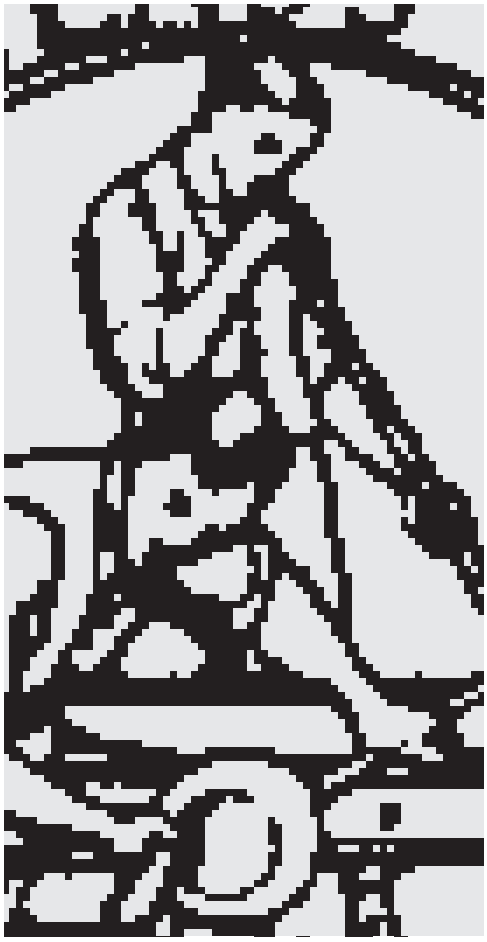

NO. 1 2004

SGT NEWS

Compiled and published by dmg world media (uk) ltd on behalf of the Society of Glass Technology

FURNACE MONITORING – BE PREPARED

It is widely realised that major cost savings can be realised by extending furnace campaign lives and delaying repairs as long as possible. But accurate and reliable information on the condition, and potential future life, of critical refractory components is required if this is to be achieved safely. The ability to monitor refractory condition can be, therefore, central to production planning and business success. Geoff Evans of GlasRef Consulting described the benefits of different monitoring methods and highlighted new areas of research to a meeting of the North West Section of the Society of Glass Technology at Pilkington Technology Centre at Lathom.

If the furnace designer has installed adequate sight holes and access points, then routine visual inspections of furnace superstructure, crown and regenerators are possible. These can be supplemented with photographic and video-records, using water-cooled periscopes to gain access to the more difficult areas. But experience shows that, although these above-glass areas can often demand high levels of on-going maintenance, they are rarely the cause of furnace shutdown.

Most shutdowns are caused by failure of the glass contact refractories. Whilst it may be possible to make some estimate of the metal-level corrosion of sidewall blocks, by inserting steel 'hooks' beneath the tuckstones, there are no such opportunities to similarly investigate the condition of other, often more critical, glass contact areas. It is the monitoring of these latter areas, particularly throats and melter bottoms, on which this paper focuses. Their failure is amongst the most common causes of unscheduled furnace shutdown and, in normal production, they are impossible to inspect directly. Their premature failure also sometimes has severe consequences for plant and personnel safety.

The simplest form of temperature monitoring is probably the visual 'lights out' survey – ideally performed at night, with minimum personnel on-site. If properly and routinely done, this can yield valuable information on furnace condition at minimum cost. Although useful for detecting 'hot spots' these surveys give us no meaningful information on the actual extent of corrosion and the thickness of refractory lining.

Several years ago there was much interest in the use of embedded thermocouples in glass-contact sideblocks, and particularly in furnace throats, as a possible means of monitoring their corrosion. Unfortunately the results from these early experiments were disappointing – due to the combined problems of temperature sensitivity (to changes in both block thickness and ambient furnace conditions) and long-term deterioration of the thermocouple elements. This activity has largely ceased.

Continued

CREATIVITY IN GLASS HISTORY AND HERITAGE

A study day is to be held on Friday 23rd April 2004 at the University of Liverpool by the Glass Heritage and History Special Interest Group in collaboration with the Association for the History of Glass. The focus will be Creativity in Glass History & Heritage. Throughout glass-making history creativity in design or use of the material has necessarily been linked to creativity in the technology and "know-how" needed to make it. Our knowledge of glassmaking history leans heavily on creativity in the realm of archaeology, the finding and interpretation of glass objects and glassmaking sites. Today's science contributes strongly to that process, as it does to the business of protecting and restoring our legacy of glass heritage. The purpose of the History & Heritage day is to bring together these diverse strands of glass expertise in celebration of the human creativity which glass has inspired throughout the ages.

A fascinating line-up of speakers and topics has been assembled.

Further details from Sara Lindley, Conference Office, Society of Glass Technology, Don Valley House, Savile Street East, Sheffield S4 7UQ, Website: www.sgt.org

Instead, infrared thermography has become increasingly used as a monitoring tool. With its ability to generate 'temperature maps' of a refractory structure it has proved of use in both identifying 'hot spots' and giving indications of rates of change in refractory condition – by comparing current temperatures with previous baseline measurements. But, as in all temperature monitoring, it can be very misleading to attempt to relate directly such data to refractory thickness. As a consequence, and despite some claims to the contrary, thermography or any form of temperature monitoring is of very little reliability where forced cooling is being used and alternative techniques must be sought.

However, in situations where forced-cooling is not being employed, it is possible to exploit temperature information as a realistic method of estimating refractory thickness. This approach is particularly applicable to the melter bottom – an increasingly critical area in many glass furnaces. But surface temperature data cannot be used directly: the above-listed complexities in the heat-loss processes will almost invariably result in higher surface temperature readings. As a consequence, a simple calculation, using a combination of surface temperature and thermal conductivity data, will almost invariably lead to a gross under estimate of refractory thickness.

However, surface refractory temperatures (particularly with insulated melter bottoms) are relatively insensitive to refractory wear – but are very much influenced by changes in the ambient temperature conditions. It is far preferable to use temperature data from above the insulation layer – by drilling and temporary insertion of thermocouples. In this way, useful and reliable estimates of refractory thickness can be made. Inevitably, this technique is only useful for determining the larger-scale features of refractory wear – it is not sufficiently sensitive to pinpoint locally accelerated wear caused, for example, by 'downward drilling'. But within these limitations useful results can be obtained and, importantly, their accuracy increases as the refractory structure becomes more worn.

ALTERNATIVE TECHNIQUES

Temperature-based methods of thickness estimation are of little use when the refractory structure is forced cooled – as is the norm for glass contact sideblocks and furnace throats. In these areas a non-temperature dependent technique is required.

Ultrasonics-fusion-cast AZS refractories overwhelmingly fulfil the essential role of glass contact and containment. Up to ~20% of these blocks is comprised of a vitreous phase – which strongly attenuates any ultrasonic signals, as it becomes soft at high temperatures. However, progress has been reported in Europe with ultrasonics based on the following:

A combination of optimum ultrasonic frequencies (~55 kHz) and high-efficiency coupling materials.

An allowance for the effect of the structural changes in the refractory, within ~20 mm of the molten glass interface.

A realisation that ultrasonic velocities can change (by up to ~ 30%) between different grades, and different brands, of AZS refractory.

Reported accuracy of some laboratory trials is better than +10% – it has now to be demonstrated that this can be replicated on an operating furnace.

Gamma radiography – The zircon raw materials, used in the manufacture of all AZS refractories, contain low levels of hafnium, thorium and uranium. These elements are all radioactive and their decay results in the emission of (low intensity) rays. The gamma radiation is potentially the most useful for monitoring purposes – due to its higher energy and more penetrative properties. Refractory thickness is determined by relating the intensity of the radiation, detected on a scintillation counter via standards measured in the laboratory.

Results obtained by researchers in Germany on a cold glass furnace prior to its demolition were not as accurate as ultrasonics. However, there are several practical problems to be overcome which involve the need to calibrate each consignment of refractory blocks (to allow for raw material variability) and sampling times of up to 15 minutes for each location.

Resistance monitoring – Of more immediate application is a monitoring technique that utilises the extreme sensitivity of a refractory's electrical resistance to changes in its temperature (for fusion-cast AZS materials a 100°C increase will reduce resistivity by ~50%). The system (commercially available as 'Saveway') involves building a network of sensing electrodes into the refractory structure in a panel arrangement. During furnace operation, a low voltage is applied to these panels. Analysis of the circuit resistances then allows the local refractory temperatures and hence their thickness to be estimated – by using a complex series of computer-based algorithms. Unlike temperature monitoring, this technique seems capable of discriminating between locally intense corrosion (as with 'downward drilling') and more uniform, larger-scale refractory corrosion. It appears to be a highly-flexible system and can be adapted to monitor the complete range of furnace situations.

In-built computer algorithms can reportedly compensate automatically for changes in furnace temperatures as part of the corrosion monitoring procedure and the results can be displayed automatically.

This resistance monitoring system has been used in metallurgical furnaces for almost 20 years. Its first use in a glass furnace was in 1997 and, reportedly, there are now 14 such installations worldwide. Published results on the monitoring of sidewall blocks in a slag-wool glass furnace (confirmed after shutdown) indicate an accuracy of better than +10%. Inevitably, such tools can be costly – but this expense must be balanced against the financial and other savings from the potential elimination of premature furnace failure, unscheduled shutdowns and repairs. In continental Europe some insurance underwriters are now encouraging the installation of such monitoring capabilities.

Other users of refractories may also offer potential solutions. There was a major accident involving a steel furnace in South Wales that has led to an investigation of the failure and the need to monitor all aspects of the furnace. It may that a new area of research may come from this and which may be of interest of the wider refractory using community. ■

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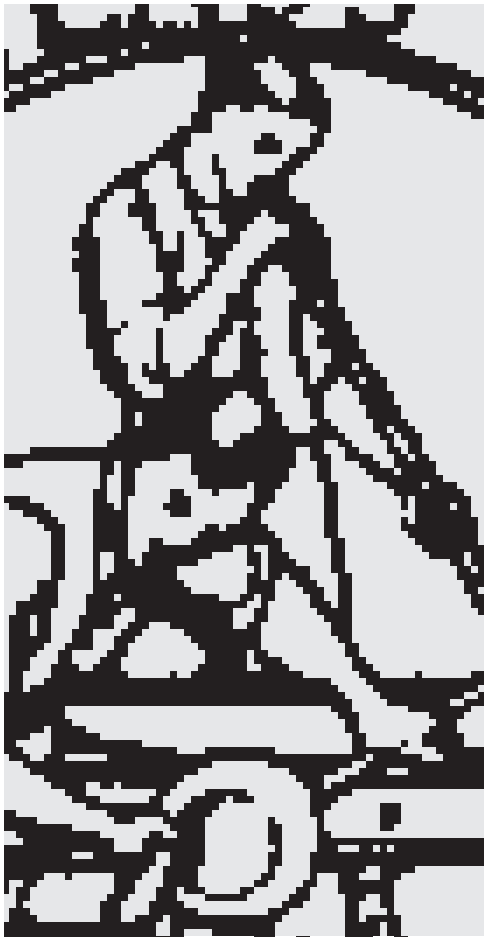

NO. 2 2004

SGT NEWS

Compiled and published by dmg world media (uk) ltd on behalf of the Society of Glass Technology

GLASS SELLERS AWARD

Candida Charlton Scotter of London won the 2003 Worshipful Company of Glass Sellers of London Award for Art and Craft for her untitled 7in high work. The "egg" is all hand carved from a 2in thick blown lead crystal piece. After completing the carving it was then acid dipped and selected areas were hand polished. It was loosely based on a William Morris theme. The piece took nearly one year to complete. Miss Charlton Scotter received £2000 from the Worshipful Company.

STUDENT AWARD

Mark Bickers of Herne Hill, London won the Student Award for 2003 for his cut, reheated and twisted glass forms. These were created as a reaction to traditional cut glass and with an aim to put a contempary twist on an unfashionable technique. Through a process of re-heating, the thinner cut glass dictates the final shape.

AWARD 2004

In 1674 George Ravenscroft, under the patronage of the Glass Sellers' Company, affected a process for the manufacture of lead-crystal glass. Manufacture subsequently commenced in a glass house situated where the Savoy Hotel now stands. The Glass Sellers' Company has patronised the art and craft of glass ever since, and has consolidated its patronage in the form of the Worshipful Company of Glass Sellers of London Award.

The successful submission shall be predominantly of glass, but exclude stained-glass windows, shall have been created within two years of the award year and shall be considered by the judges to be of a standard sufficient to warrant the Award.

The Award will consist of a cash prize of two thousand pounds.

STUDENT AWARD

From 1994 the Glass Sellers extended their patronage to the encouragement of young artists and craftsmen in glass at the beginning of their careers with the inauguration of a new Award for artistic and technical excellence in the art and craft of glass.

Entrants must be under 30 years of age for the year of the Award, studying at art school or college prior to graduation, or within three years of graduating. Entries as with the main Award must be predominantly of glass but exclude stained glass windows.

The Student Award includes a cash prize of six hundred pounds.

DEADLINE DATES

Entries for these Awards are now invited from persons resident in the United Kingdom, and must be submitted by 31 May 2004. Entrants may not submit pieces for both Awards.

The pieces must be available for judging at a date to be decided.

SCIENCE AND TECHNOLOGY AWARD

The Glass Sellers also support progress in science, technology and industry with an award presented every five years. The last Award was

ELECTRONIC JOURNALS

The refereed papers from *Glass Technology* and *Physics and Chemistry of Glasses* are now available through the Internet via the Society of Glass Technology web site. This is a new feature and is available to Society members and non-member subscribers to the journals.

The Society is working with Ingenta, the leading host of professional and academic publishers on the web, to provide this service. The issues viewable on-line will be from the 1998 volumes onwards. The 2002 volumes onwards will have links from their references to other on-line publications and reciprocal links will be built up from other electronic journals. This will provide better services for authors and researchers alike.

Since its launch in May 1998, Ingenta has grown to become a leading Web infomediary empowering the exchange of academic and professional content online. With the acquisition of another major provider, Catchword, Ingenta supplies access to: 5400+ full-text online publications, 26,000+ publications. The company serves a growing global audience of academic and professional publishers, 10,000+ academic, research and corporate libraries and institutions, incorporating 25 million users worldwide. It records around 3 million monthly user sessions.

Members with more than three years service will have full access to the available issues. More recent members will have graduated rights to view the volumes: two years for a new member, an additional two for those renewing for the second year, and full rights for subsequent renewals.

www.sgt.org www.Ingenta.com

won by Kevin Sanderson of Pilkington for the development of Activ self cleaning glass in 2001.

2006 will be the next year for this Award and more information will be released towards the end of 2004. The presentation of the Award will most likely be at the Eighth European Glass Science and Technology Conference (ESG8) held by the Society in September 2006.

The prize will include a cash sum of £5000.

7–10 SEPTEMBER 2005

Annual Meeting of the Society of Glass Technology, Sheffield, UK.

This meeting will take place in Sheffield in early September. The University of Sheffield will be celebrating its Centenary in 2005 and the 90th Anniversary of the establishment of the Department of Glass Technology. This meeting will be a focus for its many glass connections. There will be several one day events linked to a general theme of Professor W E S Turner's work. The meeting will include a one day meeting on Heritage and History on the Saturday.

10–14 SEPTEMBER 2006

ESG8, Eighth European Society of Glass Science and Technology Conference, Sunderland, UK.

The Society of Glass Technology has been chosen as the hosts of the eighth conference of the European Society of Glass Science and Technology. The meeting will be held in Sunderland, based around the University campus and the National Glass Centre. The Society held the first conference in Sheffield in 1991. ■

STANDARD SAMPLES

The Analysis & Properties Committee of the Society of Glass Technology have completed their analysis of two new certified reference materials (CRM) for amber and green coloured glasses. The standard samples were approved by the Council of the Society of Glass Technology in November 2000.

The laboratories involved in the process have all followed ISO guidelines for the production and traceability of analytical data.

INTENDED USE AND STABILITY

The samples are available in the form of glass pieces and also as 40 mm diameter discs.

They are intended for the verification of analytical methods, such as those used by the participating laboratories, for the calibration of analytical instruments in cases where the calibration of primary substances (pure stoichiometric compounds) is not possible and for establishing secondary reference materials.

The solid disc is intended for establishing and checking the calibration of x-ray spectrometers for the analysis of similar materials. The "as received" surface should be ground and polished.

The traceability of this CRM is ensured by the use of either stoichiometric analytical techniques or methods that are calibrated against pure compounds.

SGT10 Amber soda–lime–silica container glass (mass%)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	BaO	Na_2O	K_2O	TiO_2	SO_3	Cr_2O_3
72.8	1.62	0.325	10.6	1.82	0.02	12.2	0.35	0.09	0.05	0.020

SGT11 Green soda–lime–silica container glass (mass%)

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	BaO	Na_2O	K_2O	TiO_2	SO_3	Cr_2O_3
70.7	1.83	0.342	10.3	2.14	0.031	13.6	0.69	0.068	0.06	0.205

There are also values for ZrO_2 and Mn_3O_4.

These add to the existing range of standard sand and glass samples for analysis and calibration purposes.

GLASSES

Standard Glass No. 4. **Fluoride Opal Glass**
Also available as 6 mm thick sheets to special order, price on application.
Standard Glass No. 5. **Soda–Lime–Magnesia–Silica Glass**
Standard Glass No. 6. **Soda–Lime–Silica Glass**
Standard Glass No. 7. **Soda–Lime–Silica Glass**
Two lead glasses were received by the Analysis & Properties Committee but because of time limitations Glass No. 9 was not analysed by all of the collaborating laboratories. This glass has a lower lead oxide content, about 28% PbO, than Glass No. 8 and although it cannot be offered as a certified material, it could be useful as a subsidiary calibration check.
Standard Glass No. 8. **Lead oxide–potassium oxide–silica glass (30·59 wt% PbO)**
Standard Glass No. 9. **Probable composition available.**

SANDS

Standard Sand No. 1. **200g packs at £20.00 plus postage (Al_2O_3 0·061, Fe_2O_3 0·014, TiO_2 0·026).**
Standard Sand No. 6. **(Al_2O_3 0·06, Fe_2O_3 0·032, TiO_2 0·024)**
Standard Sand No. 8. **(Al_2O_3 2·07, Fe_2O_3 0·26, TiO_2 0·073, K_2O 1·06)**
Standard Sand No. 9. **(Al_2O_3 1·35, Fe_2O_3 0·103, TiO_2 0·044, K_2O 0·82).** ■

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PROCEEDINGS OF THE INTERNATIONAL CONGRESS ON GLASS

The Physics and Chemistry of Glasses special proceedings volume is now complete. The refereed papers have been passed for publication and the volumes are now available for distribution. There are 97 papers accepted for publication in the volume, totalling 512 pages.

The volume is available for £100.00, and £50.00 to members.

The Glass Technology International Congress on Glass, special proceedings volume has 80 papers in the volume, totalling 394 pages.

The volume is available for £80.00, and £40.00 to members.

Groups of papers can also be ordered from the SGT web site, members can pay for sets of four papers for £10.00, non-members pay £10.00 for three papers. Once payment is cleared, the papers will be sent by email as Adobe Acrobat files to the customer.

A CD-ROM with Acrobat versions of all the available presentations at the conference can be bought for £35.

JOURNAL SUBSCRIPTION RATES

The journal subscription rates for 2004, Volume 45 are:

	British	Overseas
Glass Technology (ISSN 0017-1050)	£185.00	£206.00
Physics and Chemistry of Glasses (ISSN 0031-9090)	£204.00	£225.00

Members of the Society of Glass Technology can choose to receive either or both journals as part of their membership. The typical rate for both journals for a Member is £107.

SGT NEWS

CRYSTALLISATION 2003

The Seventh International Symposium on Crystallisation in Glasses and Liquids was held at the University of Sheffield, UK. Starting in the United States in 1960 this is a major conference with a long tradition. With growing interest in glasses and glass-ceramics, this conference looks to bridge the gap between the scientific understanding of nucleation and growth in glasses, and the industrial applications of glass ceramics. This was an international event with representatives from Brazil, Argentina, Russia, Japan, Saudi Arabia, the US, and many European countries.

The papers that are published in the April issue of *Glass Technology* look at applied research for various applications.

George Beall of Corning reviewed work on anhedral crystallisation in phase separated glasses. Where crystallisation takes place from a co-continuous phase separated glass, a peculiar anhedral morphology may develop. The crystals are typically spherical or ellipsoidal and incorporate one of the original glass phases without change in geometry. This phenomenon requires that the crystal nuclei are widely spaced in comparison to the wavelength of the original amorphous phase separation, and that the growing crystal be similar in composition to one of the original glass phases. This form of microstructure may result in better mechanical properties in glass ceramics of high glass content than are typically obtained with standard microstructures. Examples of this anhedral morphology are found in mullite, zinc-stuffed β-quartz and fluormica glass ceramic systems.

Novel bioactive coatings for biomedical applications deposited by electrophoretic deposition were investigated by Jennifer Bibby & PM Mummery of Manchester Materials Science Centre Grosvenor, and N Bubb & DJ Wood of the Division of Restorative Dentistry, Leeds Dental Institute. There are thousands of implant operations every year that give significant pain relief to patients. Even small improvements can reduce the need for further revision surgery.

Improving the bonding of an implant, by using a bioactive coating, increases the rate of fixture of the implant so reducing the healing time. The original artificial bioactive coatings, calcium phosphates and hydroxyapatite, were absorbed quickly by the body. This leaves the substrate bare, resulting in loosening of the implant. Hench developed bioactive glass ceramics in the 1970s that were longer lasting and bonded to bone. Due to the low fracture toughness of these glass ceramics, these materials are used for non-load bearing components, or more commonly, as coatings.

Fluorapatite-mullite coatings can be successfully deposited as a glass ceramic. Initial bioactivity tests using SBF show that this coating is biologically active.

Phase separation and crystallisation induced by adding molybdenum and phosphorus to a soda–lime–silica glass was investigated by C Cousi & F Bart of Laboratoire d'Étude de Base sur les Matrices, France and J Phalippou of Laboratoire des Verres, Université de Montpellier. Silicate glasses with high molybdenum and phosphorous concentrations are partially crystallised. Their microstructure reveals the contribution of phase separation and crystallisation phenomena during cooling. These phenomena were investigated in three soda–lime–silica glasses containing phosphorous oxide and/or molybdenum oxide. Specimens were submitted to isothermal heat treatments at various temperatures, then characterised mainly by scanning electron microscopy (SEM) and x-ray diffraction (XRD) to determine their microstructure.

These observations made it possible to determine the chronology of the phenomena occurring during cooling: first, a liquid/liquid phase separation occurs, followed by phosphates crystallisation at the border of the droplets; then molybdates crystallise inside the droplets.

Crystallisation studies of biodegradable $CaO–P_2O_5$ glass with MgO and TiO_2 for bone regeneration applications were made by AG Dias, MA Lopes & JD Santos of Universidade do Porto and K Tsuru, S Hayakaw & A Osaka of Okayama University. $CaO–P_2O_5$ glass ceramics with small additions of MgO and TiO_2 were prepared in the ortho and pyrophosphate regions by powder sintering and crystallisation through heat treatment at different temperatures determined from differential thermal analysis (DTA) traces.

The glass ceramics were analysed by x-ray diffraction (XRD) and it was observed that α- and β-$Ca_2P_2O_7$ were the first phases to precipitate in the parent glass matrix at a temperature of 681°C, followed by $CaTi_2(PO_4)_6$ and TiP_2O_7 at temperatures between 703°C and 725°C. The β-$Ca_2P_2O_7$ phase is usually considered as biocompatible and $CaTi_4(PO_4)_6$ as bioactive and therefore these glass ceramics seem to show good potential for bone regeneration applications.

W Höland, V Rheinberger & E Apel of Ivoclar Vivadent, Liechtenstein looked at glass crystallisation in dental materials. Three mechanisms of controlled crystallisation are suitable for fabricating glass ceramics for restorative dental applications: surface crystallisation, volume crystallisation and two-fold crystallisation. The main crystal phases are leucite, lithium disilicate and fluorapatite.

In the two-fold mechanism, two different types of crystals, specifically apatite and leucite, are precipitated in parallel. The resulting glass ceramics are chemically durable, very strong and also translucent. These

LOCAL SECTION CONTACTS

For details of forthcoming local section events in your area, contact the following. All SGT members and non-members welcome.

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– Mr M Holden, BH-F (Engineering) Ltd, 4A Churchward, Southmead Park, Didcot, Oxon OX11 7HB. Tel 01235 517202.

Midlands
– Mr R Nickels, 4 Boundary Way, Compton, Wolverhampton, West Midlands WV6 8DL. Tel 01902 762070.

North East
– Mr W Brookes, 82 Whitfield Crescent, Penshaw, Houghton Le Spring, Tyne & Wear DH4 7QY. Tel/Fax 0191 584 3100.

North West
– Dr D Martlew, Pilkington Technology Centre, Hall Lane, Lathom, Ormskirk, Lancs. Tel 01695 54210.

Scottish
– Mr D A Rennie, United Glass Ltd, Glasshouse Loan, Alloa FK20 1PD. Tel 01259 218822.

Yorkshire
– Miss R M Sales, 20 Blackbrook Drive, Sheffield S10 4LS. Tel 0114 2306179.

NORTH AMERICA
– Dr A G Clare, School of Ceramic Engineering and Sciences, New York State College of Ceramics at Alfred University, 2 Pine Street, Alfred, NY 4802-1296, USA. Tel 607 871 2392.

INDIA
– Dr J Mukerji, Central Glass and Ceramic Research Institute, PO Jadavpur University, Calcutta 777 032, India. Tel 473 3496.

properties have enabled the development of modern dental materials that simulate the characteristics of natural teeth. The materials are used to fabricate dental inlay, onlays, crowns and veneers. The restorations are metal free and composed of a high strength lithium disilicate framework to which apatite glass ceramic veneers are applied. The materials are also suitable for fabricating small dental bridges.

In contrast to the current dental restorative glass ceramic materials, a rhenanite type glass ceramic has been found to demonstrate surface reactive properties and that living cells are capable of adhering to this material. Consequently, one can imagine the development of bioactive properties.

Crystallisation of Magnox waste glass under conditions of high temperature, very deep, geological disposal was investigated by NC Hyatt, KJ Taylor, FGF Gibb & WE Lee of University of Sheffield. The behaviour of a simulant Magnox waste glass was investigated under the likely conditions of high temperature, very deep, geological disposal, namely 760°C and 0·15 GPa, to assess the suitability of this scheme for disposal of high level vitrified nuclear waste. Partial crystallisation of the glass is observed under these conditions with the formation of $LnBSiO_5$ (Ln=Y, La, Pr, Ce, Nd, Sm and Gd), $LiNaZr_6SiO_8$ and a palladium (ruthenium) telluride phase. It was concluded that, in principle, the partial crystallisation of Magnox waste glass under these conditions presents no impediment to the very deep, high temperature, geological disposal of vitrified high level nuclear waste.

Recent developments for commercial applications of low expansion glass ceramics were explained by Wolfgang Pannhorst of Schott Glas. Examples of recent developments of low expansion glass ceramics were presented. These included new cook top panels with higher temperature stability and new base colours. The expansion properties achieved for mirror segments of several large telescopes were evaluated. For mirror substrates in extreme UV lithography the requirements for zero expansion have become tighter than in previous applications. It was shown that these requirements can be met in principle.

A Sakamoto, H Asano, M Wada, H Takeuchi & S Yamamoto of Nippon Electric Glass have investigated the durability of glass ceramic jacketed optical fibre. A novel optical fibre connecting component was fabricated by direct jacketing of silica glass single mode optical fibre (SMF) with a low expansion $Li_2O–Al_2O_3–SiO_2$ (LAS) glass ceramic. The durability of the glass ceramic jacketed SMF (GC-SMF) was evaluated by immersion, high temperature and damp heat tests. The GC-SMF displayed excellent stability in the configuration of its optical connecting endfaces in both the immersion test in hot (90°C) acidic water and the high temperature endurance test at 500°C for 1 h. The change in optical connection loss of the GC-SMF was within the range of 0·2 dB during the damp heat test at 85°C, 85% relative humidity for 2000 h. It was confirmed that the GC-SMF is suitable for high power optical communication systems as a durable optical connecting component.

Phase separation and crystallisation in nanosized spin-on glass films used in microelectronics have been researched by O Shilova of the Institute for Silicate Chemistry at the Russian Academy of Science, St Petersburg. Silicate films, spin coated on semiconductor wafers from TEOS derived sols modified by inorganic dopants including a range of salts and acids, were investigated.

The phase separation/crystallisation processes in silicate films doped with Pt or Co and Al were examined both on a micro- and macrolevel. It was shown that the nature of the anion and the concentration of the dopant affect the morphology of the film prepared. Crystal growth in the films under influence of different anions (chloride or nitrate ions) can be considered as template film formation.

Lezech Stoch of the University of Mining and Metallurgy, Kraków, Poland investigated the homogeneity and crystallisation of vitrified municipal waste incineration ashes. Amorphous C and graphite particles, K, Na and Ca chlorides and metallic inclusions have been identified and analysed. The influence of some of them on the course of crystallisation and composition of crystal phases formed adjacent to them is described.

Use of kinetic neutron diffraction to observe crystallisation of a mica based glass ceramic was looked at by DJ Wood & NL Bubb of Leeds Dental Institute, University of Leeds, PM Bentley & SH Kilcoyne of Department of Physics and Astronomy, University of Leeds, and C Ritter of Institut Laue-Langevin, Grenoble in France. The development of a microstructure of interlocking mica crystals of suitable volume fraction, size and aspect ratio is important in producing machinable glass ceramics for industrial and dental applications. This study uses kinetic neutron diffraction to monitor in real time the effect of a nucleation hold on the development of barium fluormica crystals in a glass ceramic during controlled heat treatments. Significant differences in the formation of the final monoclinic barium fluorphlogopite phase were evident when glass rods were subject to the two heat treatment regimes, including a lowering of onset temperature and the formation of a metastable orthorhombic mica phase during the nucleation hold.

Further posters were presented on:

- *Novel machinable mica based glass ceramics for dental applications* by HAO Al-Shammery, DJ Wood, NL Bubb & CC Youngson of Leeds Dental Institute, University of Leeds;
- *Reduction of the solubility of fluorcanasite based glass ceramics by additions of SiO_2 and Al–PO_4* by NL Bubb & DJ Wood of Leeds Dental Institute, University of Leeds and P. Streit of Metalor Technologies, Switzerland;
- *Comparison of direct and indirect selective laser sintering of porous apatite mullite glass ceramics* by RD Goodridge, JC Lorrison & KW Dalgarno of School of Mechanical Engineering, University of Leeds and DJ Wood of Leeds Dental Institute, University of Leeds;
- *Crystallisation mechanism in ultraviolet sensitive microstructurable glasses* by S Mrotzek, A Harnisch, D Hülsenberg & U Brokmann of Technische Universität Ilmenau, Germany;
- *Opacification of $ZnO–B_2O_3–ZrO_2$ glasses* by BD Noble, JM Parker, PF James & RJ Hand of University of Sheffield and A Smith & J Booth of Johnson Matthey;
- *Synthesis of leucite for application in dentistry* by M Novotna, V Satava, P Kostka & D Lezal of Institute of Inorganic Chemistry, Prague and J Maixner & A Klouzkova of Institute of Chemical Technology, Prague; and
- *Crystallisation and sintering of frits obtained from silicate wastes* by RD Rawlings & AR Boccaccini of Imperial College London. ■

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