in Wrocław, Poland. We have initially identified 261 fragments (about 98 vessels) dated to the 16/17th–18th centuries that do not have any exhibition value, thus creating a unique opportunity to conduct thorough technological research. Moreover, we have used extensive comparative material coming from well-known production centres and those of unknown origin, excavated in various places in Europe. The main goal is to study the complex structures of these glasses and to determine their origin and production technology. Several analytical methods have been applied to glass surfaces and their cross-sections, including XRF, SEM-EDS and -EBSD, EPMA, Raman spectroscopy and LA-ICP-MS. Moreover various imaging methods were also used, such as optical microscopy in ultraviolet, VIS and infrared range of radiation, RTI and x-ray tomography.

The preliminary results allow us to infer for the first time the typological and technological differences between glasses from various periods and areas and representing various filigree structures. The project is funded by the National Science Centre, Poland (grant no. 2023/51/B/HS2/00672).

Stuck expressions: fusing, hot sculpting and animating facial expressions for glassmation with ceramic slide transfer decals

Mark Hursty

University of North Carolina at Asheville, Asheville, North Carolina, USA

Email: mhursty@unca.edu

This project further develops a scarcely realised combination of hot glass art and animation techniques, in particular ceramic decal facial expressions for filming stop motion animated films out of glass.

Specifically, the research uses furnace and torch-worked glass, and bespoke ceramic decals on kiln-fused glass to create articulated puppets, props, sets and backgrounds as the apparatus for stop motion animation.

*While figurative glass and stop motion animation have long histories, creating hot glass figures for animation, or glassmation, is rare. Torch-worked figurative glass art was most notable in Nevers, France in the 17th–19th centuries. Contemporary Glass figures like in Wael Shawkey's *Cabaret Crusades: The Horror Show Files*, 2010, have been captured on film as marionette puppetry.⁽¹⁾ There is scant evidence of glass figures, or process in animation. Two previous examples became known to this researcher via the research of glass artist Mark Elliott: *Inspirace*, 1940, by Czech film-maker Karel Zeman,⁽²⁾ and *Dr Mermaid and the Abovemarine* 2009 by Mark Elliott and animator Jack McGrath.⁽³⁾*

Amongst the animation techniques employed in these films, replacement animation of static, room temperature glass components, is identical to how mixed media is already used in stop motion. The potential novel contribution of hot glass in animation lies in its ability – as a transparent or translucent material – to be manipulated in increments like clay in claymation. Logistical challenges for an equivalent glassmation are the torches and heat required for sculpting hot glass. They are seemingly at odds with the staged, still – and flammable – nature of stop motion studios. This opposition presents the questions for this research:

- *Is live hot worked glass, or glassmation, practical for use in stop motion animation?*
- *Can ceramic slide transfer decals be printed, applied and hot manipulated effectively for glassmation?*
- *Can procedures and a practical hot glass specific stop motion stand be developed?*
- *Can a pedagogy be developed for ready uptake of glassmation techniques?*

References

1. Shawkey, Wael, *Karbala from Wael Shawkey's Cabaret Crusades* 2010. Available at: <https://www.youtube.com/watch?v=fjxlVFcAgCQ>, last accessed 23, April, 2026
2. Zeman, Karel, *Inspirace* AKA *Inspiration* 1949. Karel Zeman. Available at: <https://www.youtube.com/watch?v=D1qYulQxmws>, last accessed 23, April, 2026
3. Elliott, Mark, *Dr Mermaid and the Abovemarine* 2009. Available at: <https://www.markelliottglass.com/video>, last accessed 23, April, 2026



Mark Hursty invents sculptural glass and animated video installations with conceptual bases in cellular, social and cosmological topographies. Hursty earned a BFA in film animation from RISD, a glass sculpture MFA from Alfred University, and a pressed Glass and digital fabrication PhD from the University of Sunderland's National Glass Centre (UK). Currently living in Glasgow, Scotland, he is a Fulbright China Fellow, and a lecturer in New Media and Glass Art at UNC Asheville. His exhibitions include: the Shanghai Museum of Glass (China), Ha'Mizgaga (Israel), Ken Saunders Gallery, S.O.F.A. (Chicago), and the Museum of Contemporary Craft (Portland, OR).

From graphic translation to structural generation: a practice-led investigation of abrasive waterjet in glass art

Dian Shi

Tianjin Academy of Fine Art, No 7, Zhicheng Road, Hebei district, Tianjin city, PR China

Email: shidian19833@gmail.com

This paper examines abrasive waterjet cutting as a generative method in contemporary glass art through a practice-led research framework. Moving beyond its conventional role as a precision fabrication tool, the study explores how waterjet technology contributes to a shift from graphic translation to structural generation. The research is grounded in two stages of the author's practice: a doctoral project (2021) translating calligraphic forms into glass through controlled cutting paths, and a recent installation (2026) employing parametric patterning and layered spatial construction. The findings suggest that abrasive waterjet cutting operates across three levels – execution, mediation, and generation – and, at its most advanced stage, becomes embedded within the creative process as a method of spatial organisation. This transformation reflects a broader shift in digital craft, where technology reshapes not only how artworks are made but how they are conceived.

Key words: Abrasive waterjet cutting; glass art; digital fabrication; practice-led research; generative method; parametric design; calligraphy; spatial organisation.

'I learnt about our 17th century Glass Heritage from this'

Colin Brain

14 St Edmunds Gate, Salisbury, SP1 1FD

Email: cjsm132@gmail.com

When my first wife and I became interested in the history of English crystal drinking glass we read all we could on the subject, but soon realised that this prevailing narrative lacked credibility. So we set out to find out for ourselves – this was well over 50 years ago. This talk looks at some of the lessons about our glass history and heritage that I have learnt along the way.

There are many definitions of 'history'. That used here is: 'the story of change over time' – reflecting that the second half of the 17th C saw rapid and far-reaching changes in all aspects of glass design, production and consumption. We soon appreciated that if we were to improve our glass story we needed more evidence, which could only come from our glass heritage. Here we encountered the first lesson. As Dillon⁽¹⁾ observed back in 1907 – our 17th century English glass heritage includes abundant documentary evidence but few examples of the glass made before the late 17th C. Put bluntly if we aspired to use these items to validate our glass story then first we needed to find a lot of more of them. This involved: identifying; accessing and correlating them with the developing historical story. In doing this we have used a much wider range of sources than the two mentioned by Dillon, such as: archaeological finds; paintings; and inherited glass-making skills and knowledge. Examples of these are discussed in the talk. Perhaps the most surprising items of all were lead tokens. In this obtaining objective evidence has been particularly important and some simple, yet effective, analysis techniques used are highlighted.

Preserving our glass heritage needs physical safeguarding with suitable opportunities for study, but it also needs documentation of its own to record how it relates to the evolving story narrative. Fortunately the lack of 17th century glass remarked on by Dillon is no longer such a problem since we have been reasonably successful in our search. For example twenty-one selected seventeenth-century glasses have recently been donated to the Victoria & Albert Museum from the Brain collection. My view of the related historical 'story' is summarised in a book in the process of publication with the working title: 'Out of the Melting Pot: The evolution of English and Irish crystal glass 1622–1699'.

It is hoped that this will put sufficient material into the public domain to allow others to criticise and to begin their own journeys to help improve our glass history and heritage for this important period.

Reference

1. Dillon, E. *Glass*. Methuen, London, 1907.

Colin is a Chartered Mechanical Engineer. He was introduced to the delights of collecting glasses by college girlfriend Sue back in 1967. Sue and Colin married in 1968. Having grown up in a world of scientific and engineering innovation they became increasingly dissatisfied with the published narratives on the early development of British crystal glass, so in the 1970s they set out to find out for themselves. Little did they realise how long this would take or how much fun and help they would have in the process? However they were right about the inadequacy of the then narratives! Sue died of cancer in September 2015, but fortunately saw the third of their trilogy of *Glass Technology* papers in print. These were subsequently reprinted under a single cover for Glass Circle members. Colin is a board member and past-president of the Association for the History of Glass. He has continued the research that he and Sue started which has culminated in a number of papers and a book in publication.

Economically driven sustainability: modernisation in the glass industry, 1870–1920

Rahel Gugelmann

Vitrocentre Romont, 108b Rue du Château, CH-1680 Romont, Switzerland

Author email: rahel.gugelmann@vitrocentre.ch

The European flat glass industry underwent a profound transformation in the late 19th and early 20th centuries. New legislation, manufacturing methods, and transport infrastructures paved the way for rapid industrial expansion, while growing competition from North America and a surge in patent applications stimulated innovation and increased output. The author's PhD thesis, which forms part of the SNSF-funded project 'Stained Glass in Islamic Lands. Trans-Mediterranean Networks, Local Identities and Glass Technology' (10.003.785), investigates the history of the European glass industry and their commercialisation strategies. It focuses on the emergence of new products, their manufacturing processes and evolving trade structures.

One major catalyst for innovation and globalised trade networks was the regularly held world fairs, which acted as hubs for the presentation and diffusion of new products, technologies, and design ideas. Drawing on patent records, corporate archives of leading firms, and contemporary journals, the paper will analyse the self-representation of leading glass manufacturers of the period, as well as their output and drive to modernise various stages of production, all in the context of regional and national fairs.



Rahel Gugelmann (*1997) studied art and architectural history as well as English language and literature at the University of Bern. From 2023 to 2025, she was a regional monument conservator at the Bern Municipal Monument Conservation Office. Since October 2025, she has been working as a doctoral student at the Vitrocentre Romont. Her research focuses on the history of the glass industry in Europe and North America between 1870 and 1940. She is particularly interested in the variety of products and the trade in decorative flat glass for architectural and stained-glass purposes.

Research on the historical origin, craftsmanship and folk culture of Boshan Bulldong glass toys

Jianyong Guo

Shandong University of Art and Design, PR China

The Boshan Bulldong glass toys, as a typical product of traditional Chinese folk glass-blowing techniques, is a folk handicraft of intangible cultural heritage that combines artistic value, folk customs value and historical memory. This paper takes the Boshan Bulldong glass toys (鼓鑪) as the research object, and through the combination of literature research, physical investigation and folk visits, it sorts out its historical development from the origin in the Song Dynasty, the prosperity in the Ming and Qing Dynasties to the inheritance and development in modern times, analyses its core high-temperature blowing techniques and shape characteristics, and explores its cultural connotations and social functions in folk temple fairs, children's entertainment and regional folk customs. The research finds that the Boshan Bulldong glass toys originated from the thousand-year-old Boshan glass industry, and with its simple blowing technique, it carries the folk life and New Year memories of the northern people. Its inheritance predicament and contemporary revitalisation path have important reference significance for the protection and inheritance of traditional folk glass handicrafts.

The full force of the law: how a Stourbridge glassmaker used nineteenth century IP law to take advantage of a fashion trend

D. C. Manison

2 St. Alban's Road, Brynmill, Swansea SA2 0BP

Corresponding author email: broga999@yahoo.com

On 18th October 1884, the Stourbridge firm of Stevens & Williams registered a design for the decoration of glassware. The decoration, which was applied to the various glass items as they were being made, used small moulded pieces of glass which were applied to glass which was freely trailed over the body of the piece. The finished glassware was marketed under the name of 'Matsu-no-Kee'.

The moulded pieces of glass applied to the body were made using a device which had been patented by John Northwood, the Art Director of Stevens & Williams, and a number of the glass bodies also had a crimped rim, which would have been facilitated using a second device which had also been patented by John Northwood.

The range of glassware seems to have been remarkably successful, such that the name became generally (and erroneously) applied all glassware with applied surface decoration that looks vaguely floral, and is all too frequently misspelled.⁽¹⁾

Reference

1. Manison, D. C. Matsu no Kee, Matsu no Ki, Matsu no Ke, or Mat-su-no-ke? *Cameo*. The Friends of Broadfield House Glass Museum, Stourbridge 2009, Issue 53.

Tracing the origins of early Iron Age glass in south east Europe

Ana Franjić^{1,2,3} Ian Freestone⁴ & Patrick Degryse¹

¹ Division of Geology, Department of Earth and Environmental Sciences, KU Leuven, Celestijnenlaan 200E – Bus 2411, 3001 Leuven, Belgium

² Austrian Archaeological Institute of the Austrian Academy of Sciences, Dominikanerbastei 16, 1010 Vienna, Austria

³ Human Evolution and Archaeological Sciences (HEAS), University of Vienna, Djerassiplatz 1, 1030 Vienna, Austria

⁴ UCL Institute of Archaeology, 31–34 Gordon Square, London, WC1H 0PY, UK

Corresponding author email: ana.franjic@oeaw.ac.at

Situated between the beginnings of glassmaking in the Late Bronze Age and the highly standardised production of Roman glass, (early) Iron Age glass technology represents a pivotal yet still somewhat understudied chapter in the history of ancient materials. This transformative period, shaped by major social, political and economic upheaval, saw profound reorganisation of production and exchange networks across Europe and the Mediterranean. At the same time, glassmaking itself underwent a technological revolution: around the turn of the first millennium BCE, traditional plant-ash recipes were replaced by evaporitic mineral flux, while silica sources shifted from purified quartz to shell-bearing sands. These early natron glass compositions laid the foundation for the standardised natron glass industries that would dominate Mediterranean production from around the sixth century BCE onward.

This presentation investigates early natron glass from south-east Europe using high-resolution trace-element and isotopic analysis. Through newly acquired data, we explore the provenance of several poorly understood early natron glass subtypes, seeking to identify compatible raw material sources and reconstruct possible production locations. The findings provide a more nuanced understanding of early natron glass compositions, offering new insight into technological choices, organisation of production, and long-distance connections linked to this key material transition and the socio-economic transformations. By tentatively tracing the origins of these compositional types, the study hopes to contribute to this critical but still incompletely understood phase in the formative period in the history of glass.



Ana is a Postdoctoral Researcher at Austrian Academy of Sciences, where she investigates ancient pigments as part of the ERC project HUE while also leading her own Seal of Excellence project, FLUX: From Sources to Societies, on Iron Age metal and glass. She received her PhD on the subject of Iron Age glass technology from UCL. Her research centres on the connections between ancient glassmaking and metallurgy, with particular emphasis on cross-craft interaction, knowledge transfer, and the entanglement of pyrotechnologies in past societies. She is especially interested in the emergence and development of early natron glass, and the ways in which technological practices both shaped and were shaped by the social, economic, and cultural contexts of production, exchange, and consumption in antiquity.

Conditions for the safe storage of early glass

Antanas Melinis

English Heritage Trust, Ranger's House, Chesterfield Walk, London SE10 8QX, UK

Author email: antanas.melinis@english-heritage.org.uk

Glass deteriorates through interaction with water and is left with a hydrated surface layer. Humid conditions may trigger 'crizzling', or microcrack formation. The object can disintegrate unless the ambient RH is low, although crizzling can also be caused by deteriorated glass drying. This study focuses on establishing a balance between humidity-induced alteration of pristine glass and crizzling. This is done through observation of experimentally aged early glass replicas subjected to environmental changes.

Experiments evaluated water, acidic and mildly alkaline solutions as artificial ageing media. The latter was the most effective for rapidly reproducing altered layers consistent with archaeological specimens.

DVS analysis was performed on reproduction and authentic archaeological glass. The principal experiment then entailed one-year storage of aged reproduction glass at 30°C across a 20–60% RH range. The resulting crizzling progression was quantified by counting flakes in 'before' and 'after' microphotographs.

The results demonstrate a negative correlation between RH and new crack formation, with damage increasing as RH decreases. The DVS and long-term storage data aligned, identifying a sharp increase in mass loss and crizzling below 35% RH. This study provides empirical evidence for the lowest acceptable RH level and guidelines for the storage and display of altered glass.



Antanas Melinis is a completing PhD student at University College London (UCL) and the RICHeS Project conservation scientist at English Heritage. He is a former participant of the EU GoGreen heritage conservation research project and received training in conservation science as part of the SEAHA (Science and Engineering for Art, Heritage and Archaeology) programme at UCL. He also has a background in archaeology and archaeometry, with a focus on preventive glass conservation and non-destructive analytical techniques.

Ultraviolet-vis spectroscopy in cultural heritage: case studies on historical glass and ceramic glazes

Andreia Ruivo,^{1,2} Vanessa Otero,^{1,2,3} Mathilda Larsson,⁴ Márcia Vilarigues,^{1,2} Susana Coentro,^{1,2} Ana Catarina Santos,^{1,2} Inês Coutinho^{1,2} & Catarina Viola^{1,3}

¹ Research Unit VICARTE: Vidro e Cerâmica para as Artes, NOVA School of Science and Technology, NOVA FCT, 2829-516 Caparica, Portugal

² Department of Conservation and Restoration, NOVA School of Science and Technology, NOVA FCT, 2829-516 Caparica, Portugal

³ LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, FCT NOVA, 2829-516 Caparica, Portugal

⁴ HERCULES Laboratory, City University of Macau Chair in Sustainable Heritage, Institute for Advanced Studies and Research, Laboratório Associado IN2PAST, University of Évora, 7000-809 Évora, Portugal

Corresponding author email: a.ruivo@fct.unl.pt

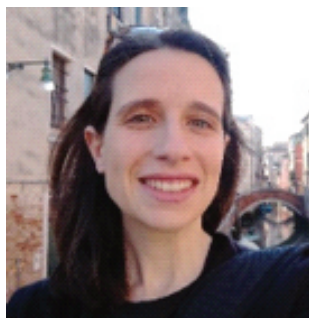
Optical spectroscopy has become a fundamental tool in the study of cultural heritage, offering non-invasive and informative approaches for the identification of colourants, manufacturing technologies, and degradation processes in historical objects.⁽¹⁾ This work explores the role of ultraviolet-vis spectroscopy and hyperspectral imaging (HSI) in the study of historical glass and glazes from the sixteenth to the twentieth centuries through a series of Portuguese case studies. These techniques were combined with complementary analytical methods in the investigation of painted glass slides, glazed ceramics and historical glass reproductions. Together, these approaches enabled the identification of several colourants, as well as the evaluation of how different material compositions influence the optical properties.

Particular attention is given to the study of both organic and inorganic colourants, including the identification of cochineal-based formulations in hand-painted magic lantern slides and the characterisation of pigments used in Portuguese azulejos, as the Hispano-Moresque tiles present in the Chapter Hall of the Royal Monastery of Our Lady of the Conception in Beja. The application of hyperspectral imaging further demonstrated the potential of optical methods for in-situ analysis and large-scale mapping of glaze colourants in architectural heritage contexts, providing a rapid and non-destructive analysis method.

In parallel, the spectroscopic characterisation of reproductions of historical Portuguese glass recipes based on archival sources from four known Portuguese arcana: Marinha Grande Factory; the glassmakers Castro and Oliveira Guerra; the Gaivotas Factory; and the Northern Portuguese Glass Centre Factory, contributed to the study and reconstruction of historical glassmaking technologies, while also creating reference data for future conservation studies.⁽²⁾ Together, these case studies demonstrate how optical spectroscopy bridges conservation science, material studies, and technical art history, contributing to both the preservation of cultural heritage and the understanding of historical artistic and technological practices.

References

1. Ultraviolet-visible-NIR reflectance spectrophotometry in cultural heritage: background paper. *Anal. Methods*, 2016, 8, 5894–6. DOI: 10.1039/C6AY90112C
2. Reis Santos, C., Ruivo, A., Carneiro, A., Veiga, J. P., Palomar, T., Coutinho, I., Amber ‘alchemy’: recreating and investigating yellow glass formulations. *Materials*, 2024, 17 (23), DOI: 10.3390/ma17235699



Andreia Ruivo graduated in Chemistry and obtained a Master's degree in Chemistry from the Faculty of Sciences of the University of Lisbon (FCUL). In 2013, she completed a PhD in Sustainable Chemistry focused on innovative luminescent glasses for artistic applications, developed in collaboration with REQUIMTE and VICARTE at NOVA FCT.

She is currently an Assistant Researcher at NOVA FCT (LAQV-VICARTE), where her research and teaching focus on the development and characterisation of sustainable glass and ceramic materials for artistic, cultural heritage, and industrial applications, combining spectroscopy, glass technology and material studies.

Fragile infrastructures: interdisciplinary glass work and the decline of expertise in art and craft education

Dr Goshka Bialek

Cambridge

Cooperation among artists, curators and scientists has become an increasingly dynamic field of practice, particularly where material-driven research intersects with artistic experimentation. Focusing on glass as a sculptural medium, this article analyses how interdisciplinary collaboration enables sculptors to draw on scientific knowledge of glass chemistry, engineering, and fabrication, while scientists and artisans benefit from artistic methods grounded in intuition, embodied skill and material sensitivity. The study shows that glass operates not only as a shared medium but also as a shared language that reshapes workflows, expands conceptual frameworks and generates hybrid forms of expertise.

One of the key contributions of the research is its examination of the structural limitations within art and craft education, where many departments lack educators with the interdisciplinary competencies required to teach the full potential of glass. This shortage results in narrow curricula, limited understanding of materials and declining institutional sustainability, affecting both glass departments and glass factories' ability to survive in the market. By situating these challenges within broader debates on material literacy and the future of craft-based disciplines, the article calls for renewed, interdisciplinary pedagogies capable of revitalising glass practice and ensuring its continued relevance for contemporary artists.

Colour and corrosion in English medieval stained glass windows

Ian C. Freestone

UCL Institute of Archaeology, 31-34 Gordon Square, London WC1H 0PY, UK

Corresponding author email: i.freestone@ucl.ac.uk

Conservators sometimes comment that glass of a particular colour has corroded more intensively than others in the same window. Although such occurrences are largely recounted in conversation rather than formally published in detail, they are frequently observed.

Drawing upon analytical work stretching over two decades, I explore colour-related corrosion phenomena in windows from the twelfth to the early sixteenth centuries. As might be expected, the direct causes of these relationships may be found in variable base glass compositions, rather than the effects of the colourants themselves, but why do the base glass compositions vary in a single window made over just a few years? And why are specific colour–corrosion relationships characteristic of some periods but not of others?

The durability of a glass depended upon the raw materials and technologies used by the glassmakers in the region where it was made, and these practices varied across Europe and also with time. Hence in England, which is thought to have imported all of its coloured glass, the relationships between colour and corrosion reflect changes in the source of the glass and the prevailing technology in the source region.



Ian Freestone is Emeritus Professor of Archaeological Materials and Technology at the UCL Institute of Archaeology, an honorary visiting researcher at the British Museum and President of the Association for the History of Glass. He trained as a geochemist and undertook doctoral and postdoctoral research on phase equilibria in silicate melt systems. His interests are in the composition, production and deterioration of artefacts and he has worked widely on ceramics, glass and metallurgy from all periods up to the nineteenth century. After 25 years working as a scientist in the British Museum, he joined Cardiff University in 2004 as Professor of Archaeological Science where he served as Head of Archaeology and Conservation before moving to UCL in 2011. He is author of over 200 articles and has co-edited nine conference proceedings. He received the Archaeological Institute of America's Pomerance Medal for scientific contributions to archaeology in 2004. He is a member of the editorial boards of *Archaeometry*, *Journal of Archaeological Science*, *Journal of Cultural Heritage* and *Journal of Glass Studies*.

A window into the medieval world: the consumption of English window glass at high status monastic sites in England, 12th to 16th Century

Bronwen Stone^{1,2} & Caroline Jackson,¹ Sarah Paynter,² Francesca Gherardi² & Colin Merrony¹

¹ Department of History, University of Sheffield, 9 Mappin St, Sheffield S1 4DT, UK

² Historic England, Fort Cumberland, Fort Cumberland Rd, Portsmouth PO4 9LD, UK

Corresponding author email: jennybstone1@gmail.com

This paper presents the results of a four year collaborative PhD study at the University of Sheffield and Historic England. The purpose of the study was to examine the consumption of English window glass at high status monastic sites across England. Seven Benedictine and Cistercian monastic sites were selected, and 284 samples of excavated window glass were examined using stylistic, technological, art historical and chemical analytical techniques. The results were used to analyse the complexities of the glassmaking industry in window glass production in England compared with the continental glasshouses.

Glassmaking in England appears to have only started in the 13th century and at this point was a nascent industry, in competition with window glass procured from the continent. All of the window glasses in the study were sourced from France, Germany and England. English window glass appears to have been used at the study sites in the first half of the 14th century and onwards. Although evidence for its use is scarce, those abbeys in closer proximity to the major glassmaking areas in the Weald and Staffordshire appear to have been the early adopters.

There is no evidence to show that coloured glass was made in England during the medieval period. An important finding from the study is that English producers limited their market appeal because of their failure to produce coloured glass (whether through choice or a lack of knowledge), while the continental producers could supply both coloured and uncoloured. This resulted in a more restricted range of decorative elements applied to the English glasses, and the majority of English glasses are used in border and background designs. Continental coloured glass could be used more widely, for example, for the brightly coloured figures popular in the 14th century.

The Black Death in the mid 14th century thwarted supply from the continent and this period correlates with an increased use of English glass at the study sites. This period is also concomitant with a creative overhaul in style when windows comprised a greater area of colourless glass and an increased use of silver stain, which exploited the range of earthy colours that could be produced more economically and which acted as a substitute for coloured glass. This could have created an opportunity for English glassmakers, although the continued small-scale nature of the industry and the dominance of German glass in the 15th century suggests it was probably not taken.

Stained glass roof lantern: fragile heritage

Oksana Kondratyeva

Gerda Henkel Stiftung, Düsseldorf, Germany

Email: mail@oksanakondratyeva.com

Stained glass roof lanterns represent a distinctive yet vulnerable element of architectural heritage, combining structural innovation and decorative artistry. This paper examines the reconstruction of the stained glass roof lantern (1885) at the Kyiv National Art Gallery, one of the earliest surviving examples of large-scale duotone overhead glazing in residential architecture in Europe. Installed within a distinguished example of late nineteenth-century Gründerzeit architecture, the Neoclassical roof lantern featured exceptionally thin red-on-clear acid-etched flashed glass with rosettes and Greek meander motifs, enriching the spatial experience of the interior.

The roof lantern was severely damaged during the missile attacks on Kyiv in October 2022. Its reconstruction required the production of oversized mouth-blown flashed glass by GlasHütte Lamberts in Germany, followed by acid-etching in the United Kingdom. The project demonstrated the technical and material challenges of recreating historic architectural glass, particularly in the context of declining access to hydrofluoric acid-etching facilities and specialist expertise. It further illustrates how international collaboration between glass manufacturers, artists and educational institutions can sustain endangered craft traditions.

Although awaiting installation, the reconstructed glazing scheme stands as a testament to cultural resilience and the enduring role of architectural glass art in preserving historical memory.

The Lycurgus Project – a modern take on an ancient artifact

Lisa Hollands¹ Christina Metcalfe,² Elliot Walker,³ John Parker¹ & Russell Hand¹

¹ School of Chemical Materials and Biological Engineering, University of Sheffield, S1 3JD, UK

² School of Mathematical and Physical Sciences, University of Sheffield, S3 7HF, UK

³ Blowfish Glass UK Ltd, Unit 15 Red House Glass Cone, Stourbridge DY8 4AZ, UK

Corresponding author email: l.hollands@sheffield.ac.uk

The Lycurgus Cup is a unique, almost intact, 4th Century Roman glass cage cup exhibiting dichroism – appearing opaque jade green in reflected light but a vivid red in transmitted light. The cup itself is made up from a single piece of glass with a carved design connected to the cup via small glass bridges; this is typical of Roman cage cups, however this cup is unusual in that it has figurative designs rather than geometric. The scene depicts the myth of King Lycurgus of Thrace being tormented by Dionysus (the Greek god of wine), Pan and a satyr, whilst being wrapped in vines following his attack on Dionysus, his female followers and Ambrosia.

This project has involved using modern reagents and equipment to attempt to replicate glass with the dichroic nature of the cup before transforming it into a modern interpretation of the Lycurgus story. The presentation outlines the developmental phase of glass production within the laboratory before discussing the challenges of scaling up production. Finally, we will show how the design of the final piece, showcasing the nature of the glass, progressed before being created in the studio. The final piece will be exhibited in the Millennium Gallery in Sheffield during the Festival of the Mind 2026 and will be housed in the Turner Museum at the University of Sheffield afterwards.



Figure 1. Early studio trial – reflected light on the left, transmitted light on the right

Online Manuscript Submission, Tracking and Peer Review System for The European Journal of Glass Science and Technology

Glass is that essential material that is taken for granted because it is there at the interface, holding the beer, allowing our fingers to navigate the internet by touch, providing a transparent layer between divergent environments, holding visibly attractive produce without tainting them.

The objects of the Society of Glass Technology are to encourage and advance the study of the history, art, science, design, manufacture, after treatment, distribution and end use of glass of any and every kind. These aims are furthered by meetings, publications, a web site, the maintenance of a library and the promotion of association with other interested persons and organisations.

Papers appearing in *Glass Technology* are concerned with glass making, glass fabrication, properties and applications of glasses or glass ceramics and other related topics. *Physics and Chemistry of Glasses* accepts papers of a more purely scientific interest concerned with glasses and their structure or properties. Thus the subject of a paper will normally determine the journal in which it will be published. Papers on structure of glass, for example will always appear in *Physics and Chemistry of Glasses* while those on furnace operation will appear in *Glass Technology*. In some cases, the way in which a subject is discussed determines the appropriate journal and the Editors will advise authors in such cases. Both journals are published six times per year.

Open Access

The Society of Glass Technology is able to offer authors the Open Access route to publication. This option is now available to our authors, on payment of a one-off fee to meet the costs of electronic production. The fee will be payable by the author after paper acceptance and prior to publication. The fee for SGT members is £500; for non-members the fee is £1000. VAT is applicable to residents in the EU.



Open Access papers are licenced under the Creative Commons licence BY:

<https://creativecommons.org/licenses/by/4.0/>

The Society of Glass Technology supports funding bodies such as UKRI in identifying funded articles and ensuring they are openly accessible to all when they are published.

AGC

Your Dreams, Our Challenge

AGC a world leader in flat glass

www.agc.com

Architectural Glass

Glass solutions
for smart cities and
sustainable living

Automotive Glass

Smart glass solutions
for a new world
of mobility



Day	Date	Time	Science Talks	Time	
			The Long Room		Vivien Stewart Room
			<i>Science1</i>		
Monday	07-Sep-26	09:00	Alex Hannon - Welcome		
		09:10	Angela Seddon (plenary)		
		09:30	Angela Seddon (plenary)		
		09:50	Grant Henderson (plenary)		
		10:10	Grant Henderson (plenary)		
		10:30	COFFEE		
			<i>Science2</i>		
		11:00	Delia Brauer (plenary)		
		11:20	Delia Brauer (plenary)		
		11:40	Oliver Alderman		
		12:00	Guglielmo Macrelli		
		12:20	Claudio Fusco		
		12:40	Gavin Mountjoy		
		13:00	LUNCH		
			<i>Science3</i>		
		14:00	Morten Smedskjaer (plenary)		
		14:20	Morten Smedskjaer (plenary)		
		14:40	Mounir El Skafi		
		15:00	Shuai Wei		
		15:20	David Vu Bui		
		15:40	Jens Moesgaard		
		16:00	COFFEE		
			<i>Science4</i>		
		16:20	Clare Thorpe (plenary)		
		16:40	Clare Thorpe (plenary)		
		17:00	Rachel Crawford		
		17:20	Casey Walsh		
		17:40	Hannah Blystra		
		18:00	Alexis Delanoë		
		18:20	END		

Day	Date	Time	Science/Industry Talks	Time	Sustainability/Industry Talks
			The Long Room		Vivien Stewart Room
			<i>Science5/Industry</i>		
Tuesday	08-Sep-26	09:00	Arun Varshneya (AGC-Professor Michael Cable Memorial Lecture)		
		09:20	Arun Varshneya (AGC-Professor Michael Cable Memorial Lecture)		
		09:40	Olivier de Lataulade (Michael Garvey Award)		
		10:00	Olivier de Lataulade (Michael Garvey Award)		
		10:20	Stuart Hakes (plenary)		
		10:40	COFFEE		COFFEE
			<i>Science6</i>		<i>Sustainability</i>
		11:00	Gin Jose	11:00	Daniel Backhouse (invited)
		11:20	Richard Carter	11:20	Daniel Backhouse (invited)
		11:40	Thomas Readyhoof	11:40	Hideyuki Imai
		12:00	Kejie Huang	12:00	Giulia Tameni
		12:20	Falak Zaman	12:20	Robert Werner
		12:40	Karolina Milewska	12:40	Roger Pauli
		13:00	LUNCH		LUNCH
			<i>Science7</i>		<i>Industry</i>
		14:00	Alex Hannon	14:00	Russell Hand
		14:20	Reuben Tosh	14:20	Federico Monegaglia
		14:40	Hikaru Ikeda	14:40	Owen McGann
		15:00	Alastair Cormack	15:00	Stuart Hakes
		15:20	Lenorah Haight-Stott	15:20	Adnan Karadag
		15:40	COFFEE		COFFEE
			<i>Early- and Mid-Career Workshop 1:</i>		
			<i>Academic and Industrial Career Pathways</i>		
		16:00	Stuart Hakes/Paul Bingham/Arun Varshneya		
		16:30	Discussion		
		17:30	END - Followed by BANQUET (19:30)		

Day	Date	Time	Science Talks	Time	H&H Talks
			The Long Room		Vivien Stewart Room
			<i>Science8</i>		<i>H&H1</i>
Wednesday	09-Sep-26	09:00	Ines Coutinho (H&H plenary)		
		09:20	Ines Coutinho (H&H plenary)		
		09:40	Karl-Michael Weitzel	09:40	Jessamy Kelly
		10:00	Joshua Sena	10:00	Jerzy Kunicki-Goldfinger
		10:20	River Pao	10:20	Mark Hursty
		10:40	Natasha Vedishcheva	10:40	Dian Shi
		11:00	COFFEE		COFFEE
			<i>Science9</i>		<i>H&H2</i>
		11:20	Paul Bingham (invited)	11:20	Colin Brain
		11:40	Paul Bingham (invited)	11:40	Colin Brain
		12:00	Luke Cooper	12:00	Rahel Guggelmann
		12:20	Anthony Bell	12:20	Jianying Guo
		12:40	Miu Onaru	12:40	Durrell Manison
		13:00	LUNCH		LUNCH
			<i>Science10</i>		<i>H&H3</i>
		14:00	Michael Ojovan (invited)	14:00	Ana Franjic
		14:20	Michael Ojovan (invited)	14:20	Antanas Melinis
		14:40	Eperke Rencz	14:40	Andreia Ruivo
		15:00	Wei Deng	15:00	Goshka Bialek
		15:20	Fatma Zahra Souissi	15:20	Ian Freestone
		15:40	COFFEE		COFFEE
					<i>H&H4</i>
		16:00		16:00	Bronwen Stone
		16:20		16:20	Oksana Kondratyeva
		16:40		16:40	Lisa Holland
		17:00	CLOSE		