

COORDINATING TECHNICAL COMMITTEE
ANNUAL REPORT
2008

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1 Executive Summary

CTC Actions in 2008

... improved output of the TCs

The monthly telephone conferences among the CTC members, the several EFONGA board meetings and the two classical CTC business meetings which took place on January 25, 2008 in Paris, France and June 24, 2008 in Trencin, Slovakia focused on:

- monitoring the work and output of the TCs,
- initiation of new actions,
- initiation of co-operation activities between TCs,
- motivating and supporting the TCs to improve the quality and effectiveness of their work.

Tighter checks of the work quality of the TCs combined with careful evaluation and constructive feedback and a better monitoring of their deliverables resulted in an improved and more visible output. The best TC annual reports (AR) have been selected by the CTC for the third year. The teams working on “Optical Properties of Glass” (TC10) and “Glass Surface Diagnostics” (TC19) received the award for the Best AR 2007. The well established process, which is based on rules agreed by the CTC and TC chairs has resulted in a continuous increase in the number of high quality of reports.

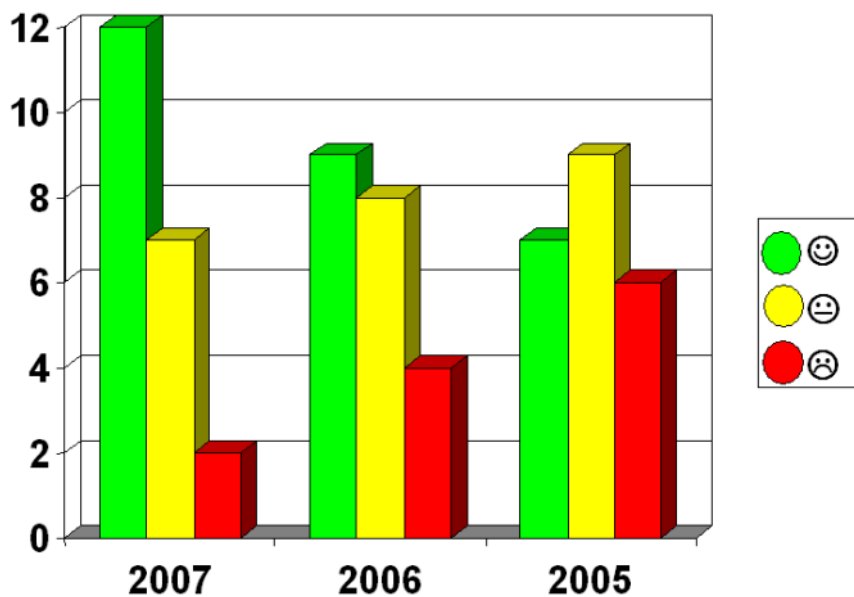


Fig 1: Number of AR reports of high quality (●) in the years 2005 - 2007

... three new TCs are initiated

In the R&D activity field “Basics and Properties”, two groups were officially created as Technical Committees. Namley “Glass Transition” (TC08) chaired by Lothar Wondraczek and “Nanomechanics” (TC09) chaired by Matteo Ciccotti. In the R&D activity field “Information, Education, History”, a Technical Committee started to work on “Glass for a Sustainable Society” (TC12) chaired by John Stockdale.

... Turner Award

The WES Turner Award 2008 was presented to Ruud Beerkens for manifold valuable actions in the ICG.

Special Events & Glass roadmapping

... new tools for future ICG actions

Clear predictions on future needs in the field of glass science, glass technology and innovative applications of glass are difficult - but they are essential in particular in R&D and focusing future R&D efforts and ICG directions. One of the most promising tools for the ICG is the **expert meeting** which focuses on **trends** to create clearer pictures and more precise perspectives on important topics for the glass community. In 2008 the following expert meetings were organized (under the auspices of the ICG and supported by EFONGA):

- "Advanced Materials and Innovative Glass Melting Technology in the Year 2020", in Brig, Switzerland, March 26-29, 2008
- "Workshop on Glass and Entropy", Trencin, Slovakia, June 25 – 26, 2008
- "Workshop on Conditioning and Forming of Glass", Eindhoven, The Netherlands, November 13 – 14, 2008.
- "Building a Sustainable Global Glass Industry" (organized by GMIC), Columbus, Ohio, November 3, 2008

Technical Committees (TCs)

... new TC chairs installed in 2008

- Beside the three chairs of the new TCs (see above), in addition three TC chairs took over existing TCs:
- Michael Dunkl, "Materials for Glass Manufacturing" (TC11)
- Eric Muijsenberg, "Modelling of Glass Melting Processes" (TC21)
- Kevin Sanderson, "Coatings on Glass" (TC24).

... very active core groups within the TCs and various highlights generated

- in the R&D field **Basics and Properties**
 - an **entropy workshop** has created a common understanding (TC08)
 - a new research focus on **crystallization of complex multi-component** glass forming systems has been implemented (TC07)
 - a summary on the **fundamental crack propagation** mechanism has been produced (TC09)
 - a trend to more fundamental work to understand the underlying science is apparent (TC02 and TC10)
- in the R&D field **Glass Production**
 - an **excellent network** with good links between TCs is installed; several joint meetings were organized between TC18 & TC 25, expert meetings with TC18, TC11, TC14, TC15 and TC21, TC11 & TC14 took place.
 - a very active R&D program on **interaction of refractory** materials with the glass melt is developed (TC11 & TC14)
 - **liquid temperature measurements** are the focus of different TCs (TC18 just published in the European Journal, Glass Technology and TC05)
 - the changing of the title of TC18 in to **Glass Melting** illustrates the shift of activities
- in the R&D field **Surface & Interfaces**
 - a **standardization test** for self-cleaning / reduced maintenance coatings is being developed in cooperation with CEN-TC129 (TC24)
 - the nature of ITO coating - alumino silicate glass interface is being investigated (TC16)

- a RRT on **imaging characterization** in the nm range is demonstrating the advantages and disadvantages of different techniques (TC19)
- in the R&D field **New Applications**
 - the **standard definitions for bioactivity** is making progress (TC04)
 - a review on **waste glass leaching, testing and performance modeling** is available (TC05)
 - **editing of special issues** (publications) of “Organic and Inorganic Photonic Materials” and “Glass and Ceramic Materials for Photonic Technology” is in progress (TC20)
- in the R&D field **Information, Communication, Education and History**
 - maintenance and update of the website **communication platform** www.icglass.org (TC01)
- **activities general nature**
 - numerous **round robins** are on-going (TC16, TC19, TC21, TC25, TC18, TC14)
 - a large number of **workshops** have been organized (TC01, TC05, TC06, TC08, TC09, TC14, TC18, TC23, TC25)
 - a letter to journal editors regarding data quality has been circulated (TC03)
 - many opportunities for collaboration and interaction have been identified and are in preparation.

ICG annual meeting

... an excellent platform with busy days

The core event of the year was the ICG annual meeting which took place in Trencin from June 23 – 26, 2008. 108 oral talks and 80 posters were presented. During the opening session of the meeting and during the ICG 75th anniversary the **current and future activities of the TCs** were presented. In addition various sessions of the congress were organized in co-operation with the TCs and some of these sessions were chaired by the TC chairs. 17 TCs organized their business meeting in Trencin. ICG and TC members co-organized a plenary session at this annual ICG meeting & 9th ESC conference to discuss the topic: **Glass – The Challenge for the 21st Century**.

EFONGA

... one year extension offers many new opportunities

The annual report of the 3rd year of the EFONGA project had been submitted and a cost-neutral extension for one more year to (May 2009) was approved by the EC. A key activity of year 2008 was the expert meeting in Brig (mentioned above) which delivered powerful **roadmaps for the fields of “Advanced Materials” and “Melting Technology”**. The extension allows the support of new actions such as summer schools for postgraduate students and other expert meetings of core fields in glass science and the initiation of investigations on new fundamental topics on glass like nanomechanics, glass transition, entropy, relaxation phenomena and structure properties relationship. A new project application to the EC is in preparation.

Plan 2009

... various actions are in the pipeline

- Expert meeting “**Glass Surface and Stress Corrosion Mechanism on Nanoscale**”, Montpellier, France, February 22 – 25, 2009
- Expert panel “**Biomaterials Brig II**”, Schaan, Liechtenstein, February 27, 2009
- Workshop on “**Glass and Entropy II**”, Aberystwyth, UK, April 22 – 24, 2009
- ICG/EFONGA “**Spring School on Glass Structure – Property Relationships**”, Montpellier, France, May 4 – 5, 2009
- EFONGA Workshop “**Summary and Roadmaps**”, Montpellier, France, May 6 – 8, 2009 with satellite expert panels on Glass Structure – Property relationships “**Bioglass**” on May 7, 2009 and “**Material Design by Computation**” on May 6, 2009
- ICG annual meeting in conjunction with PacRim8 (organizing symposia & sessions, TC meetings) Vancouver, Canada, June 2009
- CTC meeting on “**R&D activity fields**”, Vancouver, June 1, 2009
- ICG “**Tutorial on Thermodynamics & Chemical Technology in Glass Melting**”, Vancouver, June 2009
- CTC business meetings in St. Petersburg, Russia, January 30, 2009 and in Vancouver, Canada, June 2, 2009
- Joint ICG-PDA workshop on “**The Future of Glass as Parenteral Primary Packaging: Issues and Challenges**”, Venice, Italy, October 26, 2009.
- Setting up a R&D project consortium on bringing together research on Innovative Glass melting, with 4 sub-projects with the objective to develop very energy efficient and environmentally sound industrial glass melting processes.

2 Summary of R&D Activity Fields & TC Activities

2.1 Basics and Properties

Coordinator: R. Vacher

The main lines of activities in this field are:

- *Getting a better knowledge of the mechanisms of glass formation (TC08), glass stability and recrystallization (TC07), and of the microscopic structure of glasses (TC03)*
- *Improving the physical and chemical properties of glasses: chemical durability (TC02), mechanical (TC06), and optical properties (TC10)*
- *Understanding the structure-properties relationship (TC09).*

The highlights in this field were:

- **New TCs:** Basic glass science is one of the important axes that we want to develop. Two new TCs were created in this direction. The main goal of TC8 “**Glass transition**” is to increase our knowledge of thermodynamics of the glass transition and of the relaxation mechanisms associated. TC9 “**Nanomechanics**” concentrates on observations by local scanning probe techniques of the fundamental crack propagation mechanisms acting at the nanoscale in glass and glass-ceramics.
- **Expert meetings:** Meetings of experts with the purpose of clarifying the state of the art and finding the important future action lines on important problems in glass technology and productions are essential to get a clearer

picture of the development of glass industry. TC7 was one of the main organizers of the workshop on “**Advanced Materials and Innovative Glass Melting Technology in the Year 2020**” held in Brig, Switzerland, in March 2008. TC8 organised the “**Workshop on Glass and Entropy**” in Trencin, Slovakia, in June 2008. ICG was associated with the organization of the workshop “**Building a Sustainable Global Glass Industry**” organized by GMIC in Columbus, Ohio on November 3, 2008.

Joint actions of TCs

- A symposium “**Towards Ultrastrong Glasses**” was organized jointly by TC03 and TC06 at MSE 2008 (Nürnberg, Germany, 1-4 September 2008). During this symposium, a joint meeting of TC03, TC06 and TC09 concerning a round table on the “Strength of Glass” issue was organised.
- TC06 and TC19 are collaborating in the preparation of an expert meeting on the investigation of the nature of the first tens nanometers below the glass surface after different kinds of advanced polishing, to be held in Montpellier, France, in February 2009.
- Inside the frame of the EFONGA project, TC 1, TC 2, TC 8, TC 9, TC10, and TC23 have started the preparation of the “**Spring School**” and of the workshop “**Summary and Roadmaps**” which will be held in Montpellier, France, from May 3 to May 8, 2009.

2.2 Glass Production

Coordinator: Ruud Beerkens

Within the field of glass production, the technical committees focus on industrial glass melting and forming processes. This field includes:

- *melting processes with focus on properties of glass forming melts (TC18)*
- *the application of sensors and advanced process control in glass furnaces (TC15)*
- *materials used for glass melting processes (TC11)*
- *glass quality issues related to bubbles and dissolved gases in glass (TC14)*
- *development of tools to simulate industrial glass melting processes by mathematical models (TC21)*
- *comparison and testing simulation tools to describe important glass forming processes such as glass fiberizing, pressing and blowing processes (TC25)*
- *environmental aspects of industrial glass production with the focus on gaseous and particle emissions from glass furnaces (TC13)*

Several **joint events** were organized in the R&D field. The most important joint meeting was the expert **meeting in Brig**, Switzerland on March 26-29, 2009. 15 Experts from TC11, TC14, TC15, TC18 and TC21 met and presented papers on innovation in glass melting. This expert meeting resulted in an outlook for a new glass melting procedure for the year 2020. The discussion was captured in several roadmaps. One working document for new melting technologies is depicted below.

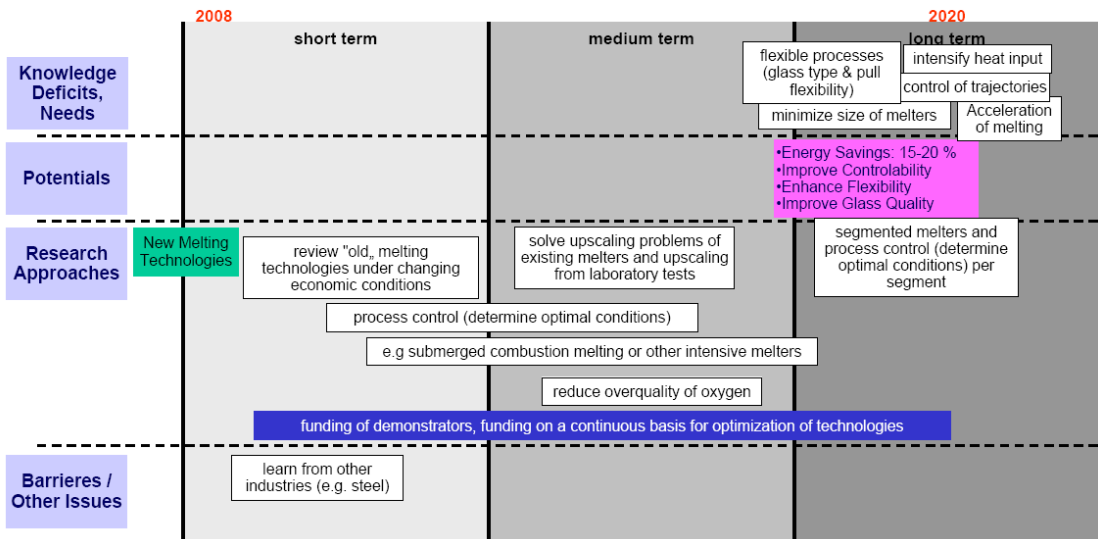


Fig. 2.2.1: Working document on new melting technologies

The expert meeting was finalized by defining 4 research directions with the aim of improving the production and energy efficiency of industrial glass melting, which are

- New glass melting concepts
- Innovative batch processing
- Glass furnace waste gas heat recovery methods
- Advanced sensor development and process control.



Fig. 2.2.2: The member of the "high-level" experts meeting on glass and glass melting (Brig/March 2008)

Follow-up meetings were held in Trenčín on June 24, 2008, and Düsseldorf on October 23, 2008. Several papers have been published in Glass Technology and Ceramics-Silikaty.

Furthermore, TC11 and TC14 met twice (in Düsseldorf and Trenčín) to discuss co-operation between these two technical committees on **characterizing blisters from glass melt – refractory** interaction and to develop a test method for characterizing the blistering potential of glass tank refractory materials.

At the plenary session of the ICG annual meeting & 9th ESG conference in Trenčín: “**Glass – the challenge for the 21st century**”, TC members of the Glass Production cluster discussed important issues for the future of glass science & technology with the audience.

A seminar on “**Conditioning of Glass Melts and Forming of Glass Products**” was organized by TC18 and TC 25 on November 13 – 14, 2008 in Eindhoven.

Manifold activities took place in the various TCs which will be highlighted in the following. The TC of **Properties of Glass Forming Melts (TC18)** finalized a Round Robin on liquidus temperature measurements of float glass (published in October 2008) and started a new Round Robin test on Modeling of the thermodynamic properties of multi-component silicates. TC18 changed its name into: “Glass Melting”.

TC15, originally a team of members from glass producers with expertise on **Sensors and Process Control**, is involving new members from institutes, sensor suppliers or control system suppliers. The group is in a phase of re-defining its goals and future activities. One of these activities is the preparation of a project proposal on advanced sensor application and process control in glass melting processes.

The team of **Materials for Glass Manufacturing (TC11)** discussed new activities such as test methods (glass defect and exudation potential) for glass furnace refractories, presentations on regenerator refractory tests were held and discussions took place on test methods for regenerator refractories and the impact of REACH on the refractory industry and refractory applicants. TC11 received several new members.

Gases in Glass (TC14) continues the execution of Round Robin tests (RRT) and methods to analyze water contents in different glass types and RRT’s on analysis of bubbles with sulfur/sulfate deposits. TC14 and TC11 co-operate intensively.

Modelling and Glass Melting Processes (TC21) started a new Round Robin on mathematical modeling of an industrial TV glass furnace for which measured data are available to validate the modeling results. The TC appointed a new chair person: Erik Muijsenberg.

Modelling for Glass Forming Process (TC25) worked further on three modeling cases for glass forming processes (Bench Mark Problems) and are in the stage of finalizing these three studies.

The group on **Environment (TC13)** compared different methods of measuring the size distribution of particles emitted by glass furnaces. Several members presented interesting results of typical concentrations and dust particle size distributions of industrial glass furnaces (e.g. float glass furnaces) equipped with or without electrostatic filter systems. Further important environmental issues are new air pollution control systems, heavy metal emission analysis, recycling of filter dust and energy efficiency (in combination with CO₂ emission trading) and IPPC regulation in the EU on emissions of the glass industry.

In 2009 co-operation between the TCs will continue, such as the TC11 – TC14 work on blistering from refractory materials in contact with glass melts. Joint seminars (of two or more TCs together) or contributions of TCs of the Glass

Production cluster, at the ICG 2009 conference in Vancouver, are planned and the Brig process on bringing together Research on Innovative Glass melting will be continued. In 2009 TC11 and TC15 need to re-vitalize their activities and start new projects.

Publications

- Beerkens, R.G.C.; Conradt, R.: *Round robin test on liquidus temperature of soda–lime–magnesia–silica float glass samples- A technical report of the ICG Technical Committee (TC 18) on Properties of Glass Forming Melts*. Glass Tech.: Eur. J. Glass Sci. Technol. A, October 2008, 49 no. 5 pp. 205-212
- Special Issue of No. 4/2008 of the Journal: Ceramics-Silikaty with 4 papers presented at the 26.-29. March seminar/expert meeting on “*Innovative Glass Melting for the Year 2020*” in Brig (Switzerland):
- R. Beerkens: *Analysis of elementary process steps in industrial glass melting tanks - some ideas on innovations in industrial glass melting*, Ceramics-Silikaty 52 [4] 206-217 (2008).
- M. Kawaguchi, T. Kato, Y. Imamura, N. Yoshida, S. Aoki: *Challenge to improve glass melting and fining process*, Ceramics-Silikaty 52 [4] 218-224 (2008).
- L. Němec, V. Tonarová: *Glass melting and its innovation potentials: bubble removal under the effect of the centrifugal force*, Ceramics-Silikaty 52 [4] 225-239 (2008).
- Lubomír Němec, Petra Cincibusová: *Glass melting and its innovation potentials: the role of glass flow in the bubble-removal process*, Ceramics-Silikaty 52 [4] 240-249 (2008).

2.3 Surfaces and Interfaces

Coordinator: *K. Bange*

The R&D Activity Field “Surfaces & Interfaces” clusters the work of the TCs which develop thin films on glasses, investigating nanoscale phenomena with focus on surfaces and interfaces, supply input and support to standardization committees including CEN and ISO, and establish the most efficient, respective characterization technique for added value topics on glasses and films.

Nanostructured Glass (TC16) is working on glasses and coatings obtained by chemical nanotechnology. The main activities concentrated in completing a “**Technical report on the nature of the ITO coating – aluminosilicate glass interface**”. A manuscript has been prepared and submitted (M.A. Aegerter, R. M. Almeida, A. Soutar, K. Tadanaga, J. Sol-Gel Sci. Technol. 47 (2008) 203-236). In the interface between the alkali alumino silicate glass substrate and ITO an approximately 8-10 nm thick layer exist which mostly disappeared after annealing of the sample at 300°C. The non-crystalline interface seems to have some relevance to the good adhesion of the ITO coatings to the glass substrate.

For the coordination of the activities various meetings took place (Paris, January 25; Padova, April 11; Frankfurt, June 12; Trencin, June 24). New members from Spain (2), Portugal (2) and China (1) joined the TC.

The TC plans to launch in 2009 new activities on studying **low index nanostructure coatings** with tailored high porosity and nanostructured glass coatings for energy saving in buildings and will be involved in the organization of a session of the PacRim conference in Vancouver, Canada.

Coatings on Glass (TC24) proposes or executes necessary and important actions aimed at technical and industrial developments in the field of coatings on glass. The main areas of activity have been based around

- self cleaning / reduced maintenance coatings
- testing of pyrolytic coated transparent conductive oxide films (TCO).

The discussion on **self cleaning / reduced maintenance coatings** focused ongoing activities on the draft standard developed so far. Existing standardization tests being developed through the Japanese Industrial Standards (JIS) and the International Organization for Standardization (ISO) were evaluated for a range of functions including self cleaning, air purification and antibacterial. In addition a discussion was held on the ongoing work towards the development of a standard via the "Comité Européen de Normalisation for Glass in Buildings" (CEN-TC129) and latest results associate with the testing at different sites. A round robin to test the methodology has been agreed via TC129 and a participation is planned. A formal communication of the results of the studies conducted as part of the ICG TC24 was warranted to CEN-TC129.

Commercial available **TCO samples** were tested with a wide range of properties including optical, electrical (sheet resistance, Hall Effect) and haze characteristics. A wide variation in thickness and Hall Effect measurements has been identified, may be due to the multiple layer nature of the films supplied to the round robin.

For 2009 a continuation of the activities on self cleaning / reduced maintenance coatings is planned with focus on the technical properties of these coatings and supply input and support as required to the standardization committees including CEN and ISO.

Glass Surface Diagnostics (TC19) established the best and most effective methods of characterization of the topology, chemical composition and reactivity of surface and sub-surfaces of glass down to nanometer scale.

Two round robins had been finished which are

- assesment of **imaging characterization** techniques in which ten laboratories are involved in the analysis of double coated glass substrated with microstrucures. A layer design of, 100 nm Cr and 100 nm Al₂O₃, structured with different patterns and different distances in the nm and µm regime had been analyzed by several analytical techniques. The characterization of the complex sample system exhibits the strength and weakness of various surface analytical techniques used by that multi method approach.
- **quantification of soda-lime glasses** using energy dispersive spectroscopy in combination with scanning electron microscope (**SEM/EDS**); nine labs participate. The results show that a high level of precision and accuracy is being implemented in the participating institutions. The results indicate that for EDS, Na and S are the most difficult elements to analyze. It seems that sodium is mobile and diffuses away under the electron beam while sulphur in the EDS spectra overlaps with a silicon/oxygen sum peak.

2.4 New Applications

Coordinator: R.K. Brow

This research cluster includes technical committees concerned with the properties and performance of specialty glasses designed for a variety of applications. In many ways, these properties are much more important than product cost, and issues related to large-scale manufacturing processes are generally not a significant priority.

Each of the three technical committees in this cluster are active, each with at least one business/technical meeting in 2008, and each developing some collaborative activity within the respective TC. Some of the highlights of the individual TC activities include:

- **Glasses for Medicine and Biotechnology (TC04)**
 - Participation in the EFONGA meeting in Brig, Switzerland in May 2008
 - Business meeting at the World Biomaterials Congress in Amsterdam in May 2008
 - Established protocols for **setting standards for the definition of bioactivity** and for developing a cell culture test to compare different bioglass compositions
 - Made progress in writing and editing a collaborative textbook on biomaterials
- **Nuclear and Hazardous Waste Vitrification (TC05)**
 - Met at the MS&T meeting in Pittsburgh, PA, USA in October 2008 and organized a forum on Waste Glass Leach Testing and Performance Modeling
 - Established protocols for **round-robin testing of melt liquidus temperatures**
 - Developed technical program for the ICG annual meeting in Vancouver, BC, Canada in June 2009
- **Glass for Optoelectronics (TC20)**
 - Met at the International Conferences on Optical, Optoelectronic and Photonic Materials and Applications in Edmonton, Canada in July 2008
 - Developed technical program for the ICG annual meeting in Vancouver, BC, Canada in June 2009
 - Organized and contributed **to a special issue** of the *Journal of the Ceramic Society of Japan* on "Glass and Ceramic Materials for Photonic Technology"

There are overlapping research interests between the TC's in this research cluster and with those in other, more traditional TC's, that could be the focus of future activities. For example, understanding the characteristics of glass melts is of great interest to TC05, as it is to many of the TC's in the **Glass Production Cluster**. The **interactions of glass surfaces with aqueous environments** is of particular concern to the members of TC04 and TC05, and both groups could benefit from closer ties with members of "Chemical Durability and Analysis" (TC02) and "Glass Surface Diagnostics" (TC19). Issues of interest to the members of TC20 overlap with those in several other groups, including "Nanostructured Glass" (TC16) and "Optical Properties of Glass" (TC10).

2.5 Information, Communication, Education, History

Coordinator: J M Parker

*As other parts of this Annual Report demonstrate, the ICG is a vital player within the glass community, bringing together scientists and technologists from Industry, Academia and Research Institutes to share, discuss and solve common issues. This happens within its technical committee structure and via the conferences and congresses it sponsors. **Effective communications and information systems are needed** to ensure that, on the one hand, the outcome of these deliberations enrich the wider community and that, on the other, the best workers are attracted to participate in these activities. TC01 and TC23 are particularly involved in these roles although all those within the ICG also play their part, particularly the Management Board, Steering Committee, CTC and the TC chairs.*

Specifically TC01 is charged with maintaining a record of the CTC activities by minuting the meetings it holds. A record of TC activity is produced in the form of an Annual Report by the CTC Chair who has introduced major improvements in the quality and hence the value of this document. Much of this information is also published on the ICG web site which also reports newsworthy developments as they happen. The importance of the latter media in communications is demonstrated by the rising traffic experienced by the site – a **sixfold increase in downloads over the previous thirty months**. The maintenance of a record of ICG committee members, together with a leaflet listing key officers with their contact details are also seen as key activities. Together with TC23, a start has been made on the database of Universities involved in teaching Glass. For the future more support needs to be given to TCs to assist them in developing their own web sites.

This year the EFONGA project was extended from June 2008 to May 2009 and has stimulated a number of ICG activities in its closing stages. These included a **road-mapping exercise** that started last year in Strasbourg with the support of the German Research Council but reached a climax in Brig, Switzerland in a very effective conference organised by TC18 and TC06. The success of this event has spawned several similar workshops due to take place in the next few months. Specifically TC01 has assisted in publicising these activities on the web and, jointly with TC23, is running a workshop for young scientists in 2009. In addition support has been given to teaching activities organised by the DGG and the SGT over the last year.

From such a base, this cluster has also taken on the role of publicising those attributes of glass which can make a major contribution to solving the wider issues facing society: e.g. **sustainability and global warming**. The newly named TC12 (Glass for a Sustainable Society) is developing this role on an international scale by aiming to communicate the positive aspects of glass products to all stakeholders, especially those in a position to influence national policy. The committee membership is growing and has met twice this year. Committee members have made significant contributions to a flat glass workshop organised by “Glass For Europe” in Brussels in October and at the GMIC parallel session to the Glass Problems Conference in November. Two presentations have also been made at the Energy Intensive Industry Conference in Brussels on “carbon leakage” in November.

Another central theme within this cluster is that of **History and Art**. The purpose of TC17, unchanged since its inception in 1982, is to bring together glass scientists, archaeologists, museum curators, and conservators to discuss research on early glass and glassmaking, and on the conservation of historical glass objects. It also aims to stimulate and encourages glass scientists and historians in developing countries. Ordinarily, TC17 meets only at the International Congresses and centers its programs on the research and glass problems of the regions where the Congresses are held; the next 18 months will see it developing a programme for ICGXXIII in Brazil.

The future for the glass community holds many exciting challenges. At one extreme these include the top-heavy age structure of the workforce in the glass industry in many developed countries that will require an increasing output from academia of enthusiastic, bright students educated in areas appropriate to the needs of the glass industry. At another extreme they involve a full, informed analysis of the positive roles that glass can play in a society where energy and raw materials are diminishing resources. For the ICG to play its role in solving these challenges requires the **maintenance of communication systems** that allows the ICG to operate efficiently, and its participants to develop clear insights into the most effective routes to achieving their aspirations.

3 Organizational issues

The following table depicts the current situation (Dec. 2008) for members of the CTC and chairs of the TCs.

CTC/Coordinator/ TC	Name	2007	2008	2009	2010	2011	2012	2013
CTC-chair	K. Bange	1st TE		2nd TE				
CTC-Vice Chair	R. Vacher		1st TE					
CTC-Secretary	J. Parker							
CTC	R. Beerkens	1st TE		2nd TE				
CTC	G. Albayrak			1st TE		2nd TE		
CTC	R. Brow	Start			1st TE		2nd TE	
CTC	J. Qiu	Start			1st TE		2nd TE	
CTC	J. Matsuoka	Start			1st TE		2nd TE	
Information	J. Parker							
Basics & Properties	R. Vacher							
Interfaces	NN							
Melting	R. Beerkens							
New Applications	D. Brow							
TC01	J. Parker				1st TE			
TC02	D Brochodt			1st TE				
TC03	A. Wright	2nd TE			3rd TE			
TC04	A. Clare/W. Höland (acting)			2nd TE			3rd TE	
TC05	J. Marra			1st TE			2nd TE	
TC06	J. Varner			3rd TE				
TC07	E. Zanotto	1st TE			2nd TE			3rd TE
TC08	L. Wondraczek		Start			1st TE		
TC09	M. Ciccotti		Start			1st TE		
TC10	C. Anderson			2nd TE			3rd TE	
TC11	M Dunkl		Start			1st TE		
TC12	J. Stockdale		Start			1st TE		
TC13	G. van Marcke	1st TE			2nd TE			3rd TE
TC14	D. Koepsel		1st TE			2nd TE		
TC15	W. Linz			2nd TE			3rd TE	
TC16	R. Almeida	Start			1st TE			2nd TE
TC17	S. Koob	1st TE			2nd TE			3rd TE
TC18	R. Beerkens (acting)		3rd TE		1st TE			2nd TE
TC19	V. Rupertus			2nd TE			3rd TE	
TC20	S. Tanabe		2nd TE			3rd TE		
TC21	E. Muijsenberg		Start			1st TE		
TC23	R. Conradt	Start			1st TE			2nd TE
TC24	K. Sanderson		Start			1st TE		
TC25	C. Berndhäuser			3rd TE				

In 2008 **three new Technical Committees** had been installed which are:

- “Glass Transition” (TC08)
- “Nanomechanics” (TC09)
- “Glass for a Sustainable Society” (TC12)

The following 6 chairs started their **first 3-year term** in 2008:

- Lothar Wondraczek (TC08)
- Matteo Ciccotti (TC09)
- Michael Dunkl (TC11)
- John Stockdale (TC12)

- Erik Muijsenberg (TC21)
- Kevin Sanderson (TC24)

The **second term** started in 2008 for:

- René Vacher (CTC)
- Detlef Köpsel (TC14)

The **third term** started in 2008 for:

- Setsuhisa Tanabe

In 2008 we gratefully **acknowledge** the very valuable contribution of:

- Ruud Beerkens for nine years work as the chair of TC18, his ongoing actions as a CTC member and coordinator of the R&D activity field “Glass melting”; he was one of the initiators and organizers of the Brig meeting.
- Wolfram Höland, who was very active as acting chair of TC04 and vice chair of TC07; he was one of the initiators and organizers of the Brig meeting.
- Lale Önsel for nine years work as the chair of TC21
- Karel Spee for eight years work as the chair of TC24

For 2009 **decisions** on the following persons/functions have to be prepared:

- Klaus Bange will finish his second term as the CTC chair and will stop this activity
- Ruud Beerkens will finish the second term as a CTC member
- Gülcin Albayrak will finish the first term as a CTC member
- Dominique Brochot will end the first term as TC02 chair
- Alix Clare will end the second term as TC04 chair
- Jim Marra will end the first term as TC05 chair
- Jim Varner will end the third term as TC06 chair
- Charles Anderson will end the second term as TC10 chair
- Wilfrid Linz will end the second term as TC15 chair
- Volker Rupertus will end the second term as TC19 chair
- Christoph Berndhäuser will end the third term as TC25 chair
- In 2009 successors have to be selected and installed for Klaus Bange, Ruud Beerkens, Jim Varner and Christoph Berndhäuser.

For several years the ICG travel budget has been significantly under-spent. Therefore no table of grants to individual TCs will be published in the future. For 2009 the budget will be spent by allocating **funds** to

- activities which **increase the quality of the work in the ICG**
- the production of **high quality ICG reports**
- the production of ICG PR material.

All TC chairs can apply for funding by submission of a list clearly describing their planned activities and the deliverables. The decisions will be made in the monthly teleco of the CTC. Additional funding is available for EFONGA activity up to May 2009.

4 Activities of the Technical Committees in Detail

4.1 R&D Activity Field "Basics & Properties"

4.1.1 BASIC GLASS SCIENCE (TC03)

Chairman:	Adrian C. Wright, Univ. Reading, U.K.
Vice-Chairs:	Akira Takada, Asahi Glass, Japan Josef Zwanziger, Dalhousie Univ., Canada
Secretary:	Natalia M. Vedishcheva, Inst. Silicate Chem., Russia
Members:	Rui Almeida, Inst. Superior Técnico, Lisboa, Portugal Alastair N Cormack, NYS College of Ceramics, USA Doris Ehrt, Otto-Schott-Institut, Germany Giuseppe Dalba, Univ. Trento, Italy Steven A. Feller, Coe College, USA Ulrich Fotheringham, Schott Glas, Germany Ondrej Gedeon, Inst. Chem. Technol., Czech Repub. Efstratios I. Kamitsos, Nat. Hellenic Res. Found., Greece Marek Liška, Inst. Inorg. Chem., Slovak Repub. Qiming Liu, Wuhan University of Technology, China Oleg Mazurin, Thermex, Russia I. Yu. Mikhailenko, Chem. Technological Inst., Russia Francisco Muñoz, Instituto de Cerámica y Vidrio, Spain Hiromichi Takebe, Kyushu University, Japan René Vacher, Univ. Montpellier, France Lothar Wondraczek, Corning Europe, France Edgar Canotto, Fed. Univ. São Carlos, Brazil

SUMMARY

- Two TC03 **Business Meetings** were held during 2008, the first on Sunday June 22 at the 9th ESG Conference (Trenčín, Slovakia), and the second on Tuesday August 19 at the 6th International Conference on Borate Glasses, Crystals & Melts (Himeji, Japan). The Russian Commission on Glass has nominated Dr. I. Yu Mikhailenko of the Russian Chemical Technological Institute, Moscow, for membership of TC03.
- Following the publication of Oleg Mazurin's paper concerning the deterioration in the **reliability of published glass property data**, a letter has been sent to the editors of relevant journals highlighting the problem and urging them to review their refereeing procedure.
- The samples for the **NMR borosilicate "round-robin"** test have been distributed to the participating laboratories.
- Four of the papers from the **Evgenii A. Porai-Koshits 100th Anniversary Symposium**, held during the XXI International Congress on Glass, have now been published in the *European Journal of Glass Science and Technology*.
- A joint session on **Structural Aspects of Glass Fracture** with TC06 was included in the MSE 2008 Symposium in Nürnberg, and TC03 will organise a session on the *Structural Basis of Glass Properties* at the 8th PacRim and ICG Annual Meeting in Vancouver.

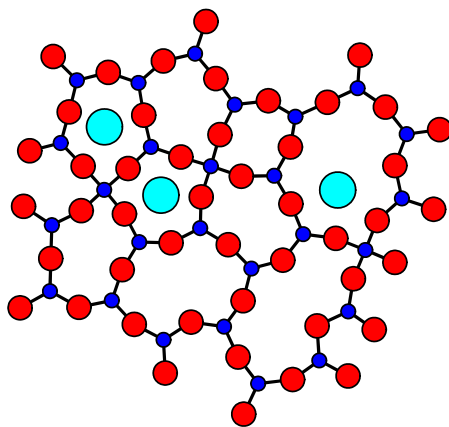


Fig. 4.1.1.1 The structure of sodium borate glass, after Biscoe & Warren [J. Amer. Ceram. Soc. 21 (1938), 287.].

PLANS FOR 2008 AND DELIVERABLES

- Appoint a Vice-Chair for North America.
- Hold Business Meetings at the 9th ESG Conference and ICG Annual Meeting (Trenčín, Slovakia; June 22 – 26) and at the 6th International Conference on Borate Glasses, Crystals & Melts (Himeji, Japan; August 18 – 22).
- Contact the relevant journal editors concerning the reliability of glass property data and encourage them to instigate refereeing guidelines that emphasise the importance of sample preparation and accurate characterization.
- Continue the assembling of a set of standard samples and initiate cutting/powdering, as appropriate for the various experimental techniques.
- Further work on a "round-robin" test for NMR spectroscopy.
- Further work on a "round-robin" test for computer simulation and on the comparison of models with experiment.
- Finish editing the proceedings volume for the Evgenii A. Porai-Koshits 100th Anniversary Symposium.

ACTIVITIES in 2008

As indicated above two Business Meetings were held during 2008, the first being on Sunday June 22, in Trenčín, Slovakia at the 9th ESG Conference. The second meeting was arranged at the 6th International Conference on Borate Glasses, Crystals & Melts (Himeji, Japan) and took place on Tuesday August

19. The second meeting was held partly to update those members who were not present at the earlier meeting in Trenčín, and hence there was some overlap between the two meetings.

1. New Member

The Russian Commission on Glass has nominated Dr. I. Yu Mikhailenko of the Russian Chemical Technological Institute, Moscow, for membership of TC03, but so far Dr. Mikhailenko has failed to respond to any e-mail message.

2. Appointment of a Vice-Chair for North America

Now that Canada has rejoined the ICG, Joe Zwanziger was appointed as the Vice Chair representing North America.

3. Reliability of Glass Property Data

As indicated in the previous TC03 Annual Report, the 2007 Business Meeting was almost entirely dedicated to a discussion of the steady degradation in the accuracy of glass property data reported in the literature, led by Oleg Mazurin. Oleg Mazurin's presentation

was subsequently published in the *European Journal of Glass Science and Technology Part A, Glass Technology*, entitled *What can the International Glass Community do to Prevent Further Deterioration of the Reliability of Published Glass Property Data?*

The reliability of glass property data remained an important agenda item for the 2008 Business Meetings, during which a letter was composed to send to the editor(s) of those journals that Oleg Mazurin had identified as having published two or more papers having gross errors during the period 1994-2007. A gross error implies a published property value that deviates from the most probable value, for a given composition, by more than 3 standard deviations. The most probable value is the average value, normally determined from data published in more than 5 sources. The journals concerned are summarized in Table 4.1.1.1.

The letter was subsequently sent to all of the editors of the journals in Table 1, together with a copy of the table, and TC03's notes on the *Decline of Data Quality and Sample Characterization*. Initially, only one reply was received, from *Fizika i Khimiya Stekla*, but a subsequent reminder elicited acknowledgements from four other journals. To date, only editors of the following journals have responded:

- Fizika i Khimiya Stekla (Glass Physics and Chemistry),
- Nuclear Instruments and Methods B,
- Special Issues Materials Science and Engineering A,
- European Journal of Glass Science and Technology A (Glass Technology) and B(Physics and Chemistry of Glasses).

It is therefore unclear as to the priority that the remaining journals place on the quality of their editorial and refereeing procedures. To increase awareness of the problem, TC03 recommends that those assembling databases, etc., adopt a policy of "naming and shaming" those authors and journals that publish data that are grossly inaccurate. It would also be helpful to compile a list of reliable authors/papers.

Journal	Gross Errors	Total
Bulletin of Materials Science	3	36
Egyptian Journal of Solids	4	5
Fizika i Khimiya Stekla	2	210
Glass Technology	2	74
Journal of Alloys and Compounds	3	77
Journal of Applied Physics	3	50
Journal of Materials Science	7	168
Journal of Non-Crystalline Solids	23	1284
Journal of Optoelectronics and Advanced Materials	3	63
Journal of Physics and Chemistry of Solids	2	94
Journal of Physics D: Applied Physics	2	13
Journal of the American Ceramic Society	2	133
Journal of the Ceramic Society of Japan	3	102
Journal of the European Ceramic Society	2	78
Materials Chemistry and Physics	8	120
Materials Letters	2	90
Materials Research Bulletin	4	60
Materials Science and Engineering	4	60
Neorganicheskie Materialy	3	46
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms	2	12
Physica B: Condensed Matter	4	96
Physica Status Solidi A	2	27
Physical Review B	2	53
Physics and Chemistry of Glasses	17	405
European Journal of Glass Science and Technology Part B	3	40
Physics and Chemistry of Glasses		

Table 4.1.1.1. Number of papers having gross errors.

The role of journal editors and referees is crucial, especially given the attitude of some authors, who are only interested in obtaining another publication and are unconcerned as to the accuracy of their data, or whether they are of use to other scientists. It is extremely important that both editors and referees insist that the sample synthesis and heat treatment are carefully and fully specified and that the resulting samples are properly characterised. With so many papers being published, there is a great temptation for editors to try to shorten manuscripts, but this must be resisted in respect of the details of the sample preparation and characterisation, and those of the experimental techniques employed. Data for samples that are not adequately characterised are of no value and those for samples that are not what is claimed damage the accumulated literature databank of glass properties. As an absolute minimum, glass property data obtained for sample characterisation **must** be compared to those already in the literature or available in databases such as SciGlass.

4. Student Training

One of the reasons suggested for the decline in data quality discussed in the previous section is the fact that supervisors have become increasingly busy (e.g. grant applications, reports, etc.), and do not have adequate time to devote to training Ph.D. students and young researchers and to teaching good experimental practice. An e-mail message was therefore sent to the Chairman of TC23 (*Education and Training in Glass Science and Engineering*) suggesting that TC23 considers recommendations as to the best way to ensure that adequate training in sample preparation and characterization is included in all of the relevant courses. TC03 would be pleased to collaborate with TC23 in the development of an appropriate course module.

5. NMR Sodium Borosilicate "Round-Robin" Test

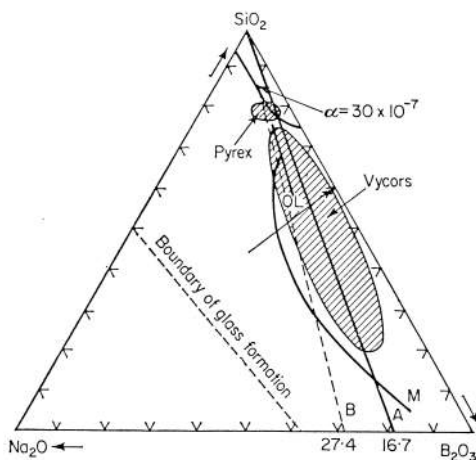


Figure 4.1.1.2. Phase diagram for the sodium borosilicate system.

Eight samples of each of four sodium borosilicate glasses for the NMR borosilicate "round-robin" test have been prepared and cut at the Otto Schott Institut, University of Jena, and sent to Joe Zwanziger for distribution to the laboratories involved. The four glasses have also been characterized at the Otto Schott Institut, and their compositions are summarised in Table 4.1.1.2, together with their glass transition temperatures, T_g , mass densities and thermal expansion coefficients, $\alpha_{100-300^\circ\text{C}}$.

Sample	Composition (mol.%)			T_g ($^\circ\text{C}$)	Density (g/cm^3)	$\alpha_{100-300^\circ\text{C}}$ ($10^{-7}/\text{K}$)
	Na_2O	B_2O_3	SiO_2			
NBS-A	12.5	62.5	25.0	415 ± 3	2.18 ± 0.01	85 ± 2
NBS-B	3.0	48.5	48.5	380	2.04	64
NBS-C	15.0	42.5	42.5	490	2.31	87
NBS-D	6.5	33.5	60.0	445	2.15	53

Table 4.1.1.2 Standard Sodium Borosilicate Glasses.

All four glasses exhibit subliquidus phase separation, as may be seen from the electron micrographs for samples NBS-A and NBS-D in Figs 4.1.1.3 and 4.1.1.4. In the SciGlass Database, the property measurements in Table 4.1.1.2 will be identified as belonging to TC03 standard glasses. Other properties in the SciGlass Database will include their refractive index and Abbe number.

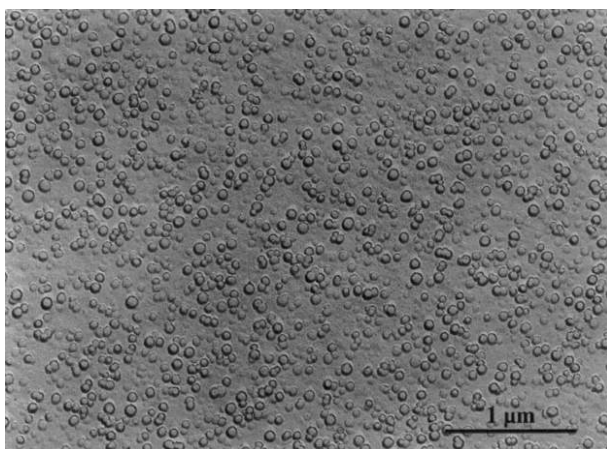


Figure 4.1.1.3. Electron micrograph of sample NBS-A, showing SiO₂-rich droplets in a sodium-borate-rich matrix (Otto Schott Institut).

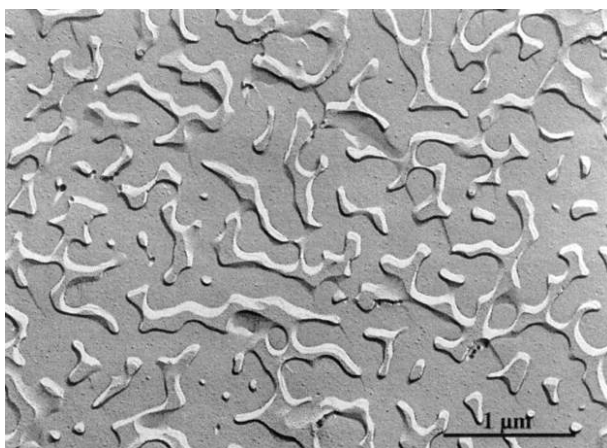


Figure 4.1.1.4. Connected phases in sample NBS-D (Otto Schott Institut).

Samples have now been distributed to 8 NMR research groups world wide. Preliminary NMR measurements have been performed in Joe Zwanziger's laboratory, using the NMR techniques summarised in Table 4.1.1.3, and thermodynamic modelling has been carried out by Natalia Vedishcheva, using the model of associated solutions. Some of the results from the thermodynamic modelling are given in Table 4.1.1.4, including the mass density and the fraction of 4-fold co-ordinated boron atoms, x_4 . The distribution of Si \emptyset_n O $_{4n}^{n4}$ tetrahedral species, denoted Q n , where n is the number of bridging oxygen atoms, \emptyset , is also shown. However, since all of the glasses have an excess of B₂O₃ over that required to balance the Na⁺ ions, the latter are mainly associated with the more acidic oxide (B₂O₃) and the SiO₂ is almost entirely present as Q⁴ species, as may be seen from Table 4.1.1.4.

Experiments	NMR facilities	Rotor/ Spinning speed	Pulse	Relaxation
¹¹ B MAS	Bruker-700	2.5-mm/20 kHz	< 15 °	10-15 s
²⁹ Si MAS	Bruker-400	7-mm / 5 kHz	30 °	40-90 s
¹¹ Na MAS	Bruker-400	4-mm / 12 kHz	< 15 °	0.5-1 s
¹¹ B MOMAS	Bruker-700	2.5-mm /25 kHz	3Q/Z-filter	10-15 s
¹¹ Na MQMAS	Bruker-700	2.5-mm / 20 kHz	3Q/Z-filter	0.5-1 s

Table 4.1.1.3 NMR facilities and experimental parameters used for the measurements performed in Joe Zwanziger's Laboratory.

Sample	Density (g/cm ³)	x_4	Q ² (%)	Q ³ (%)	Q ⁴ (%)
NBS-A	2.158	0.201	0.0	0.0	100.0
NBS-B	2.053	0.062	0.0	0.0	100.0
NBS-C	2.302	0.349	0.0	0.4	99.6
NBS-D	2.174	0.193	0.0	0.0	100.0

Table 4.1.1.4 Results from the thermodynamic modelling.

6. Possible Computer Simulation "Round Robin" Test

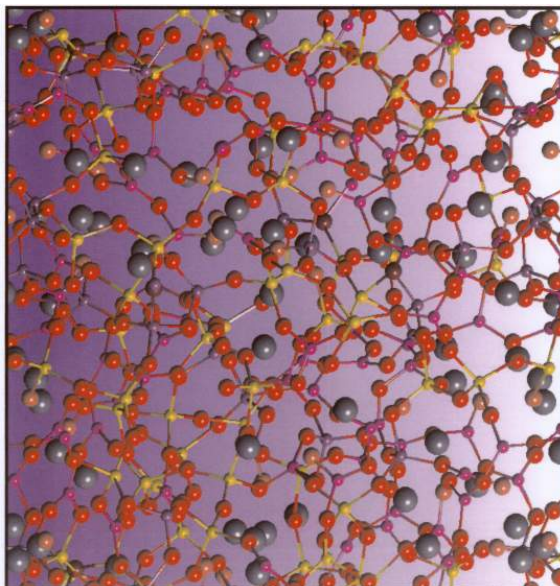


Figure 4.1.1.5 Molecular dynamics simulation of a sodium borosilicate glass.

TC03 is interested in the possibility of a "round-robin" test to evaluate the various computer simulation codes currently used to investigate the vitreous state. Although empirical (BKS) potentials are being replaced by non-empirical *ab initio* or density functional methods, a limited number of scientists have access to *ab initio* methods, which require long computational times. Hence, when specifying a "standard" simulation for a "round-robin" test, it would be better to base this on a classical potential, using BKS parameters obtained from an *ab initio* hybrid simulation. It would be best to start with pure vitreous silica, using a BKS potential. Guidelines would also be given concerning the generation of the initial structure. The comparison with experiment should include both structure (*via* diffraction studies) and elastic properties.

7. Porai-Koshits Symposium



Figure 4.1.1.6 Professor Evgenii A. Porai-Koshits (1907-1999) with a wide-angle X-ray diffractometer used for phase analysis (photograph taken during the early 1950s).

The *Evgenii A. Porai-Koshits 100th Anniversary Symposium* was held during the morning and afternoon of 5th July 2007 at the *XXI International Congress on Glass* in Strasbourg, and it was originally intended to collect the papers from the Symposium into a monograph, both as a memorial to Evgenii Porai-Koshits and as a record of the status of glass structure research at the beginning of the 21st century. However, a number of authors failed to submit a manuscript and so those that were received have been published in the June 2008 issue (Vol. 49) of the *European Journal of Glass Science and Technology Part B, Physics and Chemistry of Glasses*, where they are identified as papers from the Symposium. The full references are given below, whilst the titles of the original presentations are as follows:

- **I. Gutzow:** *E. A. Porai-Koshits: Homophase and Heterophase Fluctuations, Liquid Immiscibility and Crystallization in Silicate Melts and the Structural and Thermodynamic Nature of Glasses.*
- **A. Takada & A.N. Cormack:** *Computer Simulation Models of Glass Structure.*
- **G. Dalba & N.D. Afify:** *X-ray Absorption Spectroscopy Studies of Glass Structure.*
- E.I. Kamitsos: ***Glass Structure by Vibrational Spectroscopy.***

An earlier version of the biography of Evgenii Porai-Koshits presented at the Symposium by N.M. Vedishcheva has already been published in the proceedings of the 3rd *International Conference on Borate Glasses, Crystals & Melts: Structure and Applications* (see below). In addition, the Society of Glass Technology has expressed an interest in publishing A.C. Wright's presentation, *The Constitution of Glasses: A Brief History*, as a short monograph and this is in preparation.

8. Conference Activities

A joint session on *Structural Aspects of Glass Fracture* with TC06 was included in the MSE 2008 Symposium in Nurnberg, and TC03 is organising a session on the *Structural Basis of Glass Properties* at the 8th PacRim and ICG Annual Meeting in Vancouver.

9. Possible Database for Borate Glass NMR Data

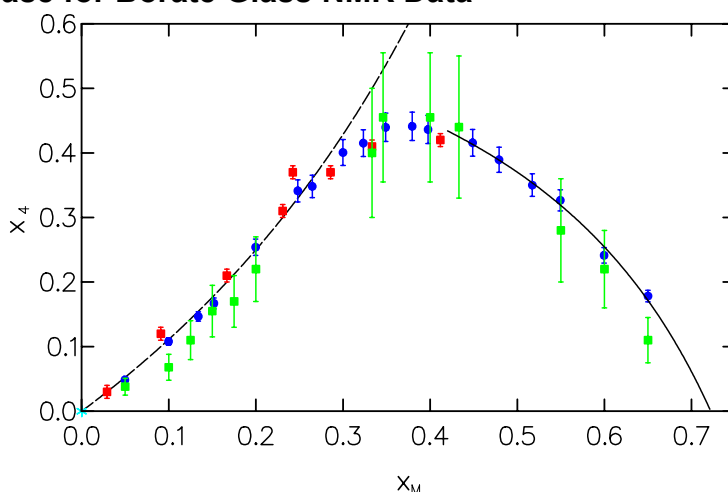


Figure 4.1.1.7 The fraction of the boron atoms in $\text{Li}_2\text{O-B}_2\text{O}_3$ glasses that are 4-fold co-ordinated. Blue, Jellison *et al.* [*Phys. Chem. Glasses* 19 (1978), 52.]; red, Kroeker *et al.* [*Eur. J. Glass Sci. Technol. B. Phys. Chem. Glasses* 47 (2006), 393.] and green, Bray & O'Keefe [*Phys. Chem. Glasses* 4 (1963), 37.]. Dashed line, $x_M/(1 - x_M)$ and solid line, fit to high x_M data (Jellison *et al.*)

During the Business Meeting held in Himeji, at the 6th *International Conference on Borate Glasses, Crystals & Melts*, the possibility was discussed of compiling a database containing NMR data, initially for borate glasses and to include parameters such as the fraction of the boron atoms that are 4-fold co-ordinated. This would greatly aid the comparison of structural models and computer simulation studies with experiment. The numerical data in question can be difficult to locate, since they are only available in Ph.D. theses, such as those of the students of the late P.J. Bray, and/or are distributed throughout many different journals.

PLANS FOR 2009 AND DELIVERABLES

- Hold a Business Meeting at an appropriate conference.
- Contact those journal editors who have not yet responded to the letter concerning the reliability of glass property data and encourage them again to instigate refereeing guidelines that emphasise the importance of sample preparation and accurate characterisation.
- Analysis of data from the "round-robin" test for NMR spectroscopy.
- Further work on a "round-robin" test for computer simulation and on the comparison of models with experiment.
- Organise a session on the *Structural Basis of Glass Properties* at the 8th PacRim and ICG Annual Meeting in Vancouver.
- Feasibility study of the establishment of a database for NMR data initially on borate glasses and later to include other glass-forming systems.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- The minutes of the 2008 TC 3 meetings in Trenčín and Himeji have been circulated to TC03 members and are available from the Chairman <a.c.wright@reading.ac.uk>.
- O.V. Mazurin, What can the International Glass Community do to Prevent Further Deterioration of the Reliability of Published Glass Property Data?, *Eur. J. Glass Sci. Technol. A Glass Technol.* 48 (2007), 297-304.
- E.I. Kamitsos, M. Dussauze & C.P.E. Varsamis, Structure of Glass Thin Films by Infrared Techniques, *Eur. J. Glass Sci. Technol. B Phys. Chem. Glasses* 49 (2008), 118-126.
- A. Takada & A.N. Cormack, Computer Simulation Models of Glass Structure, *Eur. J. Glass Sci. Technol. B Phys. Chem. Glasses* 49 (2008), 127-135.
- I. Gutzow, J.W.P. Schmelzer & S. Todorova, Frozen-in Fluctuations, Immiscibility and Crystallisation in Oxide Melts and the Structural and Thermodynamic Nature of Glasses, *Eur. J. Glass Sci. Technol. B Phys. Chem. Glasses* 49 (2008), 136-148.
- G. Dalba, N.D. Afify & F. Rocca, X-Ray Absorption Spectroscopy Studies of Glass Structure, *Eur. J. Glass Sci. Technol. B Phys. Chem. Glasses* 49 (2008), 149-159.
- N.M. Vedishcheva and A.C. Wright Evgenii Alexandrovich Porai-Koshits: Glass Scientist Extraordinaire, in: "Borate Glasses, Crystals & Melts: Structure & Applications", Eds Y.B. Dimitriev and A.C. Wright (Soc. Glass Technol., Sheffield, 2001), xvii-xxxi.

4.1.2 GLASS TRANSITION (TC08)

Chairman: Lothar Wondraczek, Univ. Erlangen-Nürnberg, Germany
Vice-Chairs: Sabyasachi Sen, Univ. California at Davis, USA
Yuanzheng Yue, Aalborg Univ., Denmark
Members: Isac Avramov, Bulgarian Academy of Science
Victor N. Bogdanov, St. Petersburg State University
Ulrich Fotheringham, Schott AG
Neville Greaves, University of Wales
Prabhat K. Gupta, Ohio State University
Andreas Heuer, University of Münster
Ian Hodge, RIT
Pierre Lucas, University of Arizona
Jun Matsuoka, Shiga University
John Mauro, Corning, Inc.
Gregory B. McKenna, Texas Tech University
Paul F. McMillan, University College
Sergei V. Nemilov, St. Petersburg State University
Kristine Niss, Roskilde University
Benoit Rufflé, University of Montpellier 2
Srikanth Sastry, JNCASR
Juern W. P. Schmelzer, University of Rostock

SUMMARY

The TC “Glass Transition” (TC08) was founded in 2008 and officially approved by CTC, Steering Committee and Council on June 24, 2008 during the ESG conference in Trenčín. Beyond the process of its creation, major activities centered around the topic “Glass and Entropy”. Following intense discussions that started in 2007 during the International Congress on Glass in Strasbourg, a high-level symposium, i.e. the “**1st International Workshop on Glass and Entropy**” was organized by the TC and took place over the course of three days as a satellite event of the Trenčín conference. This workshop was sponsored by Corning SAS, France, and endorsed by the Slovak Glass Society. The success of this workshop is reflected in the special issue “Glass and Entropy” of the Journal of Non-Crystalline Solids, a collection of 24 of the presented papers, that is in print at Elsevier. In parallel, preparation of the 2nd workshop is fast progressing, building on the results of Trenčín and focussing on experimental approaches to solve some of the controversy. The “**2nd International Workshop on Glass and Entropy**” was included into the EFONGA project. Noteworthy, a second topic started to enter the interest of TC08, i.e. the phenomenon of polyamorphism, and the 2nd workshop will cover this topic and its relation to entropy-related questions as well.

ACTIVITIES in 2008

TC-life of 2008 occurred in three phases:

- (a) Creation of the TC, including the definition of the TCs mission, first fields of interest, identification of potential members, and presentations to CTC.
- (b) Preparation and conduction of the international workshop on glass and entropy as the major event in 2008 (see below), and
- (c) Follow-up actions of the Entropy-workshop, including preparation of the proceedings book on “Glass and Entropy” as well as the second workshop.



Fig. 4.1.2.1: Photograph of attendees of the 1st International Workshop on Glass and Entropy (group incomplete).

(a) In a first whitepaper, the **mission of TC08** was formulated as follows:

“The Technical Committee “Glass Transition” will be an interdisciplinary network of people with interest, knowledge and experience in fundamental and applied aspects of the glass transition and related phenomena. It will act as a discussion platform, plan and conduct joint research efforts and organize symposia and workshops. For that, it will work closely with other TCs, particularly within the “Basics & Properties” cluster. In transferring its knowledge to other TCs and the public, it will contribute to a broader understanding of the glass transition.”

Phase (a) was completed with the official foundation of TC08 on June 24, 2008.

(b) **The workshop** comprised 36 original talks from international experts (ref. Figs. 4.1.2.1 - 3). These presentations covered the following major topics:

- The definition of non-equilibrium entropy;
- The 3rd theorem of thermodynamics and the Kauzmann Paradox;
- The entropy of glass;
- The breakdown of ergodicity at the glass transition and its impact on entropy; and
- The role of entropy in governing the viscosity and relaxation behavior of glasses and supercooled liquids.

Presentations were accompanied by intense discussions which were one of the main objectives of the meeting. The majority of the presenting authors delivered full papers for publication in a special issue of the Journal of Non-Crystalline Solids. These papers underwent a peer review process, involving at least 2 reviewers per paper. The review process was completed in January 2009, and 24 papers are now in print at Elsevier. The program of this workshop is shown in Figure 4.1.2.3.

The lively workshop was considered a big success by all attendees. Although no controversy could be solved, it presented the very first opportunity to unite some of the world’s leading scientists on a single event. Its main objective, setting a state-of-the-art with respect to interdisciplinary views at the problems related to glass and entropy, could therefore be attained. It made clear the need for a long-term communication effort and, eventually, the design of **joint experiments** if some consensus were to be reached. Figure 4.1.2.2 presents the photograph of a slide shown by Jeppe Dyre (DK) that summarizes

some of the major questions (challenges to the classical view) that were discussed by almost all speakers. **Further actions will need to refine these questions (What is the controversy about?), to specify a common nomenclature (e.g. characteristic temperatures, definition of entropy, etc.) and to design experiments that will be accepted as decisive by the broad community.**

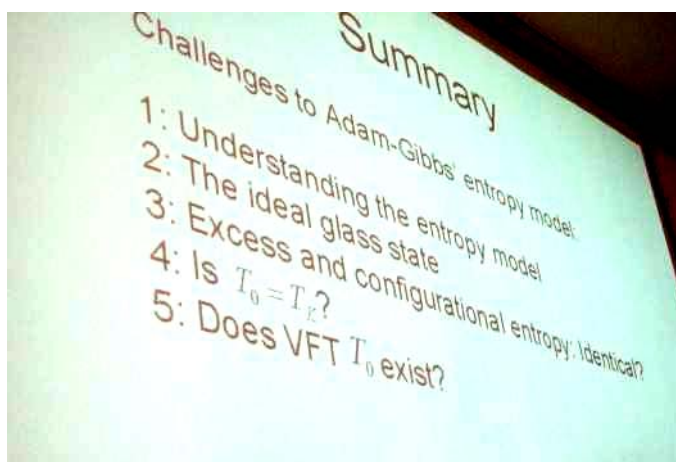


Fig. 4.1.2.2: Photograph of a slide shown by Jeppe Dyre (DK) during his presentation “A critique of the entropy model”, summarizing in a representative way major questions that were raised during the workshop.

	<i>Wednesday, June 25, 2008</i>
8:30-8:40	<i>Opening adress</i>
8:40-9:20	THE THIRD LAW OF THERMODYNAMICS AND THE ZERO-POINT ENTROPY OF GLASSES: HISTORY AND NEW DEVELOPMENTS Ivan S. Gutzow (Institute of Physics and Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria)
9:20-10:00	ENTROPY OF GLASS Prabhat K. Gupta (Dept. of Mat. Sci. & Engin., Ohio State University, Columbus, OH, USA)
10:00-10:10	<i>Discussion</i>
10:10-10:30	<i>Coffee break</i>
10:30-10:50	CRITIQUES OF THE ENTROPY MODEL Jeppe Dyre ("Glass and time" - Danish National Research Foundation Centre for Viscous Liquid Dynamics, IMFUFA, Department of Sciences, Roskilde University, Roskilde, Denmark)
10:50-11:10	PHASES IN INNER EQUILIBRIUM, FROZEN-IN PHASES, AND ABSOLUTE ZERO ENTROPY Reinhard Conradt (Insitut für Gesteinshüttenkunde, RWTH Aachen, Aachen, Germany)
11:10-11:30	THE ZERO-TEMPERATURE ENTROPY OF GLASS: DEFINITION, DETERMINATION, AND SIGNIFICANCE FOR GLASS PROBLEMS LIKE AGING Ulrich Fotheringham (Schott AG, Mainz, Germany)
11:30-11:50	EQUILIBRIUM BEHAVIOR OF GLASS FORMING LIQUIDS: THERMODYNAMIC AND DYNAMIC FRAGILITIES AND THE KAUZMANN PARADOX UNRESOLVED Gregory B. McKenna (Dept. of Chemical Engineering, Texas Tech University, Lubbock, TX, USA)
11:50-12:10	<i>Discussion</i>
12:10-14:00	<i>Lunch break</i>
14:00-14:40	ZERO-POINT ENTROPY OF GLASSES AS PHYSICAL REALITY Sergei V. Nemilov (St.-Petersburg State University of Information Technologies, Mechanics, and Optics, St. Petersburg, Russia)
14:40-14:50	<i>Discussion</i>
14:50-15:10	ENTROPY AND THE KAUZMANN PARADOX IN POLY(α-METHYL STYRENE) AND POLY(α-METHYL STYRENE)/OLIGOMER BLENDS Sindee Simon (Department of Chemical Engineering, Texas Tech University, Lubbock, TX, USA)
15:10-15:30	LIGHT-INDUCED MATRIX SOFTENING IN NETWORK GLASSES Pierre Lucas (Dept. of Mat. Sci. and Engineering, University of Arizona, Tucson, AZ, USA)
15:30-16:00	<i>Discussion</i>
16:00-16:20	<i>Coffee break</i>
16:20-17:00	KINETICS OF VITRIFICATION AS A PROCESS OF ENTROPY FREEZING-IN AND ENTROPY PRODUCTION AND THE PRIGOGINE-DEFAY RATIO Jörn W. P. Schmelzer (Department of Physics, University of Rostock, Rostock, Germany)
17:00-17:20	THE THERMODYNAMIC SIGNIFICANCE OF ORDER PARAMETERS Roger Araujo (Corning, Inc., Corning, NY, USA)
17:20-17:40	GROWING LENGTH SCALES, CONFIGURATIONAL ENTROPY AND DYNAMICS IN GLASS FORMING LIQUIDS Srikanth Sastry (Theor. Sci. Unit, Jawaharlal Nehru Centre for Advanced Scientific Research Jakkur Campus, Bangalore, India)
17:30-19:00	<i>Discussion</i>
20:00	<i>Conference Dinner</i>

	Thursday, June 26, 2008
9:00-9:40	APPARENT ENTROPY, RESIDUAL ENTROPY, CAUSALITY, METASTABILITY, CONSTRAINTS, AND THE GLASS TRANSITION Howard Reiss (Dept. of Chem. & Biochem., Univ. of Calif. at L.A., Los Angeles, CA, USA)
9:40-9:50	<i>Discussion</i>
9:50-10:10	FREE ENERGY LANDSCAPE THEORY OF GLASS TRANSITION AND ENTROPY Takashi Odagaki (Department of Physics, Kyushu University, Fukuoka, Japan)
10:10-10:30	CONFIGURATIONAL ENTROPY AND RUGGED ENERGY LANDSCAPE: WHAT WE CAN LEARN FROM MEAN-FIELD THEORY OF GLASSES WITH BUILT-IN DISORDER Luca Leuzzi (INFN, National Research Council, Rome, Italy)
10:30-10:50	<i>Coffee break</i>
10:50-11:10	BROKEN ERGODICITY AND THE GLASS TRANSITION: ENTROPY, INFORMATION, AND THE ROLE OF THE OBSERVER John C. Mauro (Corning Incorporated, Corning, NY, USA)
11:10-11:30	NEW MODEL OF ENTROPY BY MOLECULAR DYNAMICS SIMULATION Akira Takada (Asahi Research Center, Asahi Glass Co., Ltd., Japan)
11:30-11:50	THE JAMMING LANDSCAPE FOR CONFINED HARD DISCS Richard Bowles (Department of Chemistry, University of Saskatchewan, Saskatoon, Canada)
11:50-12:10	<i>Discussion</i>
12:10-14:00	<i>Lunch break</i>
14:00-14:40	ENTROPY GOVERNS NOT ONLY THE STRUCTURAL RELAXATION BUT ALSO ITS PRECURSOR, THE JOHARI-GOLDSTEIN RELAXATION Kia Ngai (US Naval Research Laboratory, Washington, DC, USA)
14:40-14:50	<i>Discussion</i>
14:50-15:10	ENTROPY AND RELAXATION KINETICS OF GLASSES Pascal Richet (Institut de Physique du Globe de Paris, Paris, France)
15:10-15:30	IS THE VISCOUS SLOWING-DOWN CONTROLLED BY THE ELASTIC CONSTANTS? Kristine Niss ("Glass and time" - Danish National Research Foundation Centre for Viscous Liquid Dynamics, IMFUFA, Department of Sciences, Roskilde University, Roskilde, Denmark)
15:30-15:50	TOWARDS AN UNDERSTANDING OF THE TRANSPORT AND RELAXATION OF SUPERCOOLED LIQUIDS Andreas Heuer (Institute of Physical Chemistry, University of Münster, Germany)
15:50-16:00	<i>Discussion</i>
16:00-16:20	<i>Coffee break</i>
16:20-16:40	MECHANICAL RELAXATION IN GLASSES BELOW AND AT THE GLASS TRANSITION TEMPERATURE Benoit Rufflé (Lab. des Verres - CC069, Université de Montpellier II, Montpellier, France)
16:40-17:00	TEMPERATURE DEPENDENCE OF THE CONFIGURATIONAL ENTROPY OF A GLASS-FORMING LIQUID Yuanzheng Yue (Section of Chemistry, Aalborg University, Aalborg, Denmark)
17:00-17:20	MIXED ISOTOPE EFFECTS ON THE HEAT CAPACITY AND VISCOSITY OF BORATE GLASSES Jun Matsuoka (Dept. of Materials Science, University of Shiga Prefecture, Shiga, Japan)
17:20-18:00	<i>Discussion</i>
18:00-19:00	INTRODUCTION OF TCS (INTERNATIONAL COMMISSION ON GLASS) – RHEOLOGY AND RELAXATION PHENOMENA IN GLASSES
	Friday, June 27, 2008
9:00-9:40	CONFIGURATIONAL CONTRIBUTIONS TO DYNAMICAL HETEROGENEITY IN GLASS-FORMING LIQUIDS Peter H. Poole (Dept. of Phys., St. Francis Xavier University, Antigonish, Canada)
9:40-9:50	<i>Discussion</i>
9:50-10:10	DYNAMIC HETEROGENEITIES, COOPERATIVITY AND CONFIGURATIONAL ENTROPY IN GLASSFORMING LIQUIDS Gilles Tarjus (Laboratoire de Physique Théorique de la Matière Condensée, Paris, France)
10:10-10:30	FREQUENCY DEPENDENT SPECIFIC HEAT OF SILICA AND GERMANIA: A COMPUTER SIMULATION STUDY Jürgen Horbach (Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) in der Helmholtzgemeinschaft, Köln, Germany)
10:30-10:50	<i>Coffee break</i>
10:50-11:10	ZEOLITE COLLAPSE AND POLYAMORPHISM G. Neville Greaves (Inst. Math. & Phys. Sciences, University of Wales, Aberystwyth, UK)
11:10-11:30	DIFFUSION OF FOREIGN PARTICLES IN GLASS-FORMING MELTS Isak Avramov (Inst. of Phys. & Chem., Bulgarian Academy of Sciences, Sofia, Bulgaria)
11:30-11:50	RELATION BETWEEN CONFIGURATIONAL ENTROPY AND RELAXATION DYNAMICS OF GLASS-FORMING SYSTEMS UNDER VOLUME AND TEMPERATURE REDUCTION Simone Capaccioli (INFN-CRS SOFT, c/o Dipart. di Fisica, Università di Pisa, Pisa, Italy)
11:50-12:10	<i>Discussion</i>
12:10-14:00	<i>Lunch break</i>
14:00-14:40	STRUCTURAL CHANGES AFFECTING THE ENTROPY IN HIGH PRESSURE GLASSES AND LIQUIDS: FRAGILITY AND POLYAMORPHIC TRANSITIONS Paul F. McMillan (Department of Chemistry and Materials Chemistry Centre, University College London, London, UK)
14:40-14:50	<i>Discussion</i>
14:50-15:10	ENTROPIC RELAXATION IN LIQUIDS AND POLYMERS AND THE EXCESS ENTROPY ALONG THE GLASS TRANSITION LINE UNDER PRESSURE Christiane Alba-Simionesco (Laboratoire de Chimie Physique, Université de Paris-Sud, Orsay, France)
15:10-15:30	THE PRIGOGINE-DEFAY RATIO OF INORGANIC GLASSES: AN EXPERIMENTAL PERSPECTIVE Lothar Wondraczek (Corning European Technology Center, Corning SAS, Avon, France)
15:30-15:50	IN – SITU RELAXATION OF DENSIFIED GLASS NEAR T_G Bernard Champagnon (Laboratoire de Physico-Chimie des Matériaux Luminescents, Université Claude Bernard Lyon1, UMR 5620 CNRS, Villeurbanne, France)
15:50-16:10	ENTROPY OF GLASS-FORMING SYSTEMS WITH INTERNAL NEGATIVE PRESSURE Leonid Landa (Sci. & Technol. Center, Guardian Industries Corporation, Carleton, MI, USA)
15:50-16:30	<i>Final discussion and Closing remarks</i>
16:00-16:20	<i>Coffee break</i>

<i>Breaks, General</i>
<i>Invited talk</i>
<i>Opening talk</i>
<i>Keynote lecture</i>
<i>Discussion</i>

Fig. 4.1.2.3: Program of the workshop on Entropy

PLANS FOR 2009 AND DELIVERABLES

In 2009, TC08 will organize two major events. Deliverables are (a) the successful conduction of these events and (b) the preparation of follow-up actions:

- (1) The “2nd International Workshop on Glass and Entropy” that will take place over three days from April 22 to April 24, 2009 in Aberystwyth, UK. Figure 4.1.3.4 is a part of the call for contributions that was released in December 2008.



International Workshop
Glass & Entropy II



*Centre for Advanced Functional Materials & Devices, Institute of Mathematics & Physics,
Aberystwyth University, Wales, UK*

Wednesday 22 – Friday 24 April, 2009

Objective:

Having identified some topics of major interest and open questions at the first workshop, held in Trencin, Slovakia last summer, this 2nd International Workshop on **Glass & Entropy** will develop and expand the research remit in a series of six, thematic sessions and workshops at Aberystwyth.

In addition to a focusing on the zero point entropy of glasses, the Aberystwyth workshop will include calorimetry, computer simulations, liquid and glass structures at the extremes of pressure and temperature and the controversial phenomenon of polyamorphism reported in water and in a range of other diverse systems. The Workshop will be Gordon Conference in style encouraging discussion as much as dissemination.



Fig. 4.1.3.4: Call for papers for the “2nd International Workshop on Glass and Entropy”, released in December 2008

- (2) Within symposium A “Glass Science” of the 8th Pacific Rim Conference on Ceramic and Glass Technology, a session on “Glass formation and Relaxation Processes in Glasses”
 - The program of this session is already finalized and includes the following presentations (selection):
 - Two Factors Governing Fragility: Stretching Exponent and Configurational Entropy (J. Mauro)
 - Impact of Fragility on Enthalpy Relaxation in Glass (R. Loucks)
 - Modelling the Nonequilibrium Viscosity of Glass (D. Allan)
 - Structural Evolution in Al₂O₃-SiO₂ Liquids and Glasses (R. Weber)
 - Boson peak, structural homogeneity and relaxation of borosilicate glasses with different thermomechanical histories (L. Wondraczek)
 - Mechanical relaxation below and at the glass transition (B. Ruffle)
 - Molecular tumbling dynamics in supercooled glycerol: Effect of nano-confinement (S. Sen)
 - Excess of vibrational density of states in densified glasses (B. Champagnon)
 - Glass Formation and Effects of Temperature on Order/Disorder of Oxide Melt Structures (J. Stebbins)
 - Relaxation features of both strong and fragile glass systems (Y. Yue)
 - Low entropy glasses from super strong zeolite amorphisation (G. Greaves)

PUBLICATIONS AND OTHER CONTRIBUTIONS

in preparation:

L. Wondraczek, R. Conradt (Eds.), *Glass and Entropy*, J. Non-Cryst. Solids, 2009

4.1.3 NUCLEATION, CRYSTALLIZATION & GLASS-CERAMICS (TC07)

Chairman: *Edgar Dutra Zanotto, Fed. University São Carlos, Brazil*

Vice-Chair: *W. Höland, Ivoclar Vivadent, Liechtenstein*

Members: *A. Sakamoto, NEG, Japan*

T. Komatsu, Nagaoka University, Japan

I. Donald, United Kingdom

M. Budd, Consultant, Norway

R. Hill, Imperial College, United Kingdom

R. Müller, BAM, Germany

M.J. Pascual, ICV, Spain

G. Völksch, Otto-Schott Institute, Germany

J. Deubener, TU Clausthal, Germany

F. Gabel, SCHOTT AG, Germany

J. Sestak, Science Academy, Czech Republic

M. Davies, Schott North America, USA

L. Pinckney, Corning, USA

M.O. Prado, CNEA, Argentina

V.M.Fokin, Vavilov Optics Institute, Russia

G. Querel, St-Gobain, France

SUMMARY

The new focus on the **crystallization of complex multi-component glass-forming system** was prepared in several meetings, e-mail exchanges and telephone conferences. Progress was made in the organization of **Crystallization 2009** and in the organization of **book on glass crystallization**. The successful **Brig meeting on Advanced Materials** produced interesting roadmaps with focus on medical and dental application of glass ceramic and will have a considerable impact on the work of TC07 (and TC04). A **roadmap** was drafted for some R&D issues of **nucleation and crystallization** of glass ceramic. In the very busy year various meetings and joint meetings with other TCs took place.

PLANS AND DELIVERABLES FOR 2008

- To carry out the annual meeting with special emphasis in the definition of a new focus for the TC07. Deliverable: a new consensual focus should be found; a CD-ROM with all presentations of the meeting should be prepared.
- To set up the international advisory board and to start the organization and advertisement of the "Crystallization 2009 - 9th International Symposium on Crystallization in Glasses and Liquids". Deliverable: the advisory boards and web page of the symposium should be operational.
- To discuss the organization of a book on glass on different aspects of glass-crystallization. Deliverable: Book chapters being decided and written.

ACTIVITIES IN 2008

2008 has been a very active year for the TC07 as described below:

- E.D. Zanotto (TC07 chair) met the TC20 chair (S. Tanabe), in Kyoto, Japan, to discuss a possible **joint meeting** of the two TCs. This activity was meant to address a request of the CTC. This joint meeting will take place in September 2009, in Brazil, during the symposium “Crystallization 2009”
- J. Deubener, R. Müller and W. Höland, met in Germany, resulting, after further discussion with E.D. Zanotto in a **new focus** for the TC07, i.e. to study the **crystallization of complex multi-component glass-forming systems**.
- Internet discussions between TC 7 members and advisory board members of the Crystallization 2009 regarding several details of the organization of this international symposium on glass crystallization “**Crystallization 2009**”. This event is now in preparation and will take place in September 2009 in Iguazu Falls, in the border between Brazil and Argentina (www.pncs-crystallization.com.br).
- Discussion in São Carlos, Brazil on the organization of a **book on glass crystallization**.
- Organization of an Efonga workshop on “**Advanced Materials and Innovative Glass Melting Technologies**” in Brig, Switzerland in March 2008, Workshop A: Advanced Materials organized by W. Höland. This workshop focused on materials for **medical and dental application**. The deliverable was a special issue of the *J. Eur. Ceram. Soc.*, with a *roadmap*, which is available in the web and will be printed in the end of 2008.
- The TC07 officially met in Trencin, Slovakia, June 22, 2008, on the occasion of the ICG annual meeting. Ten members out of 18 participated. Based on previous discussion, the 2008 meeting focused on the crystallization of **multi-component glass-forming systems** according the scheme below.

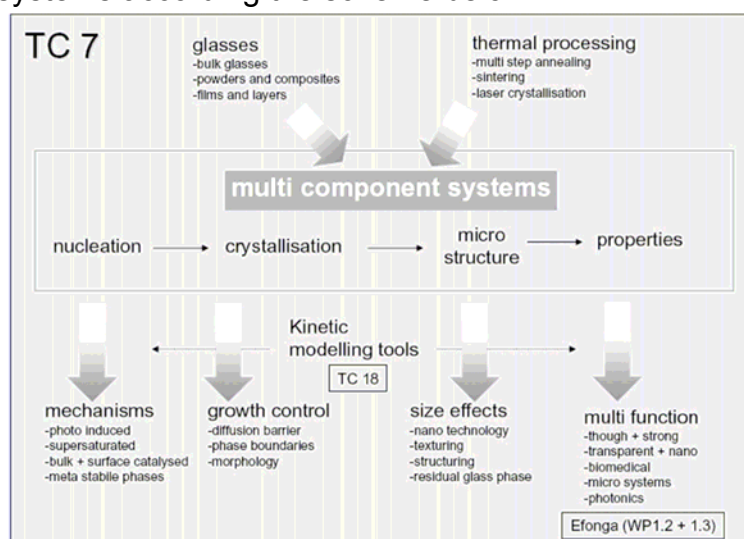


Fig. 4.1.3.1: Parameters and effects in the field of crystallization of multi-component glass-forming systems

The research progress on the following subjects was presented:

- Volume effects during crystallization of β -spodumene in multi-component glasses based on the LAS system.
- Sealing LZS glass-ceramics with additions of TMO nucleation agents to metal parts in the manufacture of glass-ceramic-to-metal electrical components.
- Effect of small additives on crystallization of glasses based on the MAS system for sealing/joining applications.
- Nano glass-ceramics of Sr-bearing apatite compositions.
- Crystallization of Ca-bearing aluminoborosilicate glasses for LTCC applications.
- Multi component glass-ceramics for sealing SOFCs.

- Analytical methods at nano scale using FESEM.
- Fracture toughness of glass-ceramics by COD methods.
- Crack propagation and COD in multi component glass-ceramics for dental applications.
- Early stage of volume crystallization of LAS based glass-ceramics.

The main results of the presentation are as following. **The microstructures, Vickers indentation and crack opening** profiles of 3 glass ceramics (GC) were investigated by SEM and AFM. The main conclusion was that the content of glass phase and type of crystal phase are very important for toughness. The maximum toughnesses achieved were: Lithium silicate GC $2.7 \text{ MPa}\cdot\text{m}^{0.5}$; Leucite GC $K_{IC} = 1.1 \text{ MPa}\cdot\text{m}^{0.5}$; Apatite GC $0.7 \text{ MPa}\cdot\text{m}^{0.5}$, respectively. A micrograph on the fracture pattern in a multiphase glass-ceramic is shown below.

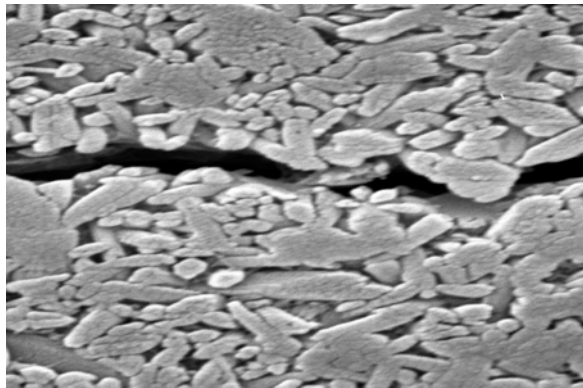


Fig. 4.1.3.2: Fracture pattern of a glass ceramic

Devitrifying glasses had been studied which are used for sealing and joining applications. They often exhibit limited flow and bonding during heating because crystallization starts at relatively high viscosities (low temperatures). However, small additions to the glass composition can improve the flow and sealing behavior significantly by delaying the crystallization process. But for high temperature applications it is important to limit the level of additions since these generally lead to a reduction in refractoriness. There have been many studies of crystallization kinetics and of crystallization mechanisms, but very few combined studies. The mechanisms by which crystallization is retarded are unclear, hence there is scope for further research work on this subject.

It was reported that **TMO** additions strongly **influence the crystallization** behavior of LZS glass, with Ta and Nb oxides in particular suppressing the formation of high expansion silica phases. This may allow glass-ceramics with tailored thermal expansion characteristics using ostensibly the same LZS glass composition. XRD patterns are complex (*LZS solid solutions*). With the exception of V and Mo oxides, TMO additions increase T_g and T_x (DSC crystallization temperature). Nucleation leads to substantial reductions in crystallization temperatures as monitored by DSC. Crystallization activation energies are reduced by TMO additions with the exception of $> 6\text{mol}\% \text{ Nb}_2\text{O}_5$.

A study of **crystallization** of ultra **low expansion glass-ceramics** demonstrated that the Avrami exponent $n > 4$. However, it is still not clear if the nucleation rate is constant or increasing; thus there is scope for further studies. The crystal phase content determined by two independent methods were: 60-70% by XRD and 75-80% by Raman. The main phase is h-quartz crystals surrounded by a diffusion zone, and its extent depends of the heat treatment.

The **crystallization of multi component F containing glasses** was studied. Crystallization of FAP raises T_g and suppresses crystal growth. Further crystal growth can take place at higher temperatures. The nano sized AP crystals can accommodate Mg^{2+} cations that larger sized crystals are unable to do. As the crystals grow they exclude Mg^{2+} from the crystal.

A study on complex **glasses for LTCC** raised a number of relevant issues for further studies summarized in the cartoon below.

Summary

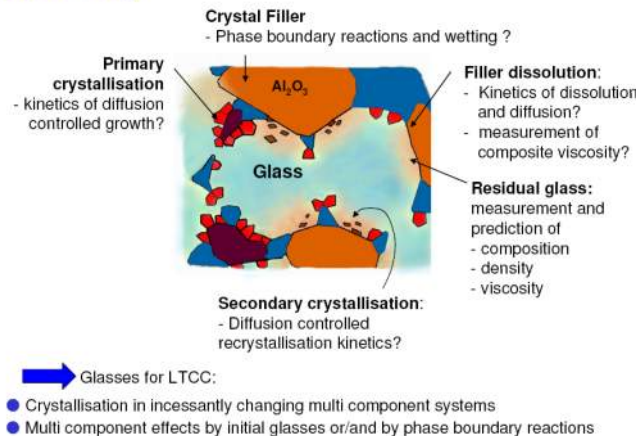


Fig. 4.1.3.3: Schematic representation of relevant factors for LTCC

Transparent glass-ceramics were obtained containing <20nm crystals at temperatures near T_g from different $SiO_2-Al_2O_3-Na_2O-K_2O-LaF_3$ glasses. LaF_3 nanocrystals were detected in a composition with 55% SiO_2 ; and $LaNaF_4$ in a composition with 70% SiO_2 . ^{19}F NMR showed the presence of Al-F-Na bonds in the base glasses. La-F-(Na) bands appear in the glass-ceramics. ^{23}Na NMR did not change, except in 70% SiO_2 glass where Na appears in the crystalline phase. The crystalline fraction was confirmed by XRD (Rietveld refinement) and NMR. Glasses and glass-ceramics doped with Tm^{3+} exhibited up-conversion phenomena. A shorter life time for some glass-ceramics indicate that Tm^{3+} is dissolved in the fluoride nanocrystals.

The interstices at the boundaries was found between the crystal grains and the matrix of β -spodumene glass-ceramic reduces its CTE. **The mechanism of crystallization** and the effect of composition on “**interstice generation**” is not clear at the moment. They will be included in NEG’s future research program.

Some general conditions had been studied for the development of **nano glass-ceramics**. Viscosity, diffusivity and rigidity may change in the diffusion zone near nuclei and crystals. The crystal growth velocity is also strongly affected. If network modifiers crystallize out or are incorporated in the crystals, the viscosities near the crystals increases. This should lead to a decrease in diffusivity near the crystals. A diffusional barrier is built up which hinders further crystal nucleation and growth near the already formed crystals. This mechanism enables the formation of nanocrystalline glass-ceramics with large volume concentrations of the crystalline phase.

The new TC07 focus is on nucleation-crystallization-microstructure-properties of multi-component systems. This theme will be pursued in the next few years.

PLANS AND DELIVERABLES FOR 2009

The TC7 will focus on the organization of the “Crystallization 2009- the **9th International Symposium on Crystallization in Glasses and Liquids**”. This symposium has a long and distinguished history. A key objective of “Crystallization 2009” is to bridge the gap between the scientific understanding of nucleation and growth in glasses and the various applications of glass-ceramic and other crystalline materials. Another important objective is to bring scientists from “other communities”, for instance geologists, polymer scientists, chemical engineers, and metallic glass researches to share their approaches to tackle a plethora of crystallization problems with the “inorganic glass community”. Crystallization 2009 will be dedicated to the life and scientific accomplishments of Peter F. James, former TC07 member. The following topics will be covered:

- Theoretical, simulation and experimental studies of nucleation, crystal growth and overall crystallization in glasses and liquids.
- Amorphous phase separation and its effect on crystallization.
- Glass-ceramic processing and the role of nucleating agents.
- Photo-induced crystallization.
- Microstructure/property relationships in glass-ceramics, including nano-crystallized materials.
- Thermal, mechanical, electrical, optical, and chemical properties of glass-ceramics.
- Applications of glass-ceramics, including medical and dental applications.
- Crystallization phenomena relevant to other types of materials, such as igneous rocks, minerals and synthetic crystals, metallic glasses, polymer glasses, sol-gel derived materials, nuclear waste glasses and glass-ceramics. Deliverable: symposium successfully organized.

Strategies to foster joint research between TC07 members will also be discussed. Some key **issues of nucleation and crystallization** in glasses were already identified in the 2008 meeting and a *road map* was drafted. The main **road map** markers so far recognized were nucleation and crystallization studies to develop glass-ceramics focused on:

- tough and strong : 2008 – 2011;
- sealing and sintering: 2008 – 2009;
- nano crystal formation: 2009 – 2012 ;
- composites (interfaces): 2012 – 2015.

In addition to these main research directions, specific points will be discussed by the TC07 members in more detail. For instance, the subject of interfaces will include those between crystal phases and the glass matrix of the glass-ceramics, but also different interfaces of glass-ceramics to metals or other composite materials. A special subject in the research activities regarding tough glass-ceramics will be the relationship between nano-phases and toughness.

Deliverable: report on the new, focused research activities of the TC07 members.

The annual meeting in 2009 will take place during the crystallization conference in Brazil, September 2009 (confirmed). Possibly a second meeting can be arranged during the ICG meeting in Vancouver, Canada, in May 2009 (depending on the number of attendees).

Deliverable: One or two formal meetings successfully take place; reports sent to the CTC.

PUBLICATIONS

J. Sestak has been working on a new book project with E.D. Zanotto and V.M. Fokin entitled: **Thermodynamic, structural and behavioral aspects of amorphous materials**

The TC07 members published more than 30 papers in ISI journals on several aspects of glass crystallization in 2008. This record clearly indicates that they have been quite active.

In addition, several joint papers of TC members (underlined) were published indicating very significant collaborative research:

- S. REINSCH; M.L. F. NASCIMENTO; R. MULLER; E.D. ZANOTTO, “Crystal growth kinetics in cordierite and diopside glasses in wide temperature ranges”, **J. Non-Cryst. Solids** (2008) accepted.
- T. BERTHIER, T.; V.M. FOKIN; E.D. ZANOTTO, “New large grain, highly crystalline, transparent glass–ceramics”, **J. Non-Cryst. Solids** 354 (2008) 1721-1730]
- J. G. LONGSTAFFE; U. WERNER-ZWANZIGER; J. F. SCHNEIDER; NASCIMENTO, M. L. F.; E.D. ZANOTTO; J. W. ZWANZIGER (TC 3 member), “Intermediate-range order of alkali disilicate glasses and its relation to the devitrification mechanism”, **J. Phys. Chem. C** 112 (2008) 6151-6159.
- M. O. PRADO; M. L. F. NASCIMENTO.; E. D. ZANOTTO, “On the sinterability of crystallizing glass powders”, **J. Non-Cryst. Solids** 354 (2008) 4589.
- E. APEL, J. DEUBENER, A. BERNARD, M. HÖLAND, R. MÜLLER, H. KAPPERT, V. RHEINBERGER, W. HÖLAND: Phenomena and mechanisms of crack propagation in glass-ceramics, **J. Mechan. Behavior of Biomedical Mat.** 1 (2008) 313-325
- R. MÜLLER, S. REINSCH, M. EBERSTEIN, J. DEUBENER, A. THIEL, AND W.A. SCHILLER: Effects of dispersed Al₂O₃ particles on sintering of LTCC. **Adv. Mat. Res.** 39-40 (2008) 375-380
- J. DEUBENER, H. BEHRENS, R. MÜLLER, S. ZIETKA, S. REINSCH: Kinetic fragility of hydrous soda-lime-silica glasses. **J. Non-Cryst. Solids** 354 (2008) 4713-4718
- D. EHRT (member of TC 3), H T. VU, A. HERRMANN, G. VÖLKSCH Luminescent ZnO-Al₂O₃-SiO₂ glasses and glass-ceramics **Advanced Materials Research** 39-40(2008)231-236.

4.1.4 NANOMECHANICS (TC09)

Chairman: *Matteo Ciccotti, Montpellier, France*

Members: *S. M. Wiederhorn, NIST, USA*

M. Tomozawa, Rennsealer, NY, USA

T. Rouxel, Univerité Rennes 1, France

C. Pantano, Pennstate Univ., PA, USA

D. Green, Pennstate Univ, PA, USA

A. Cormack, Alfred Univ, USA

G.D. Sorarù, University of Trento, Italy

T.I. Suratwala, Livermore, USA

R. J. Hand, Sheffield Uni, UK

S. Yoshida, Univ of Shiga, Japan

SUMMARY

The initiative for a new technical committee on "Nanomechanics" was started in the first half of 2007 and has officially become TC09 in the ICG's CTC during the Trençin-conference in June 2008. The mission of the new TC is to promote cooperative research activity on the comprehension of recent advances in the observations by local scanning probe techniques of the **fundamental crack propagation mechanisms** acting at the nanoscale in glass and glass-ceramics. We can cite the debated observations on the presence of plastic deformation near the crack tip, as well as the manifestation of stress induced ion migration in the neighbourhood of the crack tip, but also the subtle details of the diffusion and interaction of water molecules with the glass network. The TC joins

experts in different domains of the glass community (fracture, physical-chemistry, structural relaxation, surface properties, scanning probe microscopies, numerical simulation) with the aim of discussing how to put together different evidences in order to gain new insights in the relationship between the glass composition, nanostructure and mechanical properties. This interdisciplinary activity will also benefit from collaboration under development with other TCs, such as TC02, TC03, TC06, TC07, TC14 and TC19.

The main activity in 2008 has been the organization in collaboration with TC19 of a Brig like workshop on **“Glass surfaces and stress corrosion mechanisms at the nanoscale”** that will be held in February 2009 in Montpellier, France. This action is financed in the frame of the EFONGA project and it will bring together 20 international experts in the glass community in order to present a talk focused on own expertise and to support a roadmap process for surface related phenomena for glass/glassceramics. The results will be published later on.

A core group meeting was held on September 3, 2008 at MSE 2008 (Nürnberg, Germany, 1-4 September 2008), where a symposium "Towards Ultrastrong Glasses" was organized jointly by TC03 and TC06. The symposium was very stimulating and it was followed by a joint meeting of TC03, TC06 and TC09 concerning a Round Table on the Strength of Glass issue. Three TC09 members were present (M. Ciccotti, A. Cormack and R. Hand) and contributed with oral presentations and active discussion.

PLANS AND DELIVERABLES FOR 2008

- Core physical meeting at MSE2008 (Nürnberg, Germany, September 1 – 4, 2008) on September 3, 2008.
- Contributions in the symposium "Towards Ultrastrong Glasses" organized jointly by TC03 and TC06 from TC09 at MSE2008.
- Definitions of priorities for the future actions and research activity of TC09.
- Organization of a joint TC09/TC19 RRT on the investigation of the nature of the first tens nanometers below the glass surface after different kinds of advanced polishing.

ACTIVITIES in 2008

- A core meeting was held on September 3, 2008 at MSE 2008 (Nürnberg, Germany, September 1 – 4, 2008), where a symposium "Towards Ultrastrong Glasses" was organized jointly by TC03 and TC06.
- The symposium was very stimulating and it was followed by a joint meeting of TC03, TC06 and TC09 concerning a Round Table on the Strength of Glass issue. Three TC09 members were present (M. Ciccotti, A. Cormack and R. Hand) and contributed with oral presentations and active discussion.
- Preliminary discussion were made on the opportunity of organizing a joint TC09 and TC19 workshop on "Glass surfaces and stress corrosion mechanisms at the nanoscale" to be held in February 2009 in Montpellier. This should be an excellent opportunity to make a point of the state of the art in this research topic and settle better plans for future activities of TC09 which are likely to involve extensive cooperation with both TC19 and TC06.
- In the last four months of 2008 the main activity of TC09 has been the organization in collaboration with the chair of TC19 of a Brig like workshop on **“Glass surfaces and stress corrosion mechanisms at the nanoscale”** that will be held in February 2009 in Montpellier, France. This action is financed in the frame of the EFONGA project and it will bring together 20 international experts in the glass community in order to present a talk focused on own expertise and to support a roadmap process for surface related phenomena for glass/glassceramics. A web page for this event is created at:

<http://w3.lcvn.univ-montp2.fr/~ciccotti/TC09/EFONGAWorkShop2009.html>

- As a personal action of the chair Matteo Ciccotti has written a review on the “Stress-corrosion mechanism of silicate glasses” that is under submission and that is meant to review the state of knowledge on the subject before the workshop in order to animate discussions.
- The advancements on the project on the joint TC09/TC19 RRT test on the investigation of the nature of the first tens nanometers below the glass surface after different kinds of advanced polishing were discussed, especially concerning the choice of the standard sample and the protocols for its conditioning during the tests and transfers between different laboratories.

PLANS FOR 2009 AND DELIVERABLE

- The EFONGA workshop on “Glass surfaces and stress corrosion mechanisms at the nanoscale” that will be held in February 22-25, 2009 in Montpellier, France.
- The results of the workshop will be later on
 - Published on a scientific journal
 - Presented at the final meeting of the EFONGA project to be held in May 2009 in Montpellier
 - Presented at the “Strength of Glass” symposium at the conference PAC RIM 2009 in Vancouver in June 2009.
- Some members of TC09 will participate in the organization of the Student Workshop: “GLASS STRUCTURE-PROPERTY RELATIONS” that will be held jointly with the final EFONGA meeting in Montpellier in May 2008. Several oral contributions from TC09 members are scheduled.
- The joint TC09/TC19 RRT on the investigation of the nature of the first tens nanometers below the glass surface after different kinds of advanced polishing should turn to action in 2009. The samples will be shipped through 13 laboratories and the results will be joined and analyzed.
- Physical TC09 meetings are scheduled at the EFONGA workshop in Montpellier in February 2009. At the final EFONGA meeting in May 2009 in Montpellier and at the PAC RIM 2009 Conference in Vancouver in June 2009.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- As a personal action of the chair Matteo Ciccotti has written a review on the “Stress-corrosion mechanism of silicate glasses” that is under submission and that is meant to review the state of knowledge on the subject before the EFONGA workshop of February 2009 in order to animate discussions.
- Three contributions were given at the symposium "Towards Ultrastrong Glasses" at MSE 2008 in Nürnberg by M. Ciccotti, A. Cormack and R. Hand.

4.1.5 MECHANICAL PROPERTIES OF GLASS (TC06)

Chairman: *Jim Varner, NYS College of Ceramics, Alfred Univ., USA*

Vice-Chair: *Suresh Gulati, Corning, Inc, USA*

Members: *V. Pukh, Russian Academy of Sciences, Russia*

Jun Matsuoka, The Univ. of Shiga Prefecture, Japan

Rene Gy, Saint-Gobain Recherche, France

E. Magnato, Sperimentale del Vetro, Italy

Reha Akcakaya, Turkiye Sise ve Cam Fabrikalari A.S., Turkey

Kurt Nattermann, Schott AG, Germany

Russell J. Hand, University of Sheffield, England

Jorma Vitkala, Glaston, Finland

Paul Warren, Pilkington, UK

John Helfinstine, Corning, Inc., USA

Matteo Ciccotti, LCVN, Université de Montpellier II, France

Lothar Wondraczek, Univ. Erlangen-Nürnberg, Germany

Jian (Jimmy) Yang, Univ. of Birmingham, UK

SUMMARY

TC06 participated in organizing the session “**Towards Ultrastrong Glasses**” held as part of MSE 2008 in Nürnberg, Germany, in September. TC03 participated as well, making this session the joint TC03/06 effort that has been our goal for some time. TC06 Chair Varner and Co-Chair Suresh Gulati are members of the task Force which is organizing a symposium on glass strength that will be held during PacRim 8, June 2009, in Vancouver, Canada. A core group of TC06 met on September 4, 2008 in Nürnberg, Germany, during MSE 2008. Four TC06 members were joined by four guests for a discussion focused on the prospects of achieving ultrastrong glasses.

PLANS AND DELIVERABLES FOR 2008

- Increased use of electronic means to stay in touch
 - o Deliverable – Documented use of Yahoo chat group and email
 - o Deliverable – Development of projects
- Decide on projects and begin work on the selected projects
 - o Possible projects include
 - Edge strength of glass (focus on how edge flaws are made and what happens to them)
 - Effects of surface flaws in glass fatigue (stress corrosion) (compare fracture mechanics tests with static/dynamic fatigue tests)
 - Scratch resistance of glass (possible collaboration with TC14 (Water in Glass); needs further definition)
 - Effects of climate change (possible collaboration with TC02 (Chemical Corrosion) and TC17 (Archaeometry of Glass); needs further definition)
 - o Deliverables – identified projects; work started
- Find a “home” for the TC03/TC06 joint symposium
 - o Deliverable – Inclusion in the program of an international meeting on glass
- Continued work on examining the quality of published data on the modulus of elasticity of glass
 - o Deliverable – Report and/or publication
- Meeting of TC06
 - o Deliverable – Minutes

ACTIVITIES in 2008

The TC03/TC06 joint symposium on “The Relationship between Glass Structure and Mechanical Properties” formed part of the session “Towards Ultrastrong Glasses” at MSE 2008. Committee member Lothar Wondraczek was the primary organizer of the session. TC06 Chair Jim Varner served as co-organizer. TC06 members Matteo Ciccotti, Russell Hand, and Jim Varner presented papers in the session as did some members of TC03. Members of both TC’s were involved in identifying and inviting speakers. The papers may be published.

A symposium on glass strength is being organized as part of PacRim 8 (May 31 – June 5, 2009, in Vancouver, Canada. TC06 is involved in the planning of this session. All presentations will be by invitation only. Some members of TC06 will likely be among the invited speakers or will be members of the symposium panel.

The TC06 meeting during MSE 2008 was attended by a core group of four members and four guests. Everyone at this meeting had been a participant in the session “Towards Ultrastrong Glasses” at MSE 2008, and the meeting was held immediately after the session concluded. The meeting continued the session’s focus on increasing glass strength. A report of this meeting was distributed to the members of TC06. One new member was added to TC06 in 2008 - Jian (Jimmy) Yang (Dept. of Civil Engineering, Univ. of Birmingham, England).

The quality of published data on elastic modulus was a new topic started in 2007. Although there was no organized TC06 activity in this area in 2008, committee member Matteo Ciccotti published a paper in this area in which he made reference to the preliminary work done by TC06 in 2007.

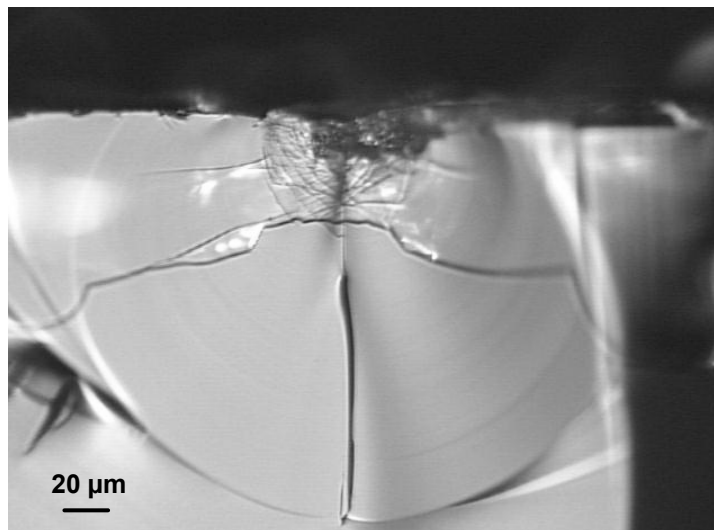


Fig. 4.1.5.1: Photomicrograph of a Vickers indentation zone

Optical photomicrograph showing a plan view of a Vickers indentation after the glass was broken; note the indentation (top center), the deformation zone (just below the indentation), the half-penny radial crack (with the edge of an intersecting radial crack in the center of the image), and the edges of lateral cracks (nearly horizontal to the original glass surface); T. Wilantewicz & J. Varner

PLANS FOR 2009 AND DELIVERABLES

- TC06 meeting – in conjunction with PacRim 8 (May 31 – June 5, 2008)
 - o Deliverable – meeting minutes; tasks
- Symposium at PacRim 8 on Strength of Glass – participate in organizing and carrying out this meeting

- Deliverable – participants; ideas for future TC06 work
- EFONGA meeting in February – participation by several TC06 members
 - Deliverable – participants; ideas for future TC06 work; collaboration with other TCs
- ICG short course on strength of glass; fractography course – participation by several TC06 members
 - Deliverable – number of course participants
- Decide on several projects and begin work on the selected projects
 - Possible projects include
 - Edge strength of glass (focus on how edge flaws are made and what happens to them)
 - Effects of surface flaws in glass fatigue (stress corrosion) (compare fracture mechanics tests with static/dynamic fatigue tests)
 - Ways to improve edge strength of glass
 - Deliverables - identified projects; work started

PUBLICATIONS AND OTHER CONTRIBUTIONS

There were no TC06 publications in 2007. The contributions of TC06 to MSE 2008, the ongoing and future contributions to PacRim 8 (session on glass strength), and the paper by member Matteo Ciccotti were included above.

4.1.6 OPTICAL PROPERTIES (TC10)

Chairman: *Charles Anderson, Saint-Gobain Recherche*
Vice-Chairs: *Peter van Nijnatten, OMT Solutions bv*
Minutes Secretary: *Helen Rose Wilson, Fraunhofer ISE*
Members: *Fehiman Akmaz, Turkye Sise ve Cam Fabrikalar, Turkey*
Joachim Bretschneider, Pilkington, Germany
Guorong Chen, East China University
Robert Davies, Pilkington Technology Centre
Alexander Dotsenko, CORNING SCIENTIFIC
Gille Flamant, BBRI
Giovanni Gagliardi, Pilkington Italia SPA, Italy
Andrei Goussarov, SCK.CEN
Thomas Hofmann, Centrosolar Glas GmbH & Co. KG
Michael G Hutchins, Sonnergy Ltd
Jacob Jonsson, Lawrence Berkeley Laboratory
Ingrid Marenne, AGC flat glass europe
H. Nakai, Nippon Sheet Glass Co., Ltd
François Olive, CSTB
Clemens Ottermann, SCHOTT AG
Arne Roos, Uppsala University
Giuseppe Rossi, I.N.Ri.M.
T. Saito, ASAHI GLASS Co., Ltd
José Simons, INISMa
Long Zhang, Shanghai Institute
Guests: *Scott Aldrich, Corning, USA*
Antonio Daneo, Stazione Sperimentale del Vetro, Italy
James Farmer, Pilkington Technology Centre
Olivier Kappertz, Interpane

SUMMARY

The four main topics in the year 2008 were:

- The current investigation into the optical characterization of diffusing and patterned glass products,
- The new investigation into the determination of the dispersion functions of bare glass substrates,
- Final points concerning the investigation into the performance of portable spectrophotometric devices,
- Updates and maintenance of the TC10 website. What more is needed in updating the TC10 document archive that is on the website?

In addition, other topics were discussed such as the comparison of publicly available simulation tools for window performance (WIS, OPTICS 5 and WINDOW 6.0). These software tools are used extensively in the industry. Also discussed were the interactions of TC10 with other bodies such as CEN/TC129/WG9 concerned with the relevant standards. TC10 held their normal 2 annual meetings, one in Murano at SSV in March with 15 members and 5 guests attending, and the other in Freiburg in September at the Fraunhofer Institute with 9 members and 7 guests attending.

PLANS AND DELIVERABLES FOR 2008

In 2007, the final report of the inter laboratory comparison to evaluate the performance of **portable colorimeters** was completed. However, as there was an extensive amount of data, a statistical analysis of the results was proposed by Mr. Rossi. He outlined a method with which each participant could evaluate their respective results. We hope to complete such an analysis in the near future.

As investigations for inter laboratory comparisons usually require in the order of three or more years, and as the two current inter laboratory comparisons are recent, there are at this point only intermediate deliverables for the two:

- **Diffusing and patterned glass products:** Samples have been distributed, initial measurement; results collect, and analysis of these results to determine important parameters.
- **Dispersion function of bare glass substrates:** Five sets of sample have been assembled and characterized by TNO. They are currently being circulated for members to measure.

In addition, the TC 10 website was changed (in the members area), to allow easier maintenance. Basically, the methods to add, modify or delete documents was improved.

ACTIVITIES in 2008

The major activities during 2008 were:

- Inter laboratory comparison for determining a feasible technique for measuring the **optical properties of highly diffusing and patterned glass products:** this is the major current activity of the TC. It was inspired by the fact that commercially available instrumentation clearly cannot measure optical properties of these products with acceptable accuracy. Besides architectural products there is a large need in the photovoltaic industry to be able to perform these measurements. There is collaboration with CEN/TC129/WG9 to improve these measurements in order to include them in EN 410. At this point initial measurements have been performed and analyzed. It appears that the design of the integrating sphere used is of extreme importance, and is the reason for the large dispersion of results obtained.
- Inter laboratory comparison for the determination of the **dispersion functions of bare glass substrates:** Many producers of coated glass products use thin film optical

modelling to develop and fabricate their products. As such, the dispersion functions of the substrates are required as input to the optical modelling. While the dispersion functions of most thin film materials can be represented by relatively simple dispersion functions, the glass substrates require up to six oscillator functions to model their absorption bands over the required wavelength region. At this point five sets of samples have been fabricated including samples with well known dispersion functions (silica) and initial measurements performed.

- While not an inter laboratory comparison, several producers have discussed the fact that different **simulation optical tools** (WIS, OPTIC 5, and WINDOW 6) produce different results. In addition, the only currently funded optical tool is WINDOW 6 from LBNL and it does not include calculations using CEN standards. Thus, members are discussing how to improve this situation.
- Updating and maintenance on the **website** has also been performed. We also believe that we have loaded all of the past available documents (going back to as early as the 1980's) into the archive which is in the public area of the website.
- Mr. Aldrich from Corning, USA has requested to be a member replacing Mr. Butcher from the same organization. Mr. Daneo and Mr. Kappertz have been encouraged to become members. Also the vice chairman Mr. van Nijnatten has left TNO and has formed a company working in the field of optical instrumentation. He will remain a member and vice chairman of TC10. It is the understanding of the chairman that the TNO group designing optical instrumentation is no longer existent.

PLANS FOR 2009 AND DELIVERABLES

There will be 2 full member TC10 meetings in 2009 The first meeting will be on March 27 at SSV in Murano. The second meeting will be in September on a date and at a location to be determined.

The main topics of these two meetings will be:

- Advancement of the inter laboratory comparisons on diffusing and patterned glass products: results from 2008 have lead to possibilities to reduce the dispersion of results between the participating laboratories. One idea, is to diffuse the incident light before interaction with the samples. Another is to measure using multiple port sizes and extrapolate results. The concept of an "ideal" integrating sphere will be discussed. Finally, Monte Carlo calculations are planed to study the problem. A deliverable in the form of an interim report will be completed by the end of April and will be available on the website. We expect to collaborate with CEN/TC129/WG9 on this activity.
- Advancement of the inter laboratory comparisons on dispersion functions of bare glass substrates: Different measurement methods (transmission and reflection, ellipsometry, Brewster angle determination ...) will be compared with each other and with dispersion function of known materials. An interim report should be available and on the website by the end of the year.
- Continued maintenance of the TC website and archive.
- We will investigate what needs to be changed or added to different optical simulation tools.

PUBLICATIONS AND OTHER CONTRIBUTIONS

Summary of the report on the inter laboratory comparison of potable colorimeters will be published in 2009

4.1.7 CHEMICAL DURABILITY AND ANALYSIS (TC02)

Chairman: *Dominique Brochot, Corning SAS CETC, Avon, France*
Vice-Chair: *Maria Malheiro, Saint-Gobain Recherche, Aubervilliers, France*
Secretary: *Peter Sundberg, Glafo, Vaxjo, Sweden*
Members: *Ryouji Akiyama, Asahi glass, Yokohama, Japan*
Ayse Kerestecioglu, Sisecam, Istanbul, Turkey
Andreas Kasper, Saint-Gobain, Herzogenrath, Germany
Elke Chorus, Saint-Gobain Deutschland, Herzogenrath, Germany
Martina Scarpa, Stazione Sper. Vetro, Venezia, Italy
Leos Bauer, Glass Institute, Hradec Kralove, Czech Republic
Isabelle Lesieur, Isover Saint-Gobain, Rantigny, France
Maria Malheiro, Saint-Gobain Recherche, Aubervilliers, France
Heinrich Kipphardt, BAM, Berlin, Germany
Ralf Eiden, Schott AG, Mainz, Germany
Christine Strubel, Schott AG, Mainz, Germany
Dominique Michiels, Glaverbel, Jumet, Belgium
Carolina Brillante, Filippine
Scott Clemons, Corning INC, Corning, NY, USA
José Simons, INISMa, Charleroi, Belgium
Stuart Jamieson, Pilkington plc, Lathom, UK
Daniel Capon, GTS, Sheffield, UK
Tepiwan Jitwatcharakomol, Glass Tech Center. Bangkok, Thailand

Hon.

Members : *Emanuel Guadagnino*
Orhan Corumluoglu

SUMMARY

Collaborative works have been successfully closed (SGT sand, slag), some others need to be continued next year (Surface Ablation Cell in comparison with other techniques, sulphur/sulphides in an amber glass) and new ones were initiated (N, C, S in AZS refractories in collaboration with TC11 and TC14, iron in low iron glass sand and low iron float glass). The papers presented at the Strasbourg workshop have been published on the Revista SSV, the "Handbook of Analytical Methods recommended by TC02" will be soon printed and the paper on SAC results will be published in Glass Technology in the next months. Our TC02 website is launched.

TC02 met twice in 2008, in Corning (US) on May 15 - 16 (8 members in attendance) and in Aachen (Germany) on October 23 - 24 (14 people). Two core meetings have been held in Avon (February 2 and October 13).

PLANS AND DELIVERABLES FOR 2008

- Surface Ablation Cell: first paper to be published, comparison with other techniques in progress.
- Proficiency test on Slag: ended: certificates to participants distributed
- Sand analysis (collaboration with SGT): certification completed.
- Sulphur/Sulphides in an amber glass: first results discussed. More work needed.
- Handbook of Analytical Methods recommended by TC02: to be print before end of year
- 2 meetings and 2 core meetings held: documents issued
- TC02 website launched

ACTIVITIES in 2008

TC02 met first in Corning (NY) in May 2008 hosted by Corning Inc. Following topics were discussed :

- Report on EFONGA activities
- "Handbook of Analytical Methods recommended by TC02" compiled by Emanuel Guadagnino and Orhan Corumluoglu (choice of methods, common format)
- Revision of ISO 4802 (Hydrolytic Resistance of the interior surface of glass container: Italian comments discussed)
- Certification of SGT sand: work completed. Sand available from SGT.
- SAC: results of 3 labs presented. Comparison with SIMS technique correlates perfectly (see B and Sn profiles)

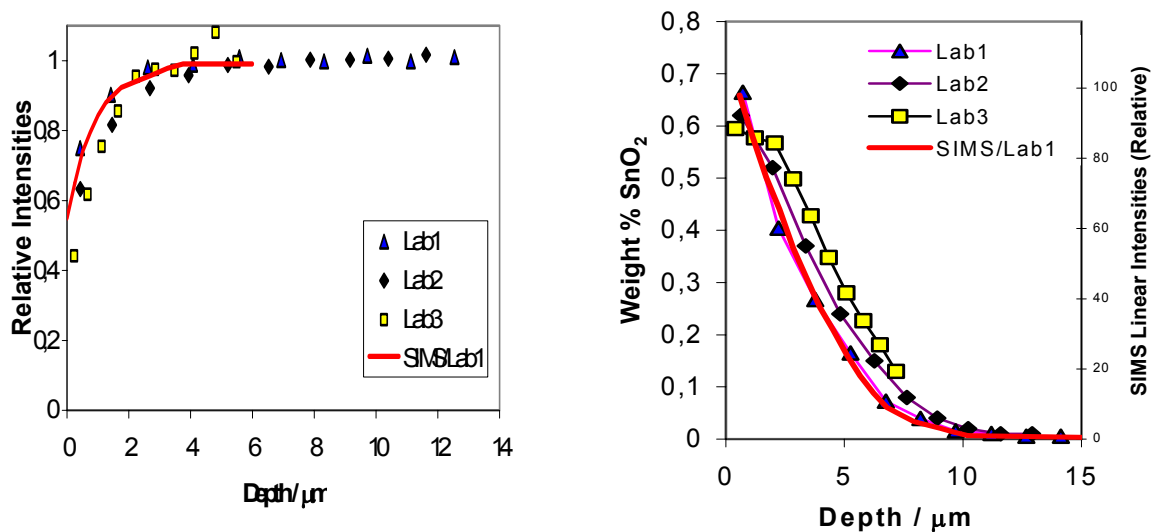


Fig. 4.1.7.1: B and Sn SAC- and SIMS-depth-profile

- Proficiency test on Slag: choice of sample, homogeneity test discussed.
- Sulphur/sulphide in amber glass: identification and distribution of the glass.
- LIBS: presentations and uses of the technique made by Corning and Pilkington.
- Collaboration with TC11 and TC14 for the determination of C, N and S in AZS refractories: understanding of the demand.
- Vitroceramic sample for certification: to be check by Corning and Schott
- Determination of main components in BAM S005
- Mercury in glass: need for a reference material to show labs ability.

TC02 met again in Aachen in October, hosted by Sekurit Saint Gobain. The following issues were discussed :

- Report on CTC meeting in Trencin
- Revision of ISO 4802: Emanuel Guadagnino invited to Berlin's meetings in November.
- Roadmap questionnaire: inputs of the group received and forwarded to Joachim Klemens
- Small presentation of EFONGA and GlaSS project to our new members
- "Handbook of Analytical methods recommended by TC02": presentation of the chosen methods under a new format. Printing in progress.
- TC02 website: presentation by Peter Sundberg of the potentialities of this tool.
- Proficiency test on Slag: discussion of results and distribution of participating certificates.

- Sulphur/Sulphide in amber glass: presentation of the results. As the sulphides results are too spread, it has been decided to focus on methods that give best results and make new trials with those methods.
- Presentations of surface studies on borofloat using LA ICPMS made by BAM and Schott.
- SAC: presentation of the results obtained by the 3 laboratories and of the draft paper for publication. Improvements discussed.
- N, C and S in AZS refractories: Detlef Köpsel presented its request concerning impurities analysis in AZS refractories. It was decided to investigate with different techniques (LECO, HR GDMS, SIMS, LA ICPMS)
- Main elements in BAM S005: search for left glass pieces to allow labs without XRF equipment to participate to this exercise.
- New topics were discussed: iron in a low iron glass sand and in a low iron float glass.

Maria Malheiro is now appointed vice-chairman, replacing Peter Sundberg. Ayse Kerestecioglu (Sisecam) replaces Ilkay Sökmen and Heinrich Kipphardt replaces Matschat (BAM). Many new members have joined or are joining the group this year: Tepiwan Jitwatcharakomol (Tech Glass Center in Bangkok), Tatiana Antropova (Institute Silicate Chemistry, St. Petersburg), Sjaak Smolders (Philips Research Europe, Eindhoven).
Decision for next meeting: Pilkington invites us in Lathom (UK) in April 2009.

Main documents issued :

- ICG/TC2/08-1469 : Minutes of core meeting / Avon February 2008
- ICG/TC2/08-1484 : Report from the 89th meeting / Corning May 2008
- ICG/TC2/08-1488 : LIBS presentation by Corning US
- ICG/TC2/08-1494 : LIBS for cullet sorting (Pilkington)
- ICG/TC2/08-1494 : Minutes of core meeting / Avon October 2008
- ICG/TC2/08-1496 : SO₃ in glass by combustion/final manuscript
- ICG/TC2/08-1500 : Report from the 90th meeting / Aachen October 2008
- ICG/TC2/08-1501 : Action sheet arising from the 90th meeting in Aachen

PLANS FOR 2009 AND DELIVERABLES

- "Surface Ablation Cell" (SAC): some more additional work will be done before submitting the final paper to Glass Technology
- LA ICPMS studies on Borofloat CS2007-1 glass (comparison with SAC results)
- Sulphur/sulphides in an amber glass: new trials to be done on sulphides determination using ICP OES and titration methods (working methods)
- In collaboration with TC11 and TC14, determination of C, S and N in AZS refractories (trials with LECO, LA ICPMS, SIMS and HR GDMS)
- Proficiency tests on iron determinations in low iron glass sand and low iron float glass.
- Determination of main components of BAM005S (previously investigated for impurities)
- Spring meeting will be held in Lathom (UK) at the invitation of Pilkington.
- Fall meeting : place to be discussed.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- E.Guadagnino, D. Brochot & P.Sundberg: "ICG-TC02 experiences in collaborative studies, method validation and proficiency testing", Riv. Staz. Sper. Vetro, 6, 2007, 5-

- U. Waetjien, E.Guadagnino: "How and why to certify reference materials", Riv. Staz. Sper. Vetro, 6, 2007, 13-18
- H. Kipphardt, R.Matschat: "Traceability and uncertainty of chemical measurements in the frame of the certification and use of the glass CRM BAM- S005", Riv. Staz. Sper. Vetro, 6, 2007, 19-23

4.2 R&D Activity Field "Glass Production"

4.2.1 GLASS MELTING (TC18)

Chairman:	Ruud Beerkens, The Netherlands
Vice-Chairs:	Reinhard Conradt, Germany
Members:	Gülcin Albayrak, Turkey
	Hande Sengel, Turkey
	Masataka Kawaguchi, Japan
	Shige Aoki, Japan
	Chikao Tanaka, Japan
	Rei Kitamura, Japan
	Alexis Clare, USA
	John Chumley, USA
	Sue Schiefelbein, USA
	Phil Ross, USA
	Oleg Prokhorenko, Russia
	Oleg Mazurin, Russia
	Thomas Pfeiffer, Germany
	Ulrich Roger, Germany
	Hayo Mueller-Simon, Germany
	Lubomir Nemeč, Czech Republic
	Jaroslav Klouzek, Czech Republic
	Marie-Helene Chopinet, France,
	Jan Hermans, The Netherlands
	Alexander Fluegel, Germany
	Christina Stålhandske, Sweden
From other TC's:	TC11: Nobuyuki Kido, Japan
	TC14: Detlef Köpsel, Germany
	TC14: John Buckett, UK
	TC15: Wilfried Linz, Germany
	TC21: Wolfgang Muschick, Germany
	TC21: Lale Önsel, Turkey/ Erik Muijsenber, The Netherlands
	TC25: Christoph Berndhäuser, Germany

SUMMARY

A team of high-level-experts, from TC18 and from other TCs of the ICG met for a workshop to discuss **future directions and innovation in the field of glass melting**. This meeting was organized in co-operation with TC07 (Prof. W. Höland) in Brig, Switzerland from March 26 –29 , 2008.

TC18 organized the annual meeting on June 22, 2008 in Trenčín, Slovakia (ESG conference, ICG annual meeting). This meeting was followed up by 2 additional meetings to define proposals for future activities on R&D on innovative glass melting.

Round Robin test was started on the determination of chemical activities of chemical constituents of three different multi-component silicate systems (glass melts) by the application of thermodynamic modelling.

A publication on liquidus temperature measurements of glass has been submitted and is published in October in the European Journal: Glass Technology: Eur. J. Glass Sci. Technol. A

The catalogue on world-wide existing facilities for measuring glass melt properties has further be extended and is available from the TC18 website (accessible through ICG website: www.icglass.org)

The name of TC18 from “Properties of Glass Forming Melts” will be changed into: “Glass Melting”



Fig. 4.2.1.1: Expert meeting on “Innovative Glass Melting for the Year 2020”: start of a roadmap for energy efficient, environmentally sound and intensive glass melting

PLANS AND DELIVERABLES FOR 2008

- Extension catalogue on: *Measurement Facilities for Investigations of Glass Melt Properties (May 2008)*
- Report on conclusions of the Expert Meeting in Brig:
 - o *Conclusions of the expert meeting on “Innovative Glass Melting Technology in the Year 2020”, Report for the ICG, Summary of workshop & abstracts of presentations, April 5, 2008 by Ruud Beerkens, Helmut Schaeffer, Stephan Speith (ISI)*
- Minutes of the TC18 meeting in Trenčín on June 22, 2008.
- Workshop on November 13-14, 2008 in co-operation with TC25 and Glass Trend on “*Conditioning of Glass Melts & Forming of Glass Products*”, Eindhoven, The Netherlands (presentations will be available from website).
- Several papers/publications (see the last section of this report).



*Glass produced by
Royal Leerdam*

Fig. 4.2.1.2: Experts from all over the world met in Brig (Switzerland) to start a roadmap process on Innovation in Glass Melting

ACTIVITIES in 2008

The TC18 finalized the **Round Robin on measuring liquidus temperatures** for three soda-lime-magnesia-silica float glass samples. The report is published in October 2008 (see deliverables).

TC18 (sponsored by EFONGA) organized an **expert meeting on innovative glass melting from March 26.-29, 2008 in Brig**, Switzerland. Experts from industry and academia were invited. Several experts from other technical committees of the ICG participated. The experts presented extended papers on their knowledge about glass melting and views of potential improvements of industrial glass melting processes with the aim of:

- Reducing energy consumption
- Reducing emissions
- Reducing melting costs
- Increasing flexibility in production
- Enabling melting of new glass compositions.

At the end of the expert meeting, 4 main issues (“sub-projects”) for further development and investigations have been identified:

1. New glass melting concepts, with segmented melter sections and new fining techniques
2. Innovative batch processing, including batch pre-treatment, new routes of batch mixing and melting, low temperature batch reactions by hydrothermal or mechanical processes and alternative raw materials in combination with new melting techniques;
3. Glass furnace waste gas (flue gas) heat recovery methods (demonstration project);
4. Advanced sensor development and process control (combustion and melting) in glass furnaces.

② Homogenization

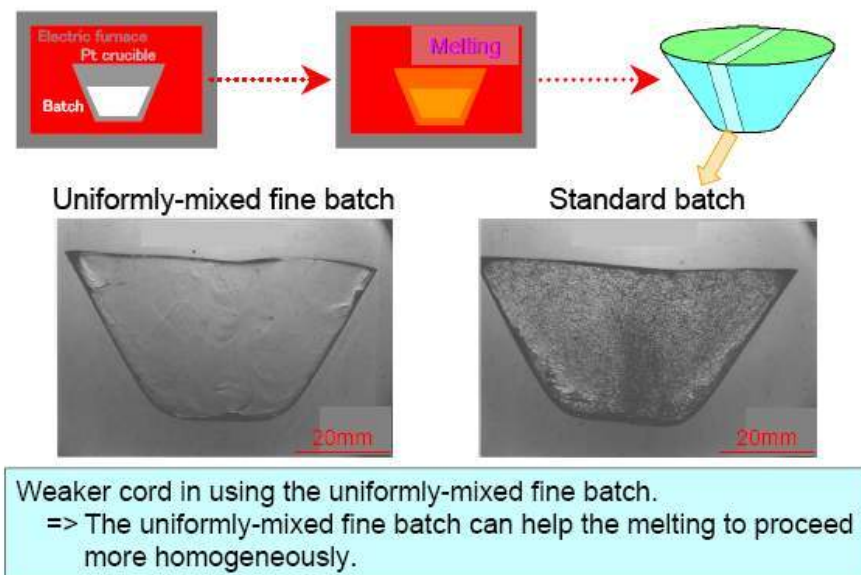


Fig. 4.2.1.3: Glass melts prepared from the same raw materials but different grain sizes.
From: M. Kawaguchi, T. Kato; N. Yoshida, S. Aoki – Nippon Electric Glass Co. Ltd. Japan, presented at expert meeting Brig

For these four projects, 4 teams have been established in Brig. Each team prepared a nutshell proposal of activities and deliverables. The teams met in Trenčín, June 25, 2008 and Düsseldorf (October 23, 2008) to refine these proposals.

These proposals will be the basis for future research activities of a consortium of industrial and academia partners. This new consortium with these 4 sub-projects is called:

Bringing together Research on Innovative Glass melting for the year 2020 (abbreviation: B.R.I.G. 2020)

During the BRIG, expert meeting, two other subjects have been proposed, as being of great interest for the glass community:

- Characterisation methods of glass quality: proposal was to set up a new technical (sub) committee for this topic within the ICG. Professor Helmut Schaeffer prepared a proposal.
- Development of a course or textbook on chemical engineering and thermodynamics for glass scientist and technologists.

The TC18 annual meeting took place in Trenčín on June 22, 2008 with 10 participants to discuss recent activities on properties of glass forming melts: Progress Round Robin Tests and proposal for future Round Robin Test (2008-2009), report on BRIG Expert meeting on Innovative Glass Melting, Submission of Paper on TC18 Round Robin Test on liquidus temperature analysis of clear float glasses, and the TC18 website.

During the TC18 meeting two oral presentations have been given:

Reinhard Conradt: Calculation of Liquidus Temperatures of Multicomponent Glasses -Options and Limits

Lubomír Němec: (Laboratory) Studies on innovative glass melting

A **new Round Robin** test has been defined: For three glass compositions (multi-component silicates), including a commercial float glass composition, the chemical activities of the constituting compounds (oxides) have to be derived by modelling. About 5 laboratories will participate. Some adaptations may be necessary to narrow the definition

of the round robin test (with or without sulfates and iron oxides in the float glass composition).

The **Website of TC18** was prepared and launched in 2007 (August) and has to be updated at least once per year.

The last activity of TC18, in 2008, was the organisation of a seminar on “**Conditioning of Glass Melts and Forming of Glass Products**” in co-operation with TC25 (Modelling of Forming Processes) and Glass Trend on November 13 – 14, 2008 in Eindhoven (deliverable presentations on WebSite). About 50 persons participated in this seminar.

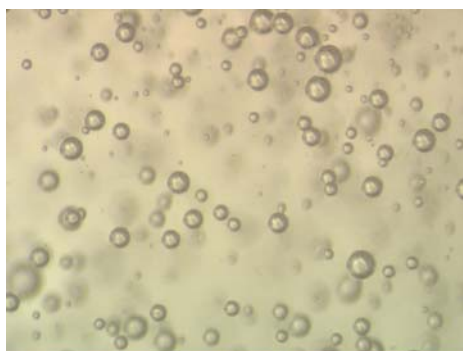


Fig. 4.2.1.4: Bubbles in Molten Glass

PLANS FOR 2009 AND DELIVERABLE

1. Further elaboration of the projects on innovative glass melting for the year 2020 and possibly submission of project proposal for EU-funding (NMP program of the EU). **Deliverable: project proposal and project plan.**
2. TC18 annual meeting in Vancouver: in the week from May 30 – June 5, 2009 at the ICG annual meeting. **Deliverable: Minutes/protocol of the meeting.**
3. Presentations of TC18 members in the Vancouver conference May 31 – June 5, 2009.
4. Round Robin test on Thermodynamic Modelling of Glass Melts. **Deliverable: a short report with comparison of the results (chemical activities of constituents in multi-component silicate melts).**
5. Seminar/expert meeting on defects in glass from melting processes. **Deliverable (envisaged): CD ROM or collection of power point presentations.**
6. Annual reports for EFONGA (WP 3.1) in May 2009 and for ICG (November 2009)

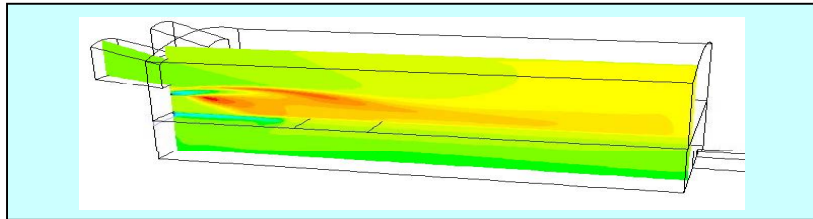
PUBLICATIONS AND OTHER CONTRIBUTIONS

Published Papers from TC18 in 2008 by:

- Beerkens, R.G.C.; Conradt, R.: *Round robin test on liquidus temperature of soda–lime–magnesia–silica float glass samples- A technical report of the ICG Technical Committee (TC 18) on Properties of Glass Forming Melts.* Glass Tech.: Eur. J. Glass Sci. Technol. A, October 2008, 49 no. 5 pp. 205-212
- Special Issue of No. 4/2008 of the Journal: Ceramics-Silikaty with 4 papers presented at the 26.-29. March seminar/expert meeting on “*Innovative Glass Melting for the Year 2020*” in Brig (Switzerland):
- R. Beerkens: *Analysis of elementary process steps in industrial glass melting tanks - some ideas on innovations in industrial glass melting,* Ceramics-Silikaty 52 [4] 206-217 (2008).
- M. Kawaguchi, T. Kato, Y. Imamura, N. Yoshida, S. Aoki: *Challenge to improve glass melting and fining process,* Ceramics-Silikaty 52 [4] 218-224 (2008).

- L. Němec, V. Tonarová: *Glass melting and its innovation potentials: bubble removal under the effect of the centrifugal force*, *Ceramics-Silikaty* 52 [4] 225-239 (2008).
- Lubomír Němec, Petra Cincibusová: *Glass melting and its innovation potentials: the role of glass flow in the bubble-removal process*, *Ceramics-Silikaty* 52 [4] 240 – 249 (2008).

4.2.2 MODELLING OF GLASS MELTING PROCESSES (TC21)



Chairman: *Erik Muijsenberg, Glass Service, Netherlands*

Members: *Wolfgang Muschick, Schott AG, Germany*
Manoj Choudhary, Owens Corning, US
Petr Schill, Glass Service, Czech Republic
Adriaan Lankhorst, TNO, Netherlands
Mathi Rongen, TNO, Netherlands
Gerd Philipp, JSJ-Jodeit, Germany
Otto Hofmann, Jena, Germany
Aaron Huber, Johns-Manville, US
Camille Moukarzel, Stein Heurtey, France
Klaus Jochem, Schott AG, Germany
Zeynep Eltutar, Sisecam, Turkey
Bruno Purnode, Owens Corning, US
Menno Eisenga, Glass Service, Netherlands
Robert Markiewicz, Videocon, Poland
Matthias Lindig, SORG, Germany
John H. Chumley, Logotec, US
Franck Pigeonneau, Saint Gobain Rech., France
Didier Bessette, Fluent, France
David Bivins, AGY, US
Bob Kosmyna, Owens-Illinois, US
Fabrice Fasilow, AGC, France/Belgium
Lale Önsel, Sisecam, Turkey

SUMMARY

TC21 studies continued in 2008 on the following topics;

i) Preparation of a report on the round robin test results of **combined modelling of glass furnaces** for investigating batch blanket models (RRT 4-4a). The draft final report was reviewed during the TC21 meetings

- on December 10, 2007 at Schott offices in Mainz an
- on March 28, 2008 at Fluent offices in Darmstadt.

ii) New round robin test study (RRT 5) of **combined modeling (modeling combustion, glass melt and batch blanket domains) of an industrial furnace** with available, real process data and measurements was started. The first preliminary studies and process data were discussed during the meetings

- on March 28, 2008 at Fluent offices in Darmstadt and
 - on June 22, 2008 in Trencin, Slovakia during the 9th ESG Conference.
- Additional information required was specified and problems that came up in modeling the furnace were discussed based on the first modeling results.
- iii) Complementary studies which could be taken up were considered.
 - iv) First meeting of TC21 in 2009 is planned during the 10th International Seminar on Furnace Simulation, scheduled to be held from June 16 - 18, 2009 in Velke Karlovice, Czech Republic.

PLANS AND DELIVERABLES FOR 2008

Studies planned and realized in 2008 were

- i) preparation of the draft final report on RRT 4-4a
- ii) first studies on the new RRT 5 and improvement of its definition and
- iii) discussions on new topics for TC21.

Deliverables in 2008

- TC21 annual report for 2008 is prepared.
- Minutes of the meetings on March 28 and June 22, 2008 are prepared.
- May 2007- May 2008 annual report and financial status for the Efonga
- workpackage 3.4. have been prepared.
- The draft final reports on RRT 4-4a studies were prepared and revised.
- Definition of RRT 5 was improved.

ACTIVITIES in 2008

Preparation of a report on the studies and results of RRT 4 and 4a;

The second draft of the final report was reviewed during the first meeting in 2008. The sections on the description of the modelling programs and computing facilities were completed. The results from the final studies of participants of RRT 4a were also discussed and the new values were integrated into the output figures and tables of the report.

After the remaining sections of the report are revised, it will be distributed to the participants of the round robin cases for a final review.

Studies on the furnace application of combined modelling; RRT 5- Combined modelling of an industrial furnace

For the new test RRT 5, data, furnace specifications (real data of existing or in the past existing furnace) and drawings are distributed to nine members and four members have started the study. The furnace was an, in the past, existing TV panel glass furnace with detailed data on process conditions and measurements. Additional data on the reaction heat of batch, existence of foam on the surface, target quality and insulation levels were included into the definition of RRT 5 after the meeting in March in Darmstadt. According to these new conditions, one of the participants: Glass Service carried out a second modeling study using the updated data, and the discussion on RRT 5 was carried based on these results. The points/aspects that could be misleading in simulation were discussed along with the possible reasons for the unexpected temperature profile along the depth at the back of the furnace. More information required on the degree of insulation / cooling in the refining end, emissivity values, temperature and thickness of batch, flue gas distribution were completed by TNO from the TV panel furnace operation history. The round robin study will continue with these final changes and the new results will be discussed in the first meeting of TC21 in 2009.

PLANS FOR 2009 AND DELIVERABLE

The round robin study (RRT 5) will continue with the final changes and the new results will be discussed in the first meeting of TC21 in 2009 that is planned during the 10th International Seminar on Furnace Simulation, scheduled to be held from June 16 - 18 June, 2009 in Velke Karlovice, Czech Republic.

Deliverables in 2009:

1. A report for Round Robin Tests 4 and 4a will be completed until May, 2009.
2. The recent round robin test (RRT 5) study will continue in 2009.
3. Minutes of the regular TC 21 meetings will be prepared.
4. An annual report and final report will be prepared for Efungo (wp 3.4.) in May, 2009.
5. Annual report for TC 21 studies in 2009 will be prepared.

4.2.3 MODELLING OF GLASS FORMING (TC25)

Chairman:	<i>C Berndhäuser, Schott AG, Germany</i>
Vice-Chair:	<i>D Locheignies, Univ. Valenciennes, France</i>
Core Group:	<i>D Hegen, TNO, The Netherlands</i> <i>M Hyre, Virginia Military Institute, USA</i> <i>A Karadag, Sisecam, Turkey</i>
Members:	<i>S Aoki, NEG, Japan</i> <i>C Bajart, ARC International, France</i> <i>Y Cai, Johns Manville, USA</i> <i>J H Chumley, Logotec Constr., Inc., USA</i> <i>O Fontaine de Ghelin, AGC FlatGlass – Belgium</i> <i>R Koch, GS Improve, The Netherlands</i> <i>T Marchal, Polyflow, Belgium</i> <i>D Martlew, Pilkington, UK</i> <i>I Matousek, University Liberec, Czech Rep.</i> <i>A Moeller, No Grid, Germany</i> <i>M Moravsky, 2M-Consulting, Slovak Rep.</i> <i>P Moreau, Univ. Valenciennes, France</i> <i>K Oda, Asahi Glass Company, Japan</i> <i>R Penlington, Univ. of Northumbria, UK</i> <i>S Primdahl, Rockwool Intl., Denmark</i> <i>O Prokhorenko, Lab. Glass Properties, Russia</i> <i>S Rekhson, Cleveland State Univ., USA</i> <i>C Richards, PPG Industries Inc, USA</i> <i>M van Iseghem, France</i> <i>R von der Ohe, St Gobain Recherche, France</i> <i>P Vrabel, Rona Crystal,</i> <i>A Yi, Ohio State University, USA</i> <i>Y Youmani, Air Liquide, France</i>
Guests:	<i>P Ngankeu, Emhart Glass, USA</i> <i>E Muijsenberg, Glass Service, The Netherlands</i>

SUMMARY

The TC25 core group met twice in 2008. The first core group meeting took place in Mainz, Germany on May 28, where the Trenčín meeting was prepared.

The second meeting was held in Eindhoven, NL on August 25 to discuss the Round Robin study (Bench Mark Problem) BMP-I results in detail, to slightly simplify output definitions and to prepare the Eindhoven meeting for November.

The 11th TC25 meeting took place on June 22, 2008 in Trenčín, Slovak Republic. The focus of our meeting was the schedule to finalize BMP-I and a discussion of the draft versions for extended Gob (BMP III.2) and Fibre forming (BMP III.2) bench marks – both new definitions and chosen boundary conditions are now in line with experimental facilities at Emhart (BMP II.2) and Cleveland State University (BMP III.2) respectively. For the latter, experimental data are already available (ref. to presentations given by Simon Rekhson in former TC25 meetings) whereas the set up of Emhart's experimental facility is ongoing and tests & measurements are scheduled to be completed by beginning of 2009.

The 12th TC25 meeting took place on November 12, 2008 in Eindhoven, NL. A detailed comparison of BMP I results was presented and intensively discussed. A first résumé is that all of the three codes involved are capable to solve 3d non-isothermal pressing problems with extremely large deformations in acceptable (CPU) times. Not all of the results were in good agreement which might be due to insufficient (not well defined exact positions of the monitor points used for comparison) position of the defined monitor points. For BMP II.2 (Gob) an advanced version of the definitions was presented and discussed and a schedule for next steps has been fixed. For BMP III.2 (Fiber drawing), a detailed definition/set of boundary conditions with all required information to set up the models is now on hand. But finally it seems that not more than one code would be capable to solve the complete coupled (glass flow / air flow / radiation) problem.

A Glass Trend & TC18 Seminar on **“Conditioning of Glass Melts and Forming of Glass Products”** held from November 13 – 14, 2008 in Eindhoven was co-organized by TC25. The program included 12 papers and an excursion to EMGO, Lommel (Belgium) to visit their glass ribbon process for the production of glass bulbs. The seminar has had about 50 international attendees.

PLANS AND DELIVERABLES FOR 2008

BENCH MARK PROBLEM I “3D TV-PANEL-PRESSING”

- Put TNO, Polyflow, NoGrid data together and check consistency; final review of the data by the core group **(done)**
- Core group: Fix a time schedule to finish BMP I **(done)**
- The final comparison shall be presented at the next TC25 meeting in Trenčín (June 2008); **(partly done in November 2008 in Eindhoven, ongoing)**
- Dries Hegen & core group: Preparation of a common paper to publish the BMP-I-results. **(ongoing)**

BENCH MARK PROBLEM II “GOB FORMING” / ADVANCED BMP II.2

- Polyflow, NoGrid: provide the required data for the final comparison to Matt Hyre **(done)**
- TNO: check whether BMP II can be done using software code TNO-GPP and give feedback to Matt Hyre when the data could be provided to him?; **(done)**
- Put TNO, Polyflow, NoGrid data together and check consistency; final review of the data by the core group; **(done, only for Polyflow & NoGrid results)**
- Core group: Fix a time schedule to finish BMP II; **(done)**
- The final comparison shall be presented at the next TC25 meeting in Trenčín 2008; **(done in November 2008 in Eindhoven)**
- Matt Hyre & core group: Preparation of a common paper to publish the BMP-II-results; **(cancelled)**

- Proposal for BMP II.2 definition & boundary conditions to be discussed in a core group meeting in early 2008. **(done)**

BENCH MARK PROBLEM III “CONTINUOUS FIBRE DRAWING” / ADVANCED BMP III.2

- Final proposal for BMP III.2 definition to be discussed in a core group meeting in early 2008. **(done)**
- Contact GS-Improve and 2M as potential candidates for BMP III.2 **(done, both will not directly participate, but eventually via Abaqus cooperation)**

FOR FURTHER TC25 ACTIVITIES

- Mechanical Contact L.A.M.I.H. / Dominique Lochegnies did already a lot of investigations on that issue; ask for his recommendations. **(done, no activities planned)**
- Thermal Contact Oleg Prokhorenko has developed a software to calculate thermal contact conditions; a short presentation is planned for the next meeting. **(postponed)**
- Radiation Model There were already some investigations at TNO, which should be checked; a short presentation is planned for our next meeting. **(done, Trencin meeting)**
- Residual Stress Might be an issue for the TC18/TC25 Glass Trend meeting & seminar: November 13 & 14, 2008, TNO Eindhoven **(no activities)**

Publications and other Contributions

- Prepare paper of BMP-I results **(ongoing)**
- Prepare paper of BMP-II results **(cancelled)**

ACTIVITIES in 2008

BENCH MARK PROBLEM I “3D TV-PANEL-PRESSING”

For the first time a detailed comparison of BMP I results of **TNO**, **NoGrid** and **POLYFLOW** codes is available now and was presented and intensively discussed at the Eindhoven meeting (November 2008). A first résumé is that all of the three codes involved are capable to solve 3D non-isothermal pressing problems with extremely large deformations in acceptable (CPU) times.

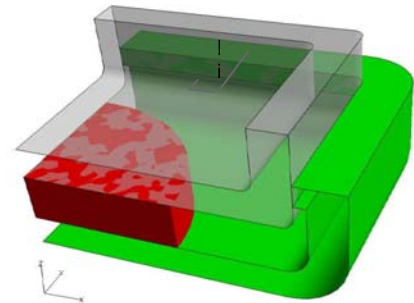


Fig.4.2.3.1: initial configuration (T.Marchal / Abaqus)

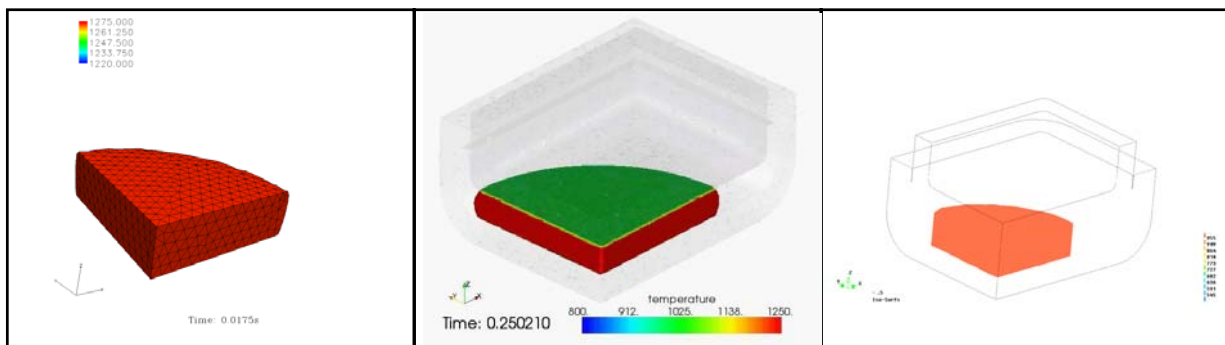


Fig. 4.2.3.2: Glass temperature distribution (1st time step of 3D animations) (T. Marchal /Abaqus, A. Möller /NoGrid, D. Hegen /TNO)

Results of temperatures, velocities and pressures have been compared in 3 different vertical cross sections for 9 fixed time steps. The tracking of the free surface and the velocity results are in good agreement with each other whereas temperature results need

further discussion. Only two codes show the typical cold layer in the glass at the glass/solid interface, for the third code this effect becomes visible only at the end.

More detailed inspection of the results can be obtained by monitoring results at precisely fixed coordinates in space (monitor points) with time. For each domain glass, mould and ring respectively 5 monitor points have been defined. Partly, the results of the three codes at these monitor points differ significantly from each other. Two explanations for this have been identified: (1) all of the glass monitor points are at the glass edge – this might cause different treatment in the post processing (extrapolation of cell values to node values and eventually interpolated values between glass/solid edge); (2) mould and ring monitor points might be too insensitive to temperature increases that are encountered after contact with the glass (monitor points don't "see" temperature increase after 1 cycle due to the distance to the glass interface ⇒ i.e. in both cases observed temperature differences between the codes might be just due to insufficient positions of the defined monitor points. To solve this post-processing problem it has been agreed to (1) slightly move monitor points to more appropriate positions, (2) add monitor points in the centre of the model, (3) add monitor lines across glass and solid domains to get continuous profiles especially at the glass/solid interfaces.

BENCH MARK PROBLEM II “GOB FORMING”

Results for a complete non-isothermal run according to the recent BMP definitions are available from *NoGrid* and *Polyflow*. A **comparison of these results** has been presented in Eindhoven in November 2008 (s. Fig. 4.2.3.4).

POLYFLOW has used a 2D axi-symmetric model according to the BMP definitions whereas *NoGrid* provided results of a full 3D model instead of axi-symmetric assumption (s. Fig. 4.2.3.3).

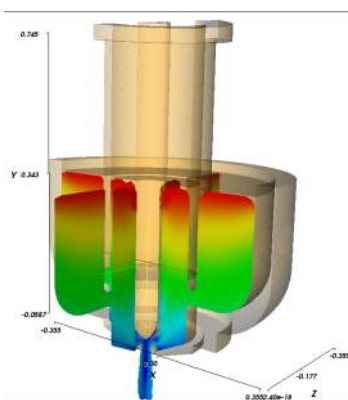


Fig. 4.2.3.3: 3D-model
(A. Möller /NoGrid)

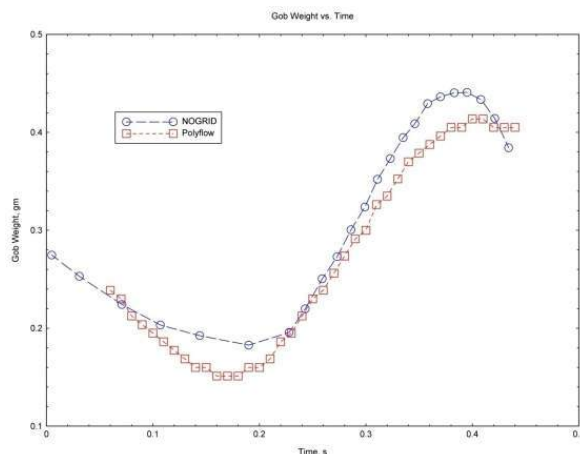


Fig.4.2.3.4: Gob weight - Polyflow vs. NoGrid results
(M.Hyre /Emhart)

In general both results show a similar behaviour of the gob weight versus time, but the relative error exceeds about 15% which seems to be not really satisfying. Potential reasons have been discussed:

1. Definition of the correction motion profile
2. Initial temperature profile led to unrealistic results (gob too short)
3. Surface boundary conditions not realistic
4. Glass flow inlet conditions not realistic
5. 2D-axisymmetric vs. full 3D model
6. Calculation not yet periodic

However, it has been demonstrated in general that *POLYFLOW* and *NoGrid* codes are capable to solve these type of gob forming problems. But due to several reasons (lack of experimental data, only two codes involved, etc) it has been decided to stop BMP-II-phase1 and to continue with an extended BMP definition.

For **BMP-II.2 an advanced version** of the definitions & boundary conditions was presented and discussed and a schedule for next steps has been fixed. At least *Polyflow*, *TNO* and *NoGrid* agreed to the proposal and would be willing to continue BMP-II activities. Participation of further codes (*ABAQUS/Simulia*, Forming code O.Prokhorenko) will be considered.

The **goal of this benchmark BMP-II.2** is to model the weight, shape and temperature of the gob at the time of its delivery to the forming process (at the point of shear cut). As opposed to Phase 1, this problem will be fully three-dimensional. The result should include the volume and length of the gob at the point of shear cut, the vertical position of the point of largest and smallest diameter, the surface area of the gob, and the average temperature of the gob.

It is planned by EMHART to provide the following experimental data for comparison and validation of the modelling results:

1. Gob weight
2. Gob diameter vs. length (through high speed video)
3. Average gob temperature
4. Gob surface temperature vs. length
5. Gob length

The definitions will be completed in February 2009 when the experimental set up at Emhart is finished and all parameters are known.

BENCH MARK PROBLEM III “CONTINUOUS FIBRE DRAWING”

For **BMP-III.2 a detailed definition** with all required information to set up the models is now on hand. TC25 members agreed that recommendations given by Simon Rekhson are widely included in the BMP definitions and that BMP-III.2 seems to be realistic enough to attract industrial interest. Furthermore, the complexity of the problem due to the coupling of glass / air flow and radiative interaction between the fibres and the cooling fins has been discussed.

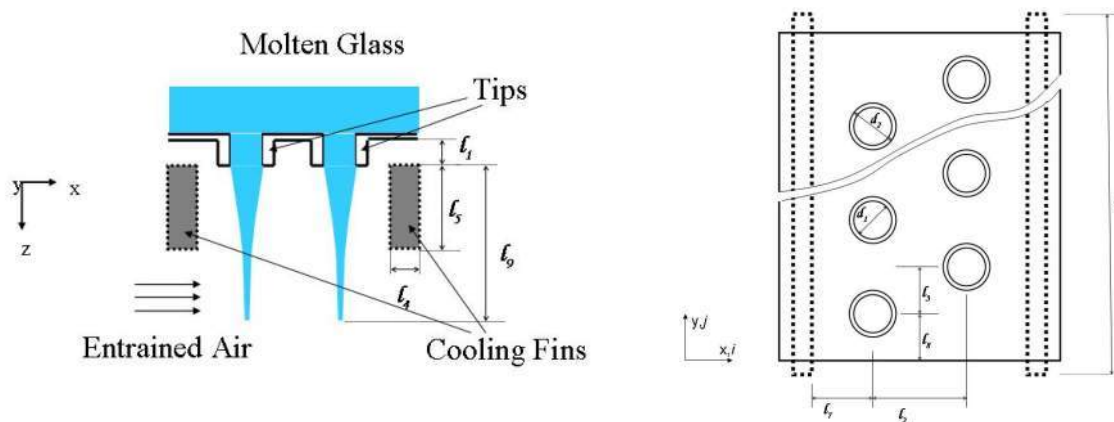


Fig.4.3.2.5: side and top view of the model geometry (A.Karadag / Sisecam)

It became apparent that the present BMP-III.2 definition would be a very challenging task and that most of the potential codes in mind would not be capable to solve the entire

problem. Present TC25 members agreed that BMP-III.2 could be solved only by coupling of at least two codes – e.g. Fluent ⇔ Polyflow. Hence it has been decided first to check whether other codes / coupling of other codes might be capable to solve the fibre forming problem according to the present definitions or not – otherwise a more simplified definition would be necessary before starting the bench mark and comparing different models.

Meetings in 2008

28.05.2008	Mainz	Core Group	Preparation Trenčín meeting
22.06.2008	Trenčín	TC25	Update status of BMP's
25.08.2008	Eindhoven	Core Group	Preparation Eindhoven November meeting Discussion BMP-I results
12.11.2008	Eindhoven	TC25	Presentation BMP-I results Presentation & discussion extended BMP definitions for gob and fibre forming
13./14.11.08	Eindhoven	Glass Trend Workshop	

PLANS FOR 2009 AND DELIVERABLES

BENCH MARK PROBLEM I “3D TV-PANEL-PRESSING”

- Update monitor point and monitor line definitions (Jan. 2009)
- Update TNO, Polyflow, NoGrid results (from new monitor points) for final comparison (Mar. 2009)
- Update final comparison to be presented at EFONGA meeting (Montpellier, May 2009) and 1st TC25 meeting 2009
- Preparation of a common paper to publish the BMP-I results

BENCH MARK PROBLEM II “GOB FORMING” / ADVANCED BMP-II.2

- Final version for BMP-II.2 definition available and distributed (Feb. 2009)
- Contact Abaqus, Prokhorenko, as potential candidates for BMP-II.2 (Mar. 2009)
- Commitment of TNO, Polyflow, NoGrid, to start BMP-II.2 (Mar. 2009)
- 1st TC25 meeting 2009
 - report of first experimental results of Emhart facility
 - discussion of first modelling experiences and decision to update BMP-II.2 definitions if necessary
- 2nd TC25 meeting 2009
 - presentation of first BMP-II.2 results

BENCH MARK PROBLEM III “CONTINUOUS FIBRE DRAWING” / ADVANCED BMP-III.2

- Review of the current BMP-III.2 definitions by all TC25 members regarding capability of codes to solve the entire fiber forming problem (decision Feb. 2009)
- Commitment / Veto of potential candidates
 - ⇒ decision to start BMP-III.2 or to simplify definitions (Mar. 2009)
- 1st TC25 meeting 2009
 - discussion of first modelling experiences OR update of BMP-III.2 definitions
- 2nd TC25 meeting 2009
 - presentation of first BMP-III.2 results

MEETINGS

- 1st TC25 meeting 2009: probably at ICG annual meeting -Vancouver, June 2009
- 2nd TC25 meeting 2009: Fall 2009 - not yet fixed

PUBLICATIONS AND OTHER CONTRIBUTIONS

- Prepare paper of BMP-I results

4.2.4 MATERIALS FOR GLASS MANUFACTURING (TC11)

Chairman: Michael Dunkl, Dr. M. Dunkl Consulting
Vice-Chairs: Nobuyuki Kido, AGC CERAMICS CO., Ltd
Secretary: Jean-Pierre Meynckens, AGC Flatglass Europe
Members: Esref Aydin, Sisecam
Janusz Zborowski, SCHOTT AG
Michel Gaubil, Saint Gobain
Rongxing Bei, RHI AG
Roland Heidrich, RHI REFEL
Chris Windle, DSF
Anne Jans Faber, TNO
Bernhard Fleischmann, DGG
Michel Maquet, Saint Gobain
Sandro Hreglich, Stazione Sperimentale del Vetro
Roel van Herten, Philips Lighting
Larry Kotaska, CORNING
Detlef Koepsel, SCHOTT AG
Wilfried Linz, SCHOTT AG
Jean Louis Heitz, CRITT
Dilip Patel, NARCO
Hans-Peter Martins, PLANSEE
Brian Harris, Pilkington
Mariano Velez, MOSCI
Amul Gupta, RHI MONOFRAX
Mathi Rongen, TNO
Mustfa Oran, SIS CAM
Samir Tablouli, FIVES STEIN

SUMMARY

- In the joint TC11/TC14 meeting in Trenčín, the results of the dynamic blister Round Robin Tests between Tank Refractory-Glass Melt were discussed and the cause of the differences between the results were found. Further common dynamic blister tests will be carried out before the other RRT (static crucible test HTO test) can be start.
- From 19 proposed topics for the future TC11 activities the most important 5 topics were chosen in Trenčín and a few of them have already been discussed in Düsseldorf. These 5 priority topics are given below in this report.
- A TC11 meeting and a joint TC11/TC14 meeting took place during the 9th ESG CONFERENCE in Trenčín on June 22, 2008 and a TC11 meeting was held during the GLASTEC in Düsseldorf on October 20, 2008. There were 12 participants at the TC11 in Trenčín, 17 participants at the joint TC11/TC14 and 13 participants at the TC11 in Düsseldorf.

PLANS AND DELIVERABLES FOR 2008

At the TC11 in Trenčín on June 22, 2008 the members have chosen the most important 5 topics from 19 proposed topics for the future TC11 activities. A few of them were already discussed during the TC11 meeting in Düsseldorf.

During the joint TC11/TC14 meeting in Trenčín, the results of the dynamic blister Round Robin Test between Refractory-Glass Melt were discussed and the reason for differences in the results were found. It was decided that further common dynamic blister tests will be carried out before the other RRT will be start.

ACTIVITIES in 2008

In TC11 meeting in Trenčín, the 19 topics of the proposed list within the “Minutes of the meeting of TC11 in Strasbourg 2007” were discussed and the following five topics with the most importance were chosen to work in the near future:

1. Recommendations for refractory choices for different parts of glass furnaces;
2. Selection and recommendation of test methods for the determination of the Glass defect potential of refractory materials;
3. Recommendation and publication of the Exudation test method;
4. Corrosion behaviour of Refractory materials for regenerators;
5. REACH= Registration, Evaluation, Authorization and Restriction of Chemical substances

In the TC11 Düsseldorf meeting, a few presentations of the various chosen topics were given by the different members:

1. REACH

A good and clear presentation of Dr. Steinle from the German Refractory Association – Verband der Deutschen Feuerfest-Industrie e. V. and a follow-up explicit discussion has increased the necessary knowledge for the refractory and glass companies regarding REACH for refractory materials.

2. **Corrosion behaviour of refractory materials** for the regenerators.
Four presentations regarding experiences, research and solutions were given.
3. Test methods for the determination of the Glass defects potential of refractory materials. Four papers about the contamination of the glass by refractory contact and its potential evaluation tests (glass defect potential tests) were given.



Fig. 4.2.4.1: Boundary layer area of a fused cast AZS 32 / soda lime silicate glass melt after a crucible test with generated glass defects, like Stones, Knots and Blisters.

In the joint TC11/TC14 meeting in Trenčín, the results of the dynamic blister Round Robin Test between Refractory-Glass Melt were discussed. A discussion was undertaken in order to try to account for the observed differences in the results. During this discussion, several differences were discovered both in the way that the refractory crucible was prepared and the way of the evaluation performed. Further a few other differences like temperature measurement and sealing of the furnace were found, too. These variations of the tests could explain the found differences in the results of blister numbers and blister rate. Based on this result, a detailed description of the dynamic blister test conditions was worked out by Michael Dunkl and the both TC11 members AGC CERAMICS and SCHOTT AG will carry out new blister tests after this guideline.

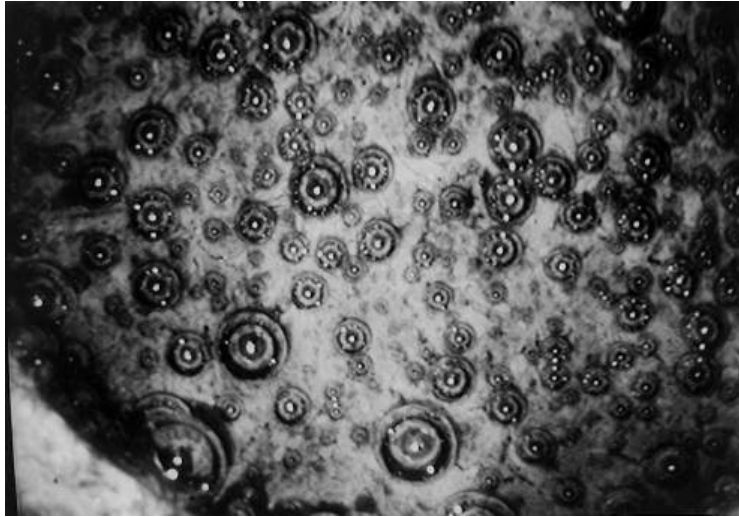


Fig. 4.2.4.2: Dynamic Blister test Method: Picture of the blistering behaviour of a porous refractory material at 1420 °C after one hour reaction time

PLANS FOR 2009 AND TARGETTED DELIVERABLES

- 1) TC11 meeting with presentations and discussions of the 5 chosen most important (priority) TC11 topics within the first half of 2009.
- 2) Joint TC11/TC14 meeting for the presentation of the repeated dynamic blister test results from AGC CERAMICS and SCHOTT AG. Determination of the further steps of the TC11/TC14 RRT.
- 3) TC11 and joint TC11/TC14 meetings during the second half of 2009, e.g. during the Refractory Colloquium in Aachen.

One deliverable in 2009 is a draft report of the comparable results of the RRT on “Blisters in Glass from Refractories”

Another deliverable in 2009 is a kind of roadmap, with a proposed schedule of activities of TC 11 in the next 3-5 years.

PUBLICATIONS AND OTHER CONTRIBUTIONS

During the Refractory session of 9th ESG2008 in Trenčín, the following papers were given by TC 11 members:

- Bernhard Fleischmann: The microstructure of fused cast AZS materials before, during und after use for glass melting
- Michael Dunkl: Boundary layers Refractory/Glass melt and Glass defects
- Nobuyuki Kido: Recent problems in glass melting form the point of view of refractory and its solutions
- J.P. Meynckens, B. Cherdon: Environmental impact for regenerators checkers materials selection in soda-lime flat glass furnaces
- Rongxing Bei, Stefan Postrach: New micro-porous and dense refractory materials for glass Industry
- Rongxing Bei, Stefan Postrach: A new silica brick without lime bonding
- H.-P. Martinz(a), J. Matej(b), B. Nigg(a), M. Sulik(a), H. Larcher(a): The Properties of the SIBOR® Oxidation Protective Coating on Molybdenum Alloys
- Michael E. Schupp, Manfred Herweg: Production and application of MoSi₂ heaters

4.2.5 SENSORS AND ADVANCED CONTROL (TC15)

Chairman:	W. Linz, SCHOTT AG, Germany
Vice-Chair:	K. Oda, AGC, Japan
Members:	A. Huber, Johns Manville, USA K. Kono, Nippon Electric Glass Co, Ltd., Japan J. Plodinec, SRNL, USA P. H. Guering, St. Gobain, France I. Solis, Vitro, Mexico
New Members:	B. Purnode, Owens Corning, USA C. Wright, NSG/Pilkington, UK M. Demeyere, AGC Flatglass Europe, Belgium H. Müller-Simon, HVG, Germany P. Laimböck, Readox, Netherlands E. Muijsenberg, GS, Netherlands

SUMMARY

The input for the BRIG-Meeting (expert meeting on **Innovative Glass Melting Processes**, from March 26 – 29, 2008 in Brig-Switzerland) was prepared with several email contacts by the chair. The presentation on “**Needs and Requirements for Sensors in Industrial Glass Production**” was given by R. Beerkens at the BRIG-Meeting. After this workshop in Brig, further work was done for a proposal of one of the 4 top themes defined at the Brig-meeting: **Advanced Sensors and Control of Glass Melting Processes**, this proposal was prepared by TC15 members and the active new members.

The annual meeting of members and potential new members for TC15 took place at the ESG-Conference in Trenčín, Slovakia, in June 2008. Another meeting was organized at the Glass Problems Conference in Columbus, USA, November 2008 and SCHOTT Mainz/Germany in November 2008. The search for potential new active members from industry, institutes and suppliers after the loss of 7 members last year was in the focus.

PLANS AND DELIVERABLES FOR 2008

The activities started in 2007 will be continued in 2008 and 2009. After loss of members in 2007, more effort will be put on the search for new active members not only from industry but also from institutes, universities and suppliers.

Meetings were in planning for the ESG-conference in Trenčín (SK) with the intention of an internal workshop at the MS&T 2008 in Pittsburgh (USA) or in Germany. Some TC15 meetings (Trenčín, Columbus OH, Mainz) have been taken place in 2008.

The envisaged road map on sensor technology will be finished and presented as a report at the end of 2008.

ACTIVITIES in 2008

New members from industry, institutes/universities and suppliers were found and they have been integrated in the active work, concerning the further evaluation of the need for better or new sensors and requirements for control software for glass production processes.

A presentation concerning the “Needs and Requirements for Sensors in Industrial Glass Production” was prepared for the BRIG-Meeting (March 2008) and in core group meetings. As a result of the Brig meeting, a proposal for future research activities of the in BRIG

identified top theme: "Sensors and Advanced Control of Glass Melting Processes" was discussed and drafted later in the year.

PLANS FOR 2009 AND DELIVERABLES

Discussion about further steps that can be taken to initiate R&D-Projects and to apply for national or international funding to continue and support the process started in Brig concerning "Innovative Glass Melting" and especially, the sensors and control theme. A TC15-meeting is scheduled at the furnace simulation seminar June 16 – 18, 2009 Velke Karlovice, Czech Republic. Additional regular net-meetings are planned during the year. In 2009 the organisation of a seminar (perhaps in co-operation with Glass Trend) on sensors, modelling and control of glass melting processes will start.

PUBLICATIONS AND OTHER CONTRIBUTIONS

Presentation at the BRIG-Meeting: "Needs and Requirements for Sensors in Industrial Glass Melting Processes."

4.2.6 GASES IN GLASS (TC14)

Chairman: Detlef Koepsel, Schott AG, Germany
Vice-Chair: Noriyuki Yoshida, NEG, Japan
Secretary: John Buckett, Pilkington Group Limited, UK
Members: Marie-Helene Chopinet, St.Gobain Recherche, France
Yukihito Nagashima, NSG, Japan
Jaroslav Klouzek, ICT Prague, Czech Republic
Fritz Kramer, Schott AG (retired), Germany
Hayo Muller Simon, HVG-DGG, Germany
Jan Hermans, Philips, The Netherlands
Ruud Beerkens, TNO, The Netherlands
Stefano Maurina, SSV, Italy
Martin Gaber, BAM Berlin, Germany
Ralf Mueller, BAM Berlin, Germany
Jiri Ullrich, Glass Service, Czech Republic
Lubomir Nemecek, ICT Prague, Czech Republic
Harald Behrens, University of Hannover, Germany
James E. Shelby, Alfred University, USA
Juergen Daniel, ZGU Ilmenau, Germany
Mustafa Oran, Şişecam, Turkey
Valery Kreisberg, Moscow State University, Russia
Toshinobu Yoko, Tokyo University, Japan
Leonid Glebov, University of Florida, USA
Oliver Collart, Asahi Flat Glass Europe, Belgium
Klaus Heide, Friedrich-Schiller University Jena, Germany
Hande Sengel, Şişecam, Turkey
Wolf S. Kuhn, Stein-Heurtey, Germany

SUMMARY

The members of the TC14 work on 3 different problems: (1) the determination of the absolute water content in borosilicate glass in order to derive reliable absorption coefficients for the IR spectroscopic water analysis, (2) developing a test procedure for the

determination of the blistering rate of refractory material and the understanding of mechanisms of blister formation at refractories, (3) the understanding of mechanisms of deposit formation in bubbles in float glass. The work has partially been performed in collaboration with TC11 and TC02.

In 2008 two meetings were held in Trenčín during the ESG conference, one of them together with TC11. Furthermore, 3 core group meetings were held at different places (Brussels/Belgium, Lathom/UK, Herzogenrath/Germany), among them one core group meeting together with TC11 and another one together with TC02.

ACTIVITIES 2008

(1) Water in borosilicate glasses

In addition to measurements undertaken in 2007 the absolute water concentration in borosilicate glasses has been analysed with a 3rd method – Karl-Fischer-Titration (KFT). This method can be used only for glasses with a relatively high water concentration. Therefore, only 3 of the 5 glass compositions could be analysed with KFT. Unfortunately, the discrepancies between the previous results obtained with Vacuum High temperature Extraction (VHE) and Nuclear Reaction Analysis (NRA) could not be explained with the help of the new results (Fig.4.2.6.1 - 2). The reproducibility of the new results is not really satisfactory. It is assumed that the glass samples are not very homogeneous due to evaporation losses of B₂O₃ during saturation of the samples with H₂O. Therefore, it was decided to prepare new glass samples under different conditions in order to prevent evaporation losses and thus inhomogeneities.

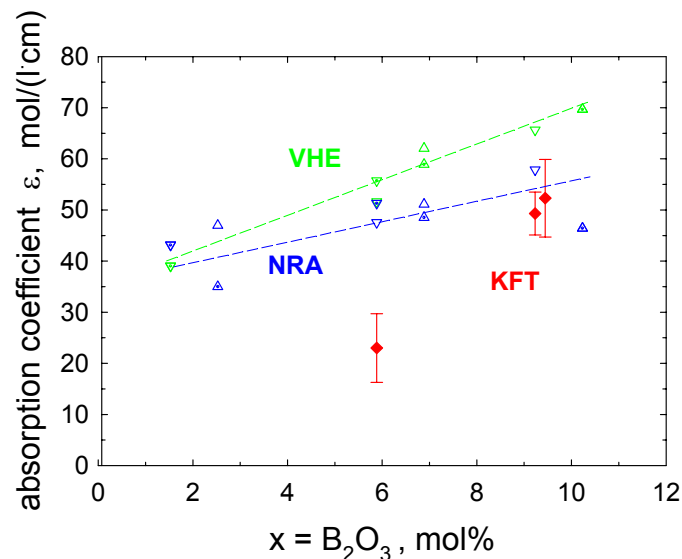


Fig. 4.2.6.1: Absorption coefficient in borosilicate glasses: $15\text{Na}_2\text{O} \cdot x\text{B}_2\text{O}_3 \cdot (85-x)\text{SiO}_2$, determined with 3 different analytical methods

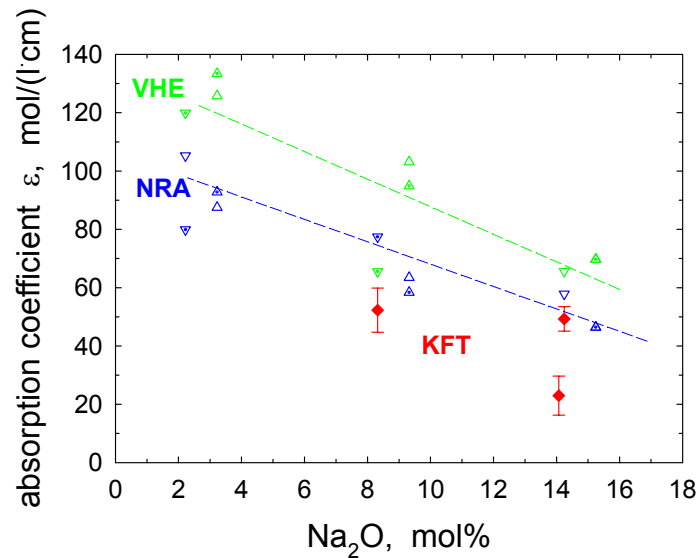


Fig. 4.2.6.2: Absorption coefficient in borosilicate glasses: $x\text{Na}_2\text{O} \cdot 10\text{B}_2\text{O}_3 \cdot (90-x)\text{SiO}_2$, determined with 3 different analytical methods

(2) Refractory blisters (in collaboration with TC11 and TC02)

The round robin test on the determination of the blistering rate with the dynamic blister test has been repeated twice. The results are still not satisfactory (Fig. 4.2.6.3). Two laboratories participated in the test using the same glass and refractory material.

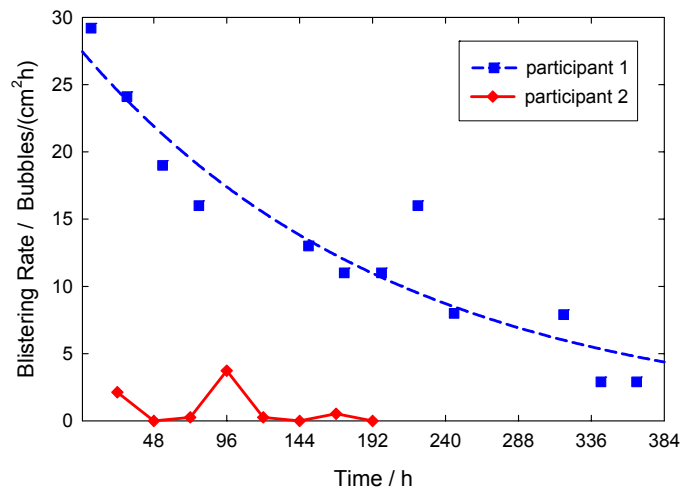


Fig. 4.2.6.3: Blistering rate determined with dynamic blister test (2 participants)

Differences in the preparation of the glass cullet used for the test and differences in the bubble counting procedures have been identified as reasons for the discrepancies. It was decided to repeat the test a 3rd time under absolutely equal pre-described conditions.

In order to understand the mechanisms of blister formation not only the analysis of the gas content/composition of freshly formed blisters at the refractory is important, but also the analysis of impurities in the refractory. Therefore, it was decided to broaden the focus of this activity by analysing the impurities in the refractory material such as carbon, sulphur and nitrogen (nitrides). Together with TC02 three different analytical methods have been identified which should be used for the impurity analysis in a next step.

(3) Sulphur deposits in bubbles

The gas composition of bubbles with deposits and the deposits themselves have been analysed with 2 different methods (SEM/EDX and Raman spectroscopy).

In this case, the bubbles contain mainly N₂ and some Ar, SO₂, CO₂ (N₂ > 90%, Ar ≈ 1, CO₂ < 6%, SO₂ < 2%). The deposits consist mainly of sulphur and/or sulphur compounds (SEM/EDX). With the help of Raman spectroscopy sulphate (Na₂SO₄) and elemental sulphur (Fig. 4.2.6.4 - 5) have been found.

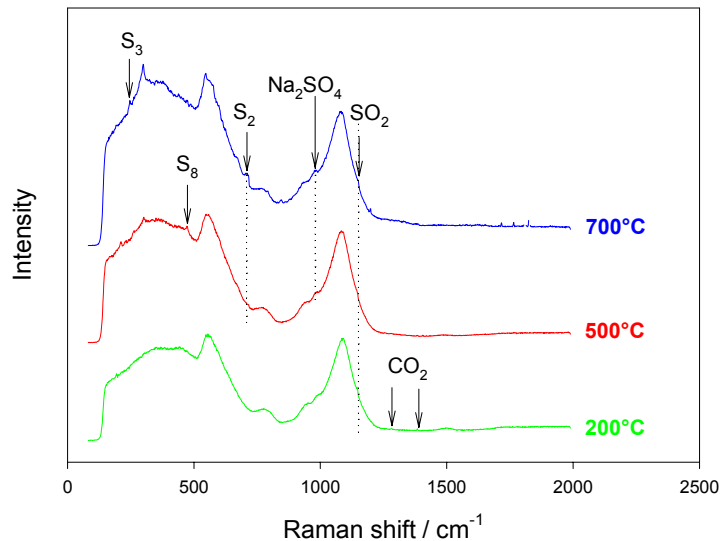


Fig. 4.2.6.4: Raman spectra of the gaseous species and the deposits at the bubble boundary (float glass, Şişecam, nitrogen peaks not shown)

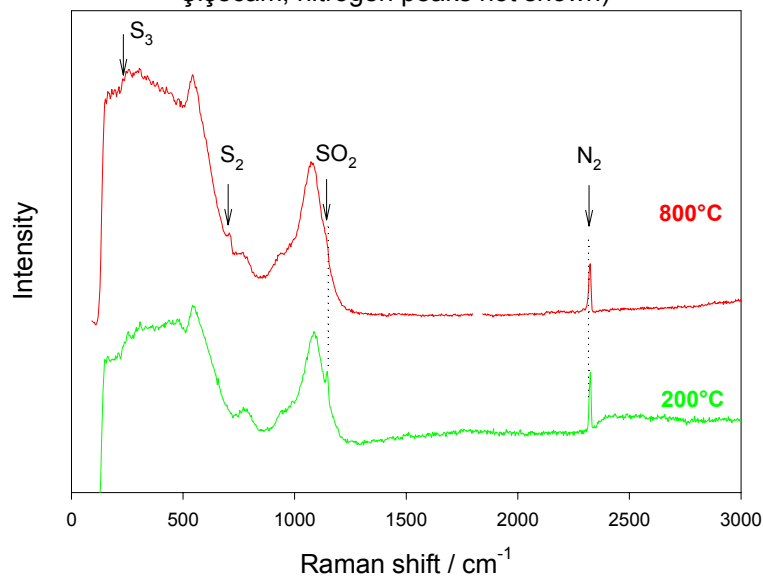
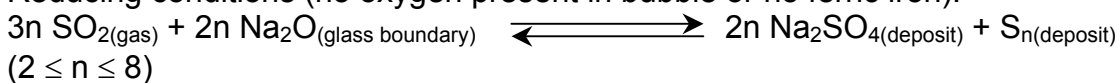


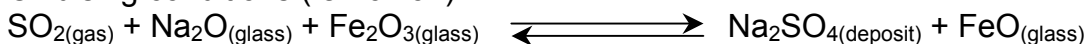
Fig. 4.2.6.5: Raman spectra of the gaseous species in a bubble (float glass, Pilkington)

It is assumed that the deposits are formed at the bubble boundary during cooling of the glass samples according to the following reactions:

Reducing conditions (no oxygen present in bubble or no ferric iron):



Oxidising conditions (ferric iron)



It was decided to investigate the influence of the redox conditions on the deposit formation in a next step.

ACTIVITIES in 2008

Meeting	Date	Place	Topics	Participants
Joint core group meeting TC11+TC14	09/04/2008	Brussels, AGC Flat glass Europe	<ul style="list-style-type: none"> • Determination of the refractory blistering rate: results of the 1st round • Discussion of the reasons for the deviations and the actions for the next round 	7
Core group meeting	18/04/2008	Lathom, Pilkington	<ul style="list-style-type: none"> • Presentation of analytical results of the deposits in bubbles • Discussion of potential mechanisms of deposit formation and next actions • TC 14 website 	6+2 guests
TC14 meeting	22/06/2008	Trenčín	<ul style="list-style-type: none"> • Presentation of new results on water in borosilicate glass and discussion of the reasons for the deviations and next steps • Presentation of analytical results of the deposits in bubbles, discussion of potential mechanisms of deposit formation and next actions 	12
Joint meeting TC11+TC14	22/06/2008	Trenčín	<ul style="list-style-type: none"> • Determination of the refractory blistering rate: results of the 2nd round • Discussion of the reasons for the deviations and the actions for the 3rd round 	17
Joint core group meeting TC02+TC14	23/10/2008	Herzogenrath, St.Gobain	<ul style="list-style-type: none"> • Presentation of literature data on impurities in refractories • Discussion of the literature data • Identification of “best” methods for a following RRT on impurities (C, N, S) in AZS material 	12

PLANS FOR 2009 AND DELIVERABLE

(1) Water in borosilicate glasses

The glasses have to be melted once more in order to achieve a relatively good homogeneity. The absolute water concentration has to be determined not only with the methods which have been used in the past (VHE, NRA, KFT) but also with an additional method (ERDA – elastic recoil detection analysis).

(2) Refractory blisters (in collaboration with TC11 and TC02)

The blistering rate has to be determined a 3rd time under absolutely equal conditions. In order to understand the mechanism of blister formation additional investigations have to be undertaken:

- analysis of the gas content of freshly formed blisters
- analysis of the gas content of “pores” in the refractory material
- analysis of impurities in the refractory and their influence on blister formation (support of TC02)

(3) Sulphur deposits in bubbles

The influence of the redox conditions of the molten glass on the deposit formation has to be investigated. Therefore, bubbles with deposits have to be collected from furnaces running under oxidising and reducing conditions. Additionally, bubbles in a glass with low iron content have to be analysed.

(4) Preparation of a session/seminar during the next ICG congress in Brazil in 2010

The TC14 and TC21 decided to prepare a seminar on modelling of bubble formation, bubble behaviour, fining and refining during the next ICG congress in Brazil in 2010.

4.2.7 ENVIRONMENT (TC13)

Chairman	Guy Van Marcke, Belgium
Secretary	Simon Slade, UK
Members	Georgy Liptak, Hungary
	Karlheinz Gitzhofer, Germany
	Andreas Kasper, Germany
	Petr Beranek, Czech Republic
	Phill Ross, USA
	Guy Tackels, France
	Denis Lalart, France
	John Stockdale, UK
	Dilek Bolcan, Turkey
	Hans van Limpt, The Netherlands
	Ruud Beerkens, The Netherlands
	N. Favarro, Italy
	Thomas Hünlich, Germany

SUMMARY

The focus topics of the year had been

- measurement and identification of dust emission
- filter dust recycling and
- new types of air pollution control,

i.e. the TC13 continues to be a very active committee proving to be useful to its members and to the wider glass community. The committee met only once at June 26, 2008 in Trenčín, Slovakia.

ACTIVITIES IN 2008

Environmental regulators around the world are increasingly focussing on the harmful impacts of fine particulate matter. **Characterising particulate matter emissions** under different operating conditions continues to be an important part of TC13s current work. The analysis of the dust **particle sizes and size distributions** of emitted flue gas dust from glass furnaces was one of the focus topics of TC13 in 2007 and 2008. Members of the sub-committee that have purchased an Anderson MkIII cascade impactor particle size analyser (equipment to determine the size distribution of fine dust in a flue gas flow) presented some of their results. It was agreed that the group's work should be published. This should become a useful document, similar to the committee's recently published paper on selenium emission sampling that has proved to be very popular reference.

Other subjects discussed included the negative effects of pollution control plant filter dust recycling and **New types of Air Pollution Control**. TC13 discusses new developments in emission control technology such as high temperature filtration. Also the new Glass BREF (revision of this document is underway in 2008) has been discussed. This document will be the main guideline for authorities to permit emissions of glass production plants.

As usual, developing **regulations** were discussed, with emphasis on the impact of the revision of the IPPC directive and the allocation of CO₂ for the next phase of the EU ETS.

4.3 R&D Activity Field "Surfaces & Interfaces"

4.3.1 NANOSTRUCTURED GLASS (TC16)

Chairman: *Rui M. Almeida, IST/ICEMS, Portugal*

Vice-Chairs: *Alex Martucci, Univ. Padova, Italy*

Members: *Sidney Ribeiro, Univ. Araraquara, Brazil*
Kiyoharu Tadanaga, Osaka Pref. Univ., Japan
David Levy, ICMM-CSIC, Spain
M. Clara Gonçalves, IST/ICEMS, Portugal
Luís Carlos, Univ. Aveiro, Portugal
Mario Aparicio, ICV, Spain
Yolanda Castro, ICV, Spain
Hui Yang, Zhejiang Univ., China
Jian Xu, Univ. Ningbo, China

SUMMARY

The activities of TC16 during 2008 were mostly related to the EFONGA project and corresponding deliverables. During the first half of the year, the TC members concentrated in completing the deliverable "**Technical report on the nature of the ITO coating - aluminosilicate glass interface**", which was finished in June. During this period, the TC16 chair attended a CTC meeting in Paris (January), an EFONGA/ TC16 meeting in

Frankfurt (June), the CTC meeting in Trencin (June) and he also met with the vice-chair Alex Martucci in Padova in April. During the second half of 2008, a few new members joined TC16 and a manuscript based on the work of deliverable described above has been under preparation for submission to the Journal of Sol-Gel Science and Technology. Meanwhile, a paper was published (M.A. Aegerter, Rui M. Almeida, A. Soutar, K. Tadanaga, Hui Yang and T. Watanabe, "Coatings made by sol-gel and chemical nanotechnology", J. Sol-Gel Sci. Technol. 47 (2008) 203 – 236).

PLANS AND DELIVERABLES FOR 2008

TC16 planned to study the nature of the glass substrate / sol-gel coating and the sol-gel coating / atmosphere interfaces, using an ITO (In_2O_3 : Sn) coating prepared at INM in Saarbrücken (Germany). This study corresponded one deliverable of the EFONGA project and it should occupy the first half of 2008. A meeting was anticipated for February 2008 and another one for Trencin (Slovakia) in June 2008. Meanwhile, an effort should also be made to find a few additional people interested in nanostructured glasses and the June meeting should be devoted to discuss new topics to work on after completion of the deliverable, depending on the particular interests and capabilities of the active members of TC16.

ACTIVITIES in 2008

There was a CTC meeting in Paris (January 25), which was attended by the TC chair, Rui Almeida. Members of TC16 started the experimental work on the EFONGA deliverable, consisting of a study of the nature of the interface between an ITO coating (previously characterized by the Round Robin tests reported in D17) and the corresponding alkali free aluminosilicate glass substrate (Schott, AF45), using different techniques available in the four participating laboratories. These included TEM, SIMS, XPS and Spectroscopic Ellipsometry. HRTEM showed that, at the interface between the glass substrate and the ITO coating, there was a layer approximately 8-10 nm thick; however, for a sample annealed at 300 °C, this interface layer mostly disappeared. Ellipsometric models have also shown that an interface layer, with a thickness varying between ~ 5 - 8 nm, was present, in good agreement with the electron microscopy data. Both this interface layer and the material between the particles appear to be formed by a non-crystalline phase, most probably the binder. The interface layer, whose sharpness was confirmed by the SIMS and XPS results, might be of high importance for a good adhesion of the ITO coatings to the glass substrate. The figure below shows the observations made by Field Emission Scanning Electron Microscopy (FE-SEM) by K. Tadanaga (Osaka Prefec. Univ., Japan).

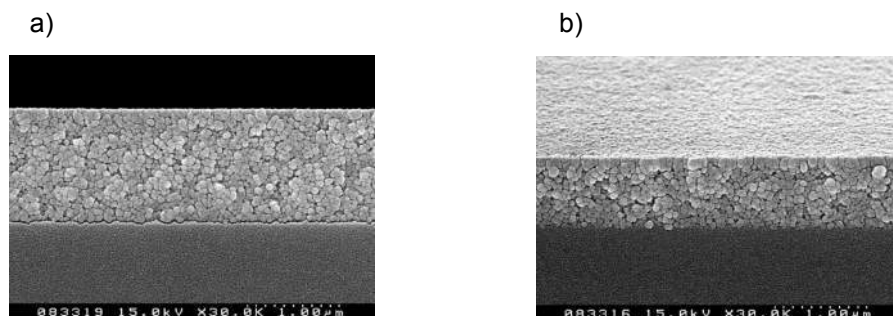


Fig. 4.3.1.1: FE-SEM cross-section images of (a) UV-cured and (b) FG post-treated ITO coating on a alkali-free aluminosilicate glass substrate (Schott, AF45).

A meeting was held in Padova on April 11, in order to finalize the report for the EFONGA project and, after a few additional experiments, this deliverable was completed and submitted in June.

In June the TC chair attended two meetings. An EFONGA TC16 meeting in Frankfurt on the 12th and the CTC meeting in Trencin (Slovakia), on the 24th, held during the 9th ESG Conference and Annual Meeting of ICG.

Since then, some new members have joined TC16: M. Clara Gonçalves and Luís D. Carlos, from Portugal, Mario Aparicio and Yolanda Castro, from Spain and Jian Xu, from China.

Since September, the main activity within the TC has been the preparation of a manuscript based on the work done for the EFONGA deliverable, for submission to the Journal of Sol-Gel Science and Technology.

PLANS FOR 2009 AND DELIVERABLE

The plans for 2009 include the organization of a meeting of TC16 in the beginning of 2009 in order to launch new activities, starting with the study of low index nanostructured coatings with tailored high porosity and nanostructured glass coatings for energy savings in buildings, to improve the thermal efficiency of low emissivity coatings on glass windows.

TC16 will also be involved in the organization of a session on Glass science / Nanostructured glasses at the 8th Pac-Rim Conference on Ceramic and Glass Technology in Vancouver (Canada), from May 31 – June 5. Deliverables will include the conference presentations by TC-16 members and meeting reports.

PUBLICATIONS AND OTHER CONTRIBUTIONS

M.A. Aegerter, Rui M. Almeida, A. Soutar, K. Tadanaga, Hui Yang and T. Watanabe, "Coatings made by sol-gel and chemical nanotechnology", J. Sol-Gel Sci. Technol. 47 (2008) 203 – 236.

4.3.2 COATINGS ON GLASS (TC24)

Chairman: *K. Spee, TNO, The Netherlands*

K. Sanderson, Pilkington, UK

Vice-Chairs: *M. Andreasen, Vacuum Edge, USA*

Members: *H. Weis, Interpane E&B, Germany*

A. Piers, TNO, The Netherlands

A. Durandea, Saint Gobain, France

C. Wagner, Velux A/S-Panes, Denmark

A. Parlar, Sisecam, Turkey

L. Hupa, Abo Academy University, Finland

P. Van.Nijnatten, TNO, The Netherlands

P. Bastianen, Vindico Surface Technologies BV, The Netherlands

R. Pylkki, Aspen Research, USA

T. Belgardt, Interpane E&B, Germany

A. Roos, University of Uppsala, Sweden

D. Sheel, University Salford, CVD Technologies, UK

D. Coster, ACG, Belgium

F.Creuzet, Saint Gobain, France
F.van.Milligen, OCLI, JDC Uniphase, USA
J.Puetz, Leibnitz INM, Germany
J.Vitkala, Tamglass Engineering, Finland
K.Makita, Central Glass, Japan
T.Kaelber, SCHOTT AG, Germany
K.Hartig, Cardinal Glass Industries, USA
K.Suzuki, Surftech Transnational/Consultant, Japan/Belgium
M.Hirata, Nippon Sheet Glass, Japan
K.Myli, Cardinal Glass, USA
S.Suzuki, Asahi Glass, Ltd.
M.Mitterhuber, ETC Products, Germany

SUMMARY

The TC24 committee has been active with three well attended meetings being held during 2008, an increase on the two conducted in 2007. The main areas of activity have been based around:

- Self cleaning / reduced maintenance coatings
 - Testing of pyrolytic coated transparent conductive oxide films (TCO)
- After many years of dedicated service as chairman of TC24, K.Spee stepped down as chairman of the committee in June and K.Sanderson was appointed chairman.

PLANS AND DELIVERABLES FOR 2008

The work plan focused around several key work areas.

- Continuation of the work program on self cleaning / reduced maintenance glass which has been run by the committee for several years.
- Characterisation of transparent conductive oxide coatings based on pyrolytic deposited SnO₂:F films
- Support during the organisation and running of the ICCG-7 conference.

ACTIVITIES in 2008

The year commenced with a meeting held at TNO in the Netherlands on the 17th January. The one day meeting was split into two half day sessions. The first half of the day was used to discuss **self cleaning / reduced maintenance** activities. Presentations reviewing the on going activities on the draft standard developed as part of the STREP Framework 6 EU funded project were presented to the committee. Agreement was reached for several of the committee members to continue to run tests on the method and provide feedback at future meetings. It was identified that the forward plan for the Framework 6 project was to progress the development of this standard via CEN (Comité Européan de Normalisation) TC129 (Glass in Building) and that a work task was being requested.

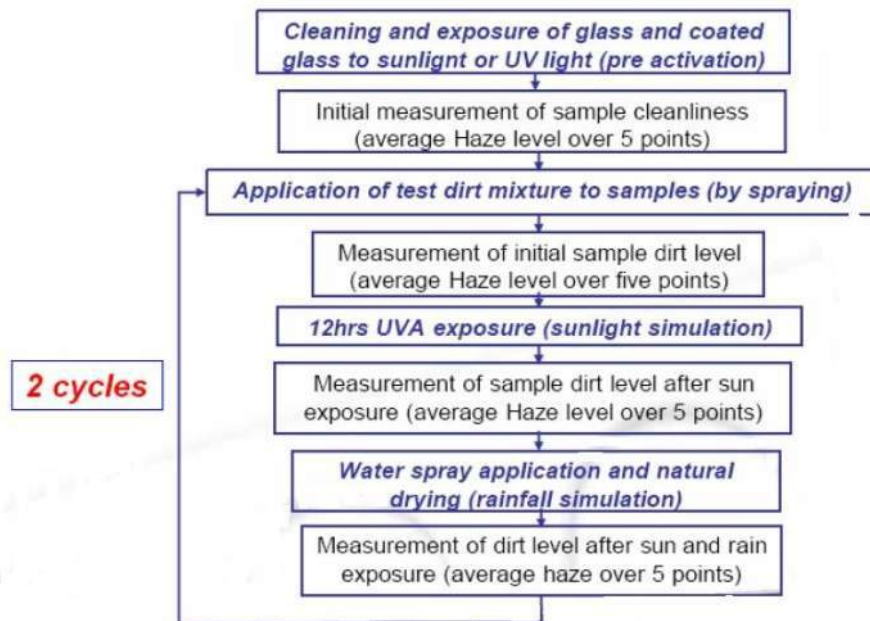


Fig. 4.3.2.1: Proposed Framework 6 Dirt Test Procedure

In addition a discussion was held on standardisation tests being developed through JIS (Japanese Industrial Standards) and ISO (International Organization for Standardization) for a range of functions including **self cleaning, air purification and anti-bacterial**. Work on these tests was discussed along with problems identified. Following the discussion key areas of concern were agreed and it was felt these should be fed back to ISO via the relevant national committees.

The second half of the day focused on the setting up of a round robin test for **transparent conductive oxide**. It was agreed that a commercially available sample should be tested with a wide range of properties agreed for inclusion in the round robbing including optical, electrical (sheet resistance, Hall Effect) and haze characteristics. The testing schedule was agreed along with a proposal to review results at a future meeting.

The second meeting of the year was held at part of ICCG-7 on June 6th 2008, at Veldhoven in The Netherlands. The meeting was again split into discussions of the self cleaning / reduced maintenance area and a review of the transparent conductive oxide area. Significant discussions were held on the on going work towards the development of a standard via CEN TC129 and latest results associated with testing at different sites were discussed. A round robin to test the methodology has been agreed via TC129 and several committee members have agreed to participate in these activities. Further updates on the progress of this and other activities being set up by individual members and their companies were agreed to be discussed at a future meeting.

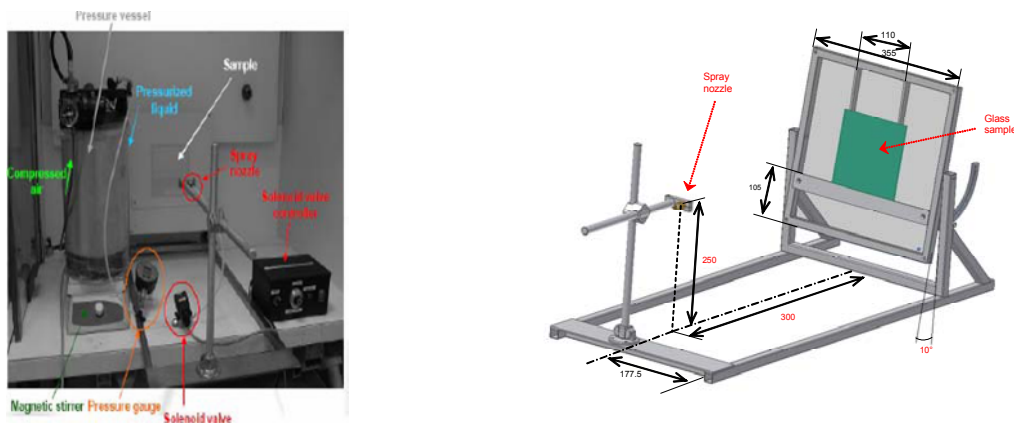


Fig. 4.3.2.2: Dirt Test Equipment which is subject to Round Robin Testing

A preliminary review was given of the initial TCO round robin results. Some difference in measurements was clearly evident following the initial round robin and it is felt further understanding of these differences was required. It was agreed that further analysis of the differences and a discussion on the forward plan for the round robin would be held at the next meeting.

K.Spee indicated that due to a job change he would have to step down as Chairman of TC24. K.Sanderson was nominated and agreed following discussions as the new Chairman.

The final meeting of the year was held at Gelsenkirchen on October 21. During the meeting updates on self cleaning / glass and reduced maintenance discussions conducted by committee members were presented. Following these reviews it was agreed that a formal communication of the results of studies conducted as part of ICG TC24 was warranted to CEN TC129. A note reviewing the key activities and findings of work to date is under preparation and will be supplied to CEN TC129 ahead of their next meeting.

A review of the TCO round robin program was also held. It was highlighted that wide variations in thickness and Hall Effect measurements had been identified. The reasons behind these were discussed and it was felt that a key variation was in film thickness measurements and may be due to the multiple layer nature of the film supplied for the round robin. As such it has been agreed to expand the round robin with non commercial single layer samples of a TCO. These will be supplied and tested ahead of a meeting in the New Year. An investigation into new angular measurements has also been agreed as part of an expanded TCO round robin. TNO have agreed to lead this activity.

Finally as part of this meeting a presentation on sol gel coatings on glass by M.Mitterhuber was provided. TC24 have agreed that a broader spread of coating technologies would be beneficial to the committee including hybrid / polymer type coatings. It has been agreed samples of these materials should form part of one of the round robins going forward

PLANS FOR 2009 AND DELIVERABLE

Key activities planned include:

- Next meeting to be held at Salford University in the first quarter of 2009
- Continuation of the activities on self cleaning and reduced maintenance glass, ensuring that TC24 remains a formal method to allow exchange of information between working groups in this area from around the world. The objective will be to focus on the technical properties of these coatings and supply input and support as required to standardisation committees including CEN and ISO.
- Continue to develop technical understanding of transparent conductive oxide coatings through the use of round robin testing and new tests aimed at developing an understanding a relationship between the properties of the films for different technical applications.
- Expand the interests of TC24 to include hybrid and polymer type coatings on glass.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- No formal publications were made by the committee during the year
- A formal note on the activities of ICG TC24 is being prepared to highlight the work conducted in the area of self cleaning glass standardisation. This note will be supplied to CEN TC129 to review our activities and assist with the development of the standard on self cleaning glass.
- K.Spee and several committee members were involved in the international organisation committee of ICCG-7

4.3.3 GLASS SURFACE DIAGNOSTICS (TC19)

Chairman: *Volker Rupertus, Schott AG, Mainz, Germany*

Vice-Chairs: *Mark Farnworth, Pilkington Technology, UK*

Herve Montigaud, Saint Gobain Recherche, France

Members: *Vladimir Balek, Nuclear Research Institute Rez, Czech Republic*

Klaus Bange, Schott AG, Mainz, Germany

Renzo Bertoncetto, Dep. Inorganic Chemistry, Padua, Italy

Elzbieta Greiner-Wronowa, Univ. of Krakow, Poland

Ales Helebrant, Inst. of Chemical Technology, Czech Republic

Philippe Le Coustumer, CDGA, France

Paolo Mazzoldi, University of Padua, Italy

Carlo Pantano, Pennsylvania State University, USA

I. Sokmen, Sisecam, Turkey

Nobuyuki Tadokoro, Hoya Corporation, Japan

Y. Yamamoto, Asahi Glass Co Ltd, Japan

Alain Menelle, CEA-CNRS, France (will act as a guest in future)

SUMMARY

In 2008 TC19 finished two round robins:

- 1) Assessment of imaging characterization techniques: Ten laboratories were involved in the analysis of a double coated glass substrate with microstructures. A final report was prepared ("**EFONGA report No.2** WP 4.3").
- 2) Quantification of soda-lime silica glass using SEM/EDS (Energy Dispersive Spectroscopy in combination with Scanning Electron Microscope). 9 laboratories participated. The results were presented in a final report ("**EFONGA report No.3** WP 4.3"), which concluded, that a high level of precision and accuracy is being implemented in the participating institutions. In addition to the EFONGA report a paper for an international Journal is in preparation.

A new round robin was initiated ("XRD-round robin") which deals with the determination of the crystalline composition, glass/crystalline ratio as well as the lattice parameters of glass ceramics using XRD.

The TC "Glass Surface Diagnostics", had three meetings in 2008. A core-group-meeting at Institut du Verre Paris/France (Jan 25) a business meeting in Trencin/Slovakia (June 22) and a core-group-meeting at Frankfurt airport /Germany (Dec 3). In addition, a number of e-mail exchanges also occurred. TC19 was represented at EFONGA advisory board meetings Paris (Jan 25), Frankfurt (March) and WP 4.3 meetings in Mainz (April 9) and Wuerzburg (March 17).

In cooperation with TC09 a expert workshop with 20 international participants is in preparation, to be held in Montpellier (Feb 2009) entitled: **Glass surfaces and stress corrosion mechanisms at the nanoscale.**

PLANS AND DELIVERABLES FOR 2008

- Report about the "Imaging techniques"- round robin (EFONGA Report No. 2 WP 4.3)
- Report about the "EDS/SEM"- round robin (EFONGA Report No. 3 WP 4.3)
- Starting a new round robin "Glassceramics analysis by XRD"
- Updating the TC19-website in conjunction with the ICG-homepage
- Support of the EFONGA-project
- Preparation of a joint expert workshop with TC09

A lot of activities around the TC19 items took place especially to support the EFONGA WP 4.3.

ACTIVITIES in 2008

1) Finishing Round robin “Imaging Techniques”

The samples with a layer design of 100nm Cr and 100 nm Al₂O₃, structured with different patterns and different distances in the nm- and μm-regime, were distributed to ten different laboratories. Several surface analytical techniques which included AFM, SEM/EDS, TEM, TOF-SIMS, GIXA, LiMi, WLI, XPS and FIB were used for the characterization of this sample system. It became apparent that the results depend drastically on the operators experience of dealing with highly electrically insulating samples. AFM, SEM/EDS and TEM instrumentation readily produced thicknesses and distances determinations. TOF-SIMS and XPS are more critical to operate and to interpret. Details can be found in the EFONGA-report No.2 WP4.3. As an example, a demonstration of the height determination in the nm-range with different analytical techniques is depicted in the following.

1. Total height of etched structures (sample B)

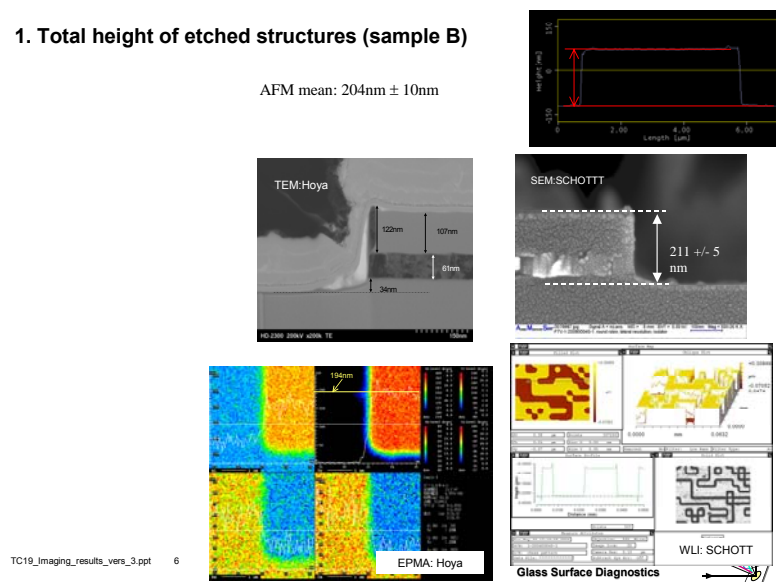


Fig. 4.3.3.1: SEM, EPMA and WLI-results for the height determination of the etched structure To see the variety of the employed techniques, the results of several participants are shown in Tab 4.3.3.1.

Laboratory	Methods	Results	Error interval
Wilkinson	AFM	205,3 nm	
IFOS	AFM	193,5 nm	10 nm
Univ. Padua	AFM	189 nm	10 nm
Univ. Krakow	AFM	224,5 nm	10 nm
Saint Gobain	AFM	210 nm	10 nm
Schott	AFM	204 nm	10 nm
	WLI	210 nm	5 nm
	SEM	211 nm	5 nm
PSU	AFM	199,1 nm	1,5 nm
Hoya	EPMA	194 nm	15 nm
	TEM	202 nm	12 nm?

Tab. 4.3.3.1: Results of height measurement

The results from the different laboratories and instruments showed a standard deviation of 5%. This indicates that topographic determinations, carried out with several techniques, can produce fairly good agreement.

A second aim of the round robin concentrated on the determination of lateral structures in the μm -range. For this task, a “chessboard-structured” samples was employed, composed of a lot of cubes with $5\mu\text{m}$ edge length. As can be seen in Figure 4.3.3.2 and Table 4.3.3.2 the participating laboratories produced results which were in fairly good agreement.

2. Determination of Chessboard structure (sample B)

ToF-SIMS: 10 squares → results of a single square

Conclusion:

Within the error all results agree very well; the values beyond the dot have to be skipped!

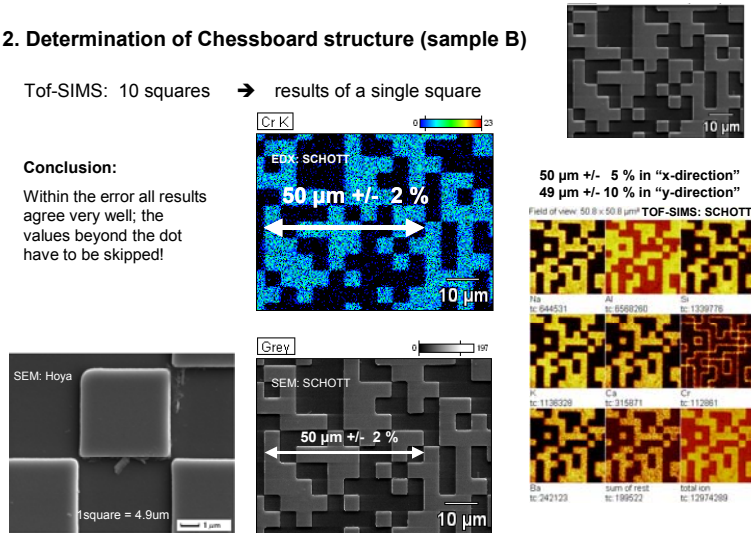


Fig.4.3.3.2: Examples of results done by SEM, EPMA and TOF-SIMS

2. Determination of Chessboard structure (sample B)

Laboratory	Methods	Results	Error interval
Pilkington	AFM	50,4 μm	1,0 μm
	SEM	49,6 μm	1,0 μm
	Optical	50,4 μm	1,0 μm
IFOS	AFM	50.16 – 50.39 μm	3 μm
		47.11 – 51.33 μm	
Hoya	AFM	49,7 μm	1.0 μm
	SIMS	51.0 μm	1.5 μm
	EPMA	49.0 μm	1.0 μm
PSU	AFM	49,36 μm	0,31 μm
Saint Gobain	AFM	49 μm	0,2 μm
Schott	AFM	50 μm	2,5 μm
	SIMS	50 μm	3 μm
	SEM	50 μm	2 μm
	EDX	50 μm	2 μm

Tab.4.3.3.2: Results of the lateral determination of the depicted chessboard structure

2) Finishing Round robin “Quantification of soda-lime silica glass using SEM/EDS”

The round robin was aimed at the standard analysis technique SEM/EDS to establish the variation in the results obtained from the analysis of common glass sample. Nine laboratories took part. The results showed that it is possible to use EDS to analyse both accurately and precisely a range of glass types (demonstrated by 4 laboratories). Sodium (oxide) and sulphur (trioxide) were the most difficult elements for the laboratories to analyse, with eight of the nine laboratories having an error of more than 0.1% for their analysis. In glass, sodium ions are mobile and are caused to diffuse away from the electron beam impact site, which makes quantitative analysis difficult. It is probably for this

reason that sodium oxide proved troublesome. Sulphur is overlapped in EDS spectra by a silicon/oxygen sum peak at 2.26keV, which makes identification and quantitative analysis difficult. This explains why four of the laboratories failed to detect sulphur and of those that did two had large errors.

A few laboratories need to re-examine their rules for deciding whether a peak is real or not, as these laboratories all reported iron in the float glass (which is not present in the glass above the XRF detection limit). Additionally one laboratory reported magnesium oxide and manganese oxide in the experimental glass, which were not present in the glass above the XRF detection limit.

The fresh fracture surface results appear similar to those obtained from the resin-mounted sample, both in terms of accuracy and precision. This is an unexpected result, because specimens with rough and/or non-planar surfaces should give inferior results, as a consequence of indeterminate take off angles. Details can be found in the EFONGA-report No.3 WP4.3.

3) Starting Round robin “Glass-Ceramic determination by XRD”

The aim of this round robin is the characterization of these two sample types in each participating laboratory with their individual measurement and quality procedures. The comparison made will allow an assessment of the strength and limitations of these procedures.

We provide two different sample types:

Type 1: Commercially available Ceran Suprema glass ceramic (one piece).

Type 2: MAS- ($\text{MgO-Al}_2\text{O}_3\text{-SiO}_2$) glass ceramic powder, produced with an laboratory melt process.

The samples were distributed to more than ten laboratories.

4) Organizing a expert-workshop “Glass surfaces and stress corrosion mechanisms at the nanoscale” in collaboration with TC09 (M.Ciccotti)

In order to collect the state-of-the-art scientific knowledge about stress corrosion mechanisms at the glass surface TC09 and TC19 are jointly organizing an event in Montpellier/France, Febr 22 – 25, 2009. The aim of the workshop is to bring together international experts to present their own specialized activities and participate in discussion about various workshop topics in. The current situation will be identified and a roadmap for future activity will be agreed. The results will be presented later to the international scientific community via contributions to conferences and/or published papers.

PLANS FOR 2009 AND DELIVERABLE

- Paper at an int. Journal about the “Quantification by EDS/SEM”- round robin (EFONGA Report No. 3 WP 4.3)
- Report about the expert workshop “Glass surfaces and stress corrosion mechanisms at the nanoscale”
- Discussion and finishing of the round robin “Glassceramic determination via XRD”
- Start of a new round-robin (2 projects are in preparation)
- Discussion about the next steps within TC19

Febr 22 - 25: 3 days expert workshop at Montpellier

March/April: Core group meeting

May: EFONGA- final meeting and summer school at Montpellier

June: TC19 meeting during PAC-RIM conference at Vancouver

Oct/Nov.: Core-group-meeting at Manchester

PUBLICATIONS AND OTHER CONTRIBUTIONS

Two contributions about the ongoing work of WP4.3 (Paris and Frankfurt)
Report about the Imaging techniques-Round Robin
Report about the EDS/SEM-Round Robin

4.4 R&D Activity Field "New Applications"

4.4.1 GLASSES FOR MEDICINE AND BIOTECHNOLOGY (TC04)

Chairman: *Wolfram Höland (acting Chair)*

Alexis G. Clare

Members: *Delbert Day*

Enrica Verne

Julian Jones

Aldo Boccaccini

Robert Hill

Carlo Pantano

Sam Conzone

Alastair Cormack

Matthew Hall

David Greenspan

Akiyoshi Osaka

Leena Hupa

Larry Hench

Matthew O'Donnell

SUMMARY

In 2008, members of TC04 met in two different venues to **advance road-mapping activities** related

- to **standard definitions for bioactivity** and
- to **organize a textbook on biomaterials**.

PLANS AND DELIVERABLES FOR 2008

- GLASS FOR MEDICINE AN BIOTECHNOLOGY BOOK- chapters contributed by members of TC04
- Road-mapping activities related to biomaterials for the EFONGA project

ACTIVITIES in 2008

Members of TC04 met at the World Biomaterials Congress in Amsterdam, The Netherlands, on May 29, 2008. Research activities related to bioactive glass scaffolds, an example of which is shown in Fig. 4.4.1.1 (from J. Jones), novel bio-glasses, and dental restoratives based on glass-ceramics and sintered ceramics were reviewed. The roadmap activities from the EFONGA Workshop in Brig, Switzerland (March 2008)

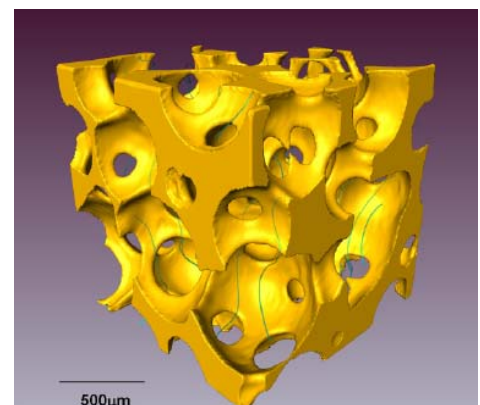


Fig. 4.4.1.1: Bioactive glass scaffolds

were reviewed and a research program was agreed to. The most important elements of this program involve a clear, standard definition of **bioactivity of biomaterials for hard tissue (bone) regeneration.**” To that end, the following activities were defined:

- Produce a **scientific paper** that addresses a standard definition for bio-activity. This will include round-robin style experiments on standard materials and the development of a standard bioactivity test, modeled on ISO/FDIS 23317. Julian Jones will lead this project and has initiated discussions with other members of TC04.
- Develop a **new EFONGA project on Biomaterials**. Julian Jones and Robin Hill are leading this activity and a planning meeting will be held in Montpellier, France in May 2009.
- Produce a second paper related to standard culture tests for new bioglass compositions. This new test will be a focus of the proposed EFONGA project.

Progress has been made on the **biomaterials textbook**, with the drafts of the following chapters completed:

- The unique nature of glass (A. Clare)
- Sol-gel derived glasses (J. Jones)
- Bioactive glass- and glass-ceramic-coatings (E. Verné)
- Bioactive glass-containing composites in bone engineering (A. Boccaccini and Qi-Zhi Chen)
- Glass-ceramics (W. Höland)

The textbook is intended for students and young professionals active in the areas of biology or biotechnology. Alexis Clare will be the editor, with the goal of creating a seamless textbook, not a collection of review papers.

Finally, A.Clare wishes to “thank W. Höland for doing a splendid job as acting chair while A. Clare was recovering from her accident and for the help of all of TC04 members in her efforts to try to get back to normal operations.”

PLANS FOR 2009 AND DELIVERABLE

- Develop a standard test for bioactivity, based on Kukubo’s simulated body fluid. (Bioactivity is often associated with the formation of hydroxyapatite on a material surface, as shown in the micrograph Fig. 4.4.1.2, from the presentation by T. Kokubo at the Brig Workshop in March 2008.)
- Organize the EFONGA planning meeting in Montpellier in May 2009
- Organize the TC04 meeting during the ICG annual meeting in Vancouver, BC on Sunday May 31, 2009.

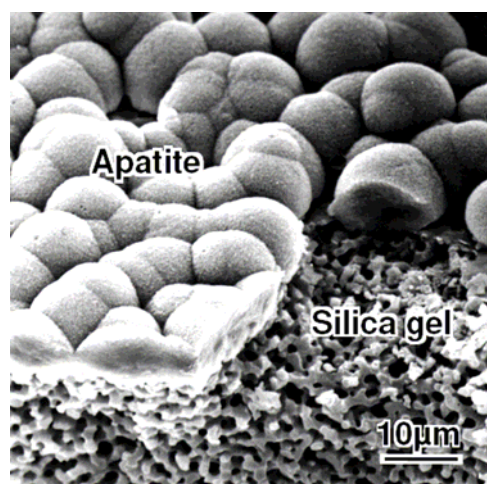


Fig. 4.4.1.2: Microscope exhibiting hydroxyapatite formation

4.4.2 NUCLEAR AND HAZARDOUS WASTE VITRIFICATION (TC05)

Chairman: J. C. Marra, Savannah River National Laboratory, U.S.A.

Vice-Chair: R. DoQuang, Areva, Inc. France

Secretary: D. K. Peeler, Savannah River National Laboratory, U.S.A.

Members: A. Boccaccini, Imperial College London, UK

T. Bessman, Oak Ridge National Laboratory, US

D. Davidson, Areva, Inc., U.S.A.

W. Ebert, Argonne National Laboratory, U.S.A.

C. Fillet, Commissariat à l'Énergie Atomique, France

R. Hand, University of Sheffield, U.K.

W. Lee, Imperial College London, U.K.

C. Leonelli, University of Modena and Reggio Emilia, Italy

R. Monteiro, Nova. University of Lisbon, Portugal

M. Ojovan, University of Sheffield, U.K.

M. J. Pascual, Ceramic and Glass Institute, ICV, Spain

J. Rincon, CSIC, Spain

C. Scales, Nexia Solutions, U.K.

S. Stefanovsky, SIA Radon, Russia

P. Stoch, Institut of Atomic Energy Swierk, Poland

C. Veyer, Consultant, France

J. Vienna, Pacific Northwest National Laboratory, U.S.A.

S. Weisenburger, Institut für Nukleare Entsorgung, Germany

SUMMARY

The Technical Committee on Nuclear and Hazardous Waste Vitrification was approved by the ICG Coordinating Technical Committee (CTC) and the Steering Committee in 2006. TC05 has been very successful in involving technical committee members and sharing technical information during its first two years of existence.

The **vision and mission** of the committee are as follows:

- ◆ The vision of this committee is to establish a forum to present, discuss and disseminate technical information on waste glass chemistry, vitrification processes, vitrification melter technologies, and waste glass environmental performance.
- ◆ The mission and goals of the committee are to facilitate the dissemination of technical information through promoting programming at technical conferences, conducting technical workshops and facilitating publication of information through established channels. Promoting the exchange of technical data is also a goal of this committee.

The technical committee held one “face-to-face” meeting and three teleconference meetings in 2008. The face-to-face meeting was held at the Materials Science and Technology (MS&T) meeting in Pittsburgh, PA, U.S.A.. The highlight of TC05 activities in 2008 was organizing a **Waste Glass Leach Testing and Performance Modeling Forum** at the MS&T meeting. Financial support was obtained from both the ICG and ACerS to enable the participation of key European experts in this field. Additionally, TC05 members were very active in presenting papers in the **Environmental Issues and Waste Management Technologies in the Ceramic and Nuclear Industries Symposium**. The technical committee also initiated a liquidus temperature determination round-robin testing project in 2008.

PLANS AND DELIVERABLES FOR 2008

The primary objectives were to organize and conduct technical programming at the MS&T meeting in the U.S.. Technical programming in 2007 was conducted by TC05 at the ICG

meeting in France and the Materials Research Society meeting in England so a meeting in the U.S. was deemed to be worthwhile in extending the activities of TC05 to a broader audience. Based on previous discussions among TC05 members, the current state of waste glass leach testing and performance modeling was identified as an area of interest to TC05 members and the broader waste vitrification community. A **Waste Glass Leach Testing and Performance Modeling Forum** was organized by TC05 and held at the MS&T meeting in October 2008 to meet this need.

In 2007, the committee initiated an effort to identify round-robin test opportunities with the objective to develop a plan to conduct round-robin testing as early as 2008. In 2008, TC05 members identified a common need for test method development and initiated a round-robin testing project. Liquidus temperature (T_L) is an important glass property for vitrification processing regardless of the melter technology being used and is, therefore, of world-wide interest. An isothermal T_L determination technique has been developed at Pacific Northwest National Laboratory in the U.S. (under the direction of a TC05 member) that appears to be repeatable and accurate. Round-robin testing is needed to verify and validate the experimental technique for eventual adoption as an ASTM procedure. A procedure was developed to support the round-robin and institutions interested in participating were identified. Round-robin testing will commence in early 2009.

ACTIVITIES IN 2008

The technical committee held one “face-to-face” meeting and three teleconference meetings in 2008. Teleconference meetings were held in February and June 2008. Discussions at these meetings focused on the upcoming technical programming to be conducted at the MS&T meeting. Committee members also discussed their interests and needs for glass property testing. It was decided that liquidus temperature round-robin testing would address an immediate need of the community and be a relatively straight-forward means to engage many TC05 members. At these teleconferences, plans to sponsor a symposium at the 2009 ICG/PacRim meeting in Vancouver, BC Canada were also developed. The committee members also agreed that a focus in 2009 should be on hazardous waste vitrification since technical programming in previous years centered on nuclear waste vitrification.

A face-to-face meeting was held at the MS&T meeting in Pittsburgh, PA U.S.A. with eight TC05 members in attendance. At the meeting, the technical programming conducted at the MS&T meeting was reviewed. The response to the Waste Glass Leach Testing and Performance Modeling Forum was very favorable and it was agreed that similar initiatives in the future should be pursued. Plans were finalized for the liquidus temperature round-robin at this meeting. Finally, plans for conducting technical programming at the ICG/PacRim meeting were discussed. All TC05 members were encouraged to submit abstracts and solicit abstracts for the TC05 sponsored symposium. It was noted that a MSR conference on nuclear waste management will be held in St. Petersburg, Russia the week preceding the ICG/PacRim conference so there will likely be competition for papers at the ICG/PacRim meeting.

Waste vitrification facilities are in operation in many countries; however, permanent repositories for vitrified waste are non-existent. Therefore, the current status of glass performance testing and modeling is of significant interest to TC05 and the waste vitrification community as the next phase of efforts will be towards proper disposal of vitrified waste. A **Waste Glass Leach Testing and Performance Modeling Forum** was organized by TC05 and held at the MS&T meeting in October 2008. The ICG provided

financial support to facilitate participation by two experts and the ACerS also supported participation by providing complimentary registrations to the conference. The forum consisted of presentations by five invited speakers followed by a two hour open forum discussion between the audience and the five invited speaker “panel” members. The invited speakers and their presentation titles were as follows:

- ◆ Pierre Van Iseghem (SCK•CEN, Belgium), “SCK•CEN R&D on the interaction between nuclear waste glass and clay near- and far-field materials”
- ◆ Pierre Van Iseghem (SCK•CEN, Belgium), “GLAMOR - Or how we achieved a common understanding on the decrease of glass dissolution kinetics”
- ◆ Stephane Gin (CEA, France), “Leach Testing Applied to the Investigation of Long-term Behavior of High-level Waste Glass: French Experience”
- ◆ Carol Jantzen (Savannah River National Laboratory, U.S.), “The Product Consistency Test (ASTM C1285): How and Why It Was Developed”
- ◆ William Ebert (Argonne National Laboratory, U.S.), “Using Glass Dissolution Test Results in Performance Models”
- ◆ Eric Pierce (Pacific Northwest National Laboratory, U.S.), “Accelerated Weathering of Waste Glass at 90°C with the PUF Apparatus: Implications for Predicting Glass Corrosion with a Reactive Transport Model”

The forum was very well received by both the panel members and the audience. An outcome of the forum will be a CD containing the presentations from all invited speakers as well as a summary of the open forum discussions. These CDs will be distributed to TC05 members and other interested parties.

TC05 members also participated extensively in the ACerS sponsored **Environmental Issues and Waste Management Technologies in the Ceramic and Nuclear Industries Symposium**. Ten papers were presented by TC05 members in this symposium.

In waste glass processing, there are product and process constraints that must be met to assure successful vitrification operations. One constraint deals with avoiding crystal accumulation in the melter that may lead to processing issues or plugging of the melter discharge system. The **liquidus temperature** is defined as the maximum temperature at which crystals can co-exist with the melt in thermodynamic equilibrium. Fig. 4.4.2.1 shows an optical photomicrograph of a crystallization front in a glass. Constraints can be imposed on the glass composition to ensure that the liquidus temperature of the glass is below the nominal melt temperature by some safety margin. An alternative control strategy could be to ensure that the amount of crystallization that may occur in the melt is below a limit to ensure that the crystals can be drained from the melter without accumulation. With either of these process control strategies, a precise method to determine the glass liquidus temperature is needed.

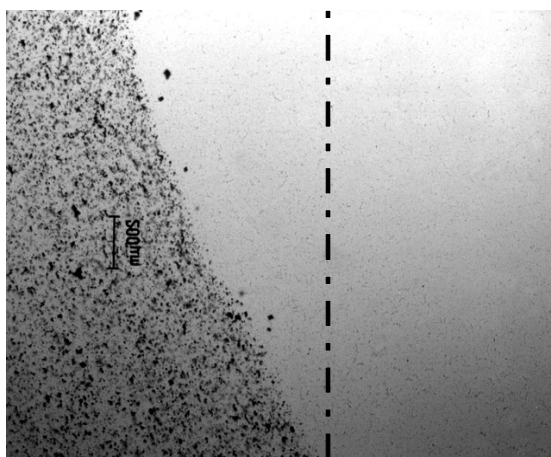


Fig. 4.4.2.1: Optical micrograph of a crystalline front determined using a gradient furnace.

Liquidus temperature determination round-robin testing was identified by TC05 as a need of interest to many TC05 members. In most cases, the gradient furnace method for T_L determination in waste glasses is not applicable due to the difficulty of discerning the crystallization front in these dark (often opaque) glasses. An isothermal T_L determination technique has been developed by PNNL researchers that appears to be repeatable and accurate. In this method, sequential isothermal treatments are used to bracket the temperature where crystals are and are not found and, thus, identifying the liquidus temperature. Fig. 4.4.2.2 shows crystals identified in a waste glass after heat treatment. At the TC05 meeting held at MS&T, John Vienna (PNNL) discussed the scope of the round-robin testing and answered questions from the TC05 members. He indicated that the primary goal of the testing is to verify and validate the experimental technique for formalization as an ASTM procedure. He proposed that 2 glass standards be tested by the participating laboratories with the results statistically analyzed to determine the efficacy of the methods. As agreed at the meeting, initiation of the round-robin testing project would occur immediately after the MS&T conference with an invitation letter sent to all potential participants.

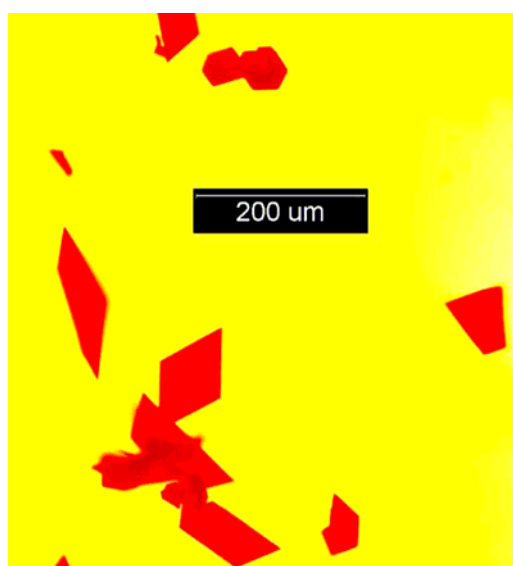


Fig. 4.4.2.2: Hematite crystals in a waste glass after heat treating at 1157 °C. Colors in the image are not original: the crystals appear very dark red.

Positive responses to the invitation have been received from the following institutions:

- ◆ CEA, France

- ◆ Immobilization Science Laboratory, University of Sheffield, England
- ◆ Institute of Chemical Technology, Czech Republic
- ◆ National Nuclear Laboratory, England
- ◆ Pacific Northwest National Laboratory, U.S.
- ◆ Savannah River National Laboratory, U.S.
- ◆ Viterous State Laboratory, Catholic University, U.S.

The final procedure will be sent to the participating laboratories with initiation of testing to commence in early 2009.

A final teleconference call was held in November 2008. At this meeting, a review of the activities at the 2008 MS&T meeting was provided to those TC05 members that could not attend. The status of the liquidus temperature round-robin testing was also discussed and any TC05 members that were interested in participating were encouraged to respond promptly to the PNNL leads to be included in the testing. The plans for the TC05 symposium at the ICG/PacRim meeting were also discussed and TC05 members were encouraged to submit and solicit abstracts to meet the November 2008 deadline. Finally, long-range plans (e.g. publishing a book on waste vitrification) were discussed. These plans will be further developed in 2009.

TC05 leadership also identified a candidate interested in becoming a member of the technical committee. The candidate is as follows:

Dr. Milota Kovacova (Institute of Geotechnics, Slovak Academy of Sciences, Slovak Republic)

This candidate will be forwarded to the Chair of the Coordinating Technical Committee for consideration for membership.

PLANS FOR 2009 AND DELIVERABLE

The primary objectives for 2008 will be to conduct and complete the liquidus temperature round-robin testing project and to continue technical programming efforts through sponsoring a symposium at the ICG/PacRim meeting in Vancouver. Based on the success of the technical programming sponsored by TC05 in 2007 and 2008, it is expected that this symposia will provide excellent opportunities for committee members to learn about vitrification activities being conducted in other countries and share technical information. Furthermore, since a focus for this symposium will be hazardous waste vitrification, it is hoped that interactions in this area will be increased.

Finally, the committee will actively work to identify longer-term activities such as joint publication of books and/or conducting workshops similar to the successful waste glass leach testing and performance modelling forum conducted in 2008.

4.4.3 GLASS FOR OPTOELECTRONICS (TC20)

Chairman: Setsuhisa Tanabe, Kyoto Univ., Japan
Vice-Chairs: Giancarlo C. Righini, CNR, Italy
Peter Kazansky, Southampton Univ., UK
Chair Emeritus: Kazuyuki Hirao, Kyoto Univ., Japan
Secretary: Jianrong Qiu, Zhejiang Univ, PRC
Members: John Ballato, Clemson Univ., USA
Matthew Dejneka, Corning Inc., USA
Ulrich Fotheringham, Schott AG, Germany
Jong Heo, Pohang Univ., Korea
Daniel Hewak, Southampton Univ., UK
Animesh Jha, Univ. of Leeds, UK
Shibin Jiang, AdValue Photonics Inc, USA
P Mazzoldi, Uni di Padova, Italy
Koichi Nishizawa, Japan (Past chair)
Yasutake Ohishi, Toyota Technological Institute, Japan
Guodong Qian, Zhejiang Univ, PRC
Kathleen.Richardson, Clemson Univ., USA
B K Sarkar, Ind Assoc for the Cultivation of Sci, India
George H Sigel, Rutgers, State Univ. of New Jersey, USA
Naoki Sugimoto, Asahi Glass Co., Japan
Hisayoshi Toratani, Hoya Corporation, Japan
V P Veiko, St Petersburg Inst of Prec Mech & Optics, Russia
X.Zhang, Univ. of Rennes, France



Green Fiber Laser (Toyota TI)

SUMMARY

In 2008 we had a business meeting in July at Edmonton Canada, where the 3rd *International Conferences on Optical, Optoelectronic and Photonic Materials and their Applications (ICOOPMA2008)* was held. Various topics such as the organization of the conferences in 2009, new membership, etc. were discussed. Photonic glass session was successfully organized during the conference. Proceeding of this conference is now being edited and will be published in a 2009 issue of Journal.

Based on the proposed plan of IEEE-LEOS, a special issue of "*Organic and Inorganic Photonic Materials*" was edited in the *IEEE Journal of Selected Topics in Quantum Electronics*. The issue was published as September issue of 2008.

A special issue of "Glass and Ceramic Materials for Photonic Technology", was edited in *Journal of the Ceramic Society of Japan*. It collected 20 papers and published as October issue of the journal, which attracts great attention. Many members also contributed for this special issue.

ACTIVITIES in 2008

In conjunction with *ICOOPMA 2008*, in Edmond, Canada, TC20 had a **business meeting** on July 23, 2008. The main topic discussed in the meeting were:

- the organization of the "Optoelectronic Glass" session at the PacRim ceramics conference 2009 in Vancouver
- the preparation of a workshop of *PRE09* in Firenze, date setting
- the preparation of a joint cluster meeting with TC07 (Crystallization) in September 2009 in Brazil in conjunction with *PNCS* or *Crystallization Conference*.
- Invitation of Prof. Daniel W Hewak of Southampton University as a new member.

On the same day, as one of several sessions in *ICOOPMA*, the photonic glass session was successfully organized, which attracted many audiences. Most of our member attendee gave an invited talk at the session.

ICOOPMA2008shots (July 23, 2008)



TC20 members during lunch time



Members shot after



Photonic Glass Session

Based on the proposal of IEEE-LEOS, J. Ballato, our member, **edited a special issue** of "Organic and Inorganic Photonic Materials" in the *IEEE Journal of Selected Topics in Quantum Electronics*. The issue was published as September issue.

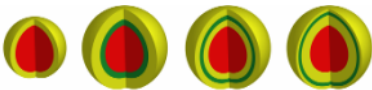
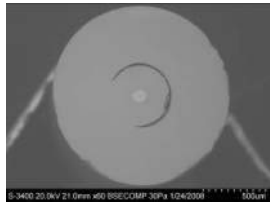
Also, K. Hirao and S. Tanabe planned and edited a special issue of "**Glass and Ceramic Materials for Photonic Technology**", in *Journal of the Ceramic Society of Japan*. It has collected 25 papers and published as October issue of the journal. Many members also contributed for this special issue, which is attracting great attentions.



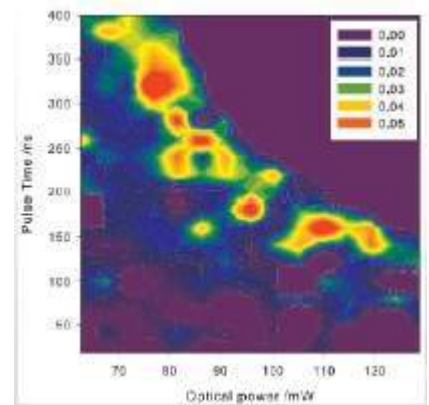
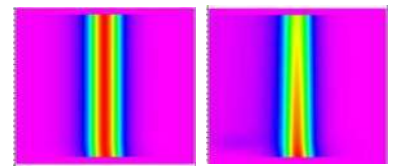
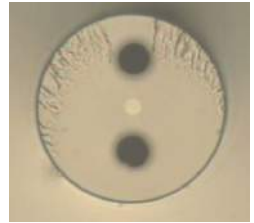
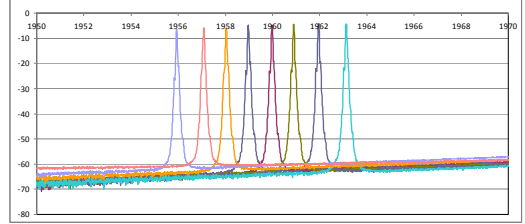
PLANS FOR 2009 AND DELIVERABLE

We will meet on May 31 at Vancouver, where the *ICG/GOMD/PacRim ceramics conference 2009* will be held. We are organizing the Symposium 25, "Glasses for Optoelectronics and Optical Applications", which is a part of the glass-related symposia, "Innovations in Glass Science and Technology" as joint organization with GOMD and ICG. As the third organization of successful series since 2005 for every other years, we prepare the Workshop of *PRE09* in Firenze on September 2 - 3. G.Righini, our vice chair, is heading the organization and many members are also cooperating as co-organizers. After the workshop, many of us will move to Brasil to attend the *Physics of Non-Crystalline Solids (PNCS2009)* and *Crystallization Conference* in September 2009. Based on discussion with Prof. Zanotto, a joint session on "Glass ceramics for photonics" with TC07 (Crystallization) is planned.

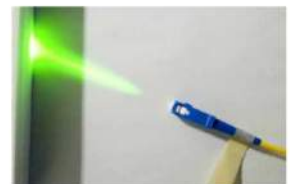
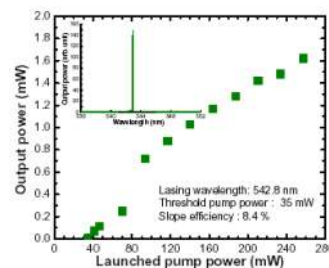
PUBLICATIONS AND OTHER CONTRIBUTIONS

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- B. Kokuoz, J. DiMaio, C. Kucera, D. Evanoff and J. Ballato, "Color Kinetic Nanoparticles," *J. Am. Chem. Soc.* **130**, 12222 - 12223 (2008).
- J. Ballato, T. Hawkins, P. Foy, R. Stolen, et al., "Silicon Optical Fiber," *Optics Express* **16**, 18675 - 18683 (2008). 

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- S. Fujita, A. Sakamoto, S. Tanabe, "Luminescence characteristics of YAG glass-ceramic phosphor for white LED", *J. Selected Topics Quant. Electron.* 14[5], (2008) 1387-1391.
- H. Hayashi, S. Tanabe, N. Sugimoto, "Quantitative analysis of optical power budget of bismuth oxide-based erbium-doped fiber", *J. Luminesc.* 128, (2008) 333-340.
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- T. Yamashita and Y. Ohishi, "A new green fiber laser using Terbium-doped fluoride fiber", *Optical Fiber Communication Conference and The National Fiber Optic Engineers Conference, IEEE/OSA, JWA18*, 2008.
- K. Miura, K. Hirao, Y. Shimotsuma, M. Sakakura, S. Kanehira, "Formation of Si structure in glass with a femtosecond laser", *Appl. Physics A* 93, (2008), 183-188. S. Kanehira, K. Miura, K. Hirao, "Ion exchange in glass using femtosecond laser irradiation", *Appl. Phys. Lett.* 93, (2008) 023112(3p).

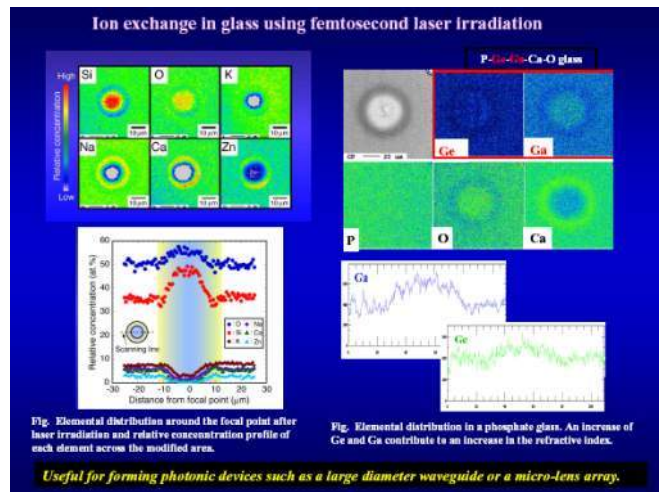


First demonstration of Tb³⁺-doped fiber green laser



W. Yang, P. G. Kazansky and Yu. P. Svirko, "Non-reciprocal ultrafast laser writing," *Nature Photonics*, **2**, (2008) 99-105.

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- P. G. Kazansky and Y. Shimotsuma, "Self-assembled sub-wavelength structures and form birefringence created by femtosecond laser writing in glass: fundamentals and applications", *J. Ceram. Soc. Jpn*, **116**, 1052 (2008).



*Towards 'Cosmic Wheels'
by Ultrafast Laser Writing
in Glass*



4.5 R&D Activity Field "Information, Communication, Education and History"

4.5.1 INFORMATION AND COMMUNICATIONS (TC01)

Chairman: J M Parker, *The University of Sheffield, UK*
Vice Chairman: A Makashima, *Japanese Adv Inst of Sci & Technol, Japan*
Secretary: E Flygt, *Glafo, Sweden*
Members: K Bange, *Schott, Germany*
 I Debaisieux, *St Gobain, France*
 H Schaeffer, *Germany*
 W Schaeffer, *Germany*
 J Vitkala, *Tamglas, Finland*

SUMMARY

The EFONGA project was extended for a further year this year and has generated a number of activities in its closing stages. These included a road-mapping exercise held at Brig, whose success has spawned several similar events to take place in the next few months. TC01 has been involved in publicising these activities on the web and in running one of the planned workshops for 2009 jointly with TC23. In addition support has been given to activities organised by the DGG and SGT. A start has been made on the database of Universities involved in teaching Glass.

PLANS AND DELIVERABLES FOR 2008

The main deliverables have been:

- Continuing revision and updating of the ICG Web site
- Revision of the leaflet listing ICG officers
- Seedcorn funding for a Glass Trend workshop for young people organised by the DGG in Hameln Germany.
- Assistance with a Sol Gel workshop held in Cambridge, UK in September.

ACTIVITIES in 2008

The committee met at the ICG Annual Conference in Trecin to discuss the updating of the ICG web pages. Contact has been maintained electronically.

The ICG web site and the associated EFONGA web site have been significant activities of TC01 assisted by the preparation by various members of the CTC and Steering Committees of informative news items on: the ICG Roadmapping Process; the EFONGA Brig conference; and the Opening Session of the ICG Annual Meeting in Trecin. The growing content of the web site has been mirrored by an increasing quantity of data downloaded from the web site as shown in Figure 1. This figure also highlights the peak in interest generated by the ICG Congress held in Strasbourg 2007 (Month 15).

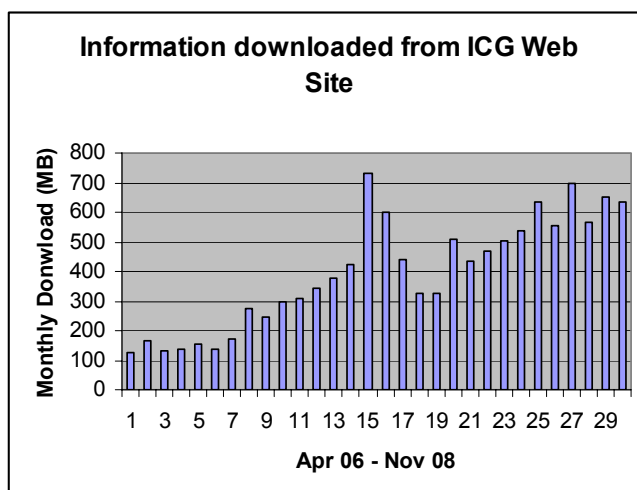


Fig. 4.5.1.1: Downloads from www.icglass.org

During the last year there were almost 50 000 pages on the web site accessed, not including a very significant number of additional hits by search engines. The table below indicates the distribution of hits by country in order of the number of pages accessed, and it illustrates the very wide range in interest generated throughout the world.

Country	Pages	Hits	Bandwidth
United States	20428	114584	1.96GB
Great Britain	7356	16633	289.42 MB
Japan	3393	21714	268.96 MB
Germany	2692	18855	312.79 MB
Unknown	1815	4802	63.90 MB
European country	1593	10308	169.72 MB
France	1240	10027	175.66 MB
Australia	949	6293	117.67 MB
Netherlands	862	5579	92.14 MB
Spain	634	3224	71.54 MB
Canada	524	2113	47.18 MB
China	380	2953	39.79 MB
Belgium	343	2608	65.52 MB
Italy	312	2464	36.48 MB
South Korea	279	1707	39.43 MB
Poland	265	2517	34.42 MB
Turkey	260	1816	18.53 MB
Russian Federation	251	2218	25.38 MB
Slovak Republic	243	2017	29.77 MB
Thailand	240	1815	26.32 MB
Czech Republic	225	1862	38.40 MB
Switzerland	224	1784	25.54 MB
Denmark	177	1885	17.86 MB
India	164	933	23.32 MB
Brazil	164	1055	18.90 MB

Other	2142	14402	255.47 MB
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Tab. 4.5.1.1: Hits by country and number of pages

As planned for 2008 the leaflet listing ICG officers has been revised in format and now includes information concerning three new TCs and the structure of clusters.

Special arrangements were made for students to attend the DGG Annual meeting in Hameln at low cost, and support was provided for two speakers at the Workshop on Sol Gel targeted at younger researchers and held in Cambridge, UK.

Two members of TC01 attended a meeting in Paris to discuss the future of Glassfile as run by the Institut du Verre and Stazione Sperimentale del Vetro.

PUBLICATIONS AND OTHER CONTRIBUTIONS

ICG Web site

ICG booklet

ICG Officers leaflet

EFONGA Web site

Preparation of minutes for both the CTC and the EFONGA management committee

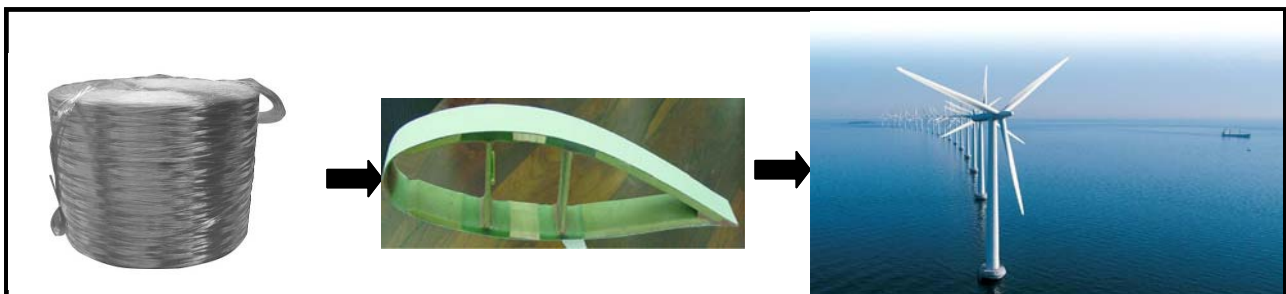
PLANS FOR 2009 AND DELIVERABLES

A meeting of TC01 is planned during the ICG Annual Meeting in Vancouver, Canada. Other telephone conferences and meetings will be arranged as appropriate. There is increasing interest in an ICG members database as well as a database of educational institutions; the currently available databases need updating and extending.

The specific goals for TC01 during the next year include:

- 1) Maintain ICG Web site information, add links to TC web pages
- 2) Encourage and support more TCs to produce their own web pages
- 3) Develop and maintain the EFONGA web site
- 4) Work with TC23 under the EFONGA banner to produce a database of European Universities offering courses in Glass Science and Technology
- 5) Help to run the planned student workshop in Montpellier with TC23

4.5.2 GLASS FOR A SUSTAINABLE SOCIETY (TC12)



Chairman: *John Stockdale, British Manufactures Confederation, UK*

Vice-Chair: *Michael Greenman, GMC, USA*

Members: *Lucien Belmonte, Abividro, Venezuela*
Manoj Choudhary, Owens Corning, USA

Alastair Cormack, Alfred University, USA
Alicia Duran, SECV-ICV, Spain
Nicola Favaro, Stazione Sperimentale Vetro, Italy
Wilfried Linz, Shott AG, Germany
John Parker, University of Sheffield, UK
Phil Ross, GICI, USA
Guy Tackels, St Gobain, France

SUMMARY

The mission in brief: to promote the use of environmental friendly glass products (initially those applicable in the climate change context) and generate better awareness by policy makers and the public about the benefits of glass.

The Committee met in Trencin on June 26, 2008 and again in Columbus on November 5, 2008. At the Trencin Plenary session the chairman highlighted the need to communicate the positive aspects of glass products to all stakeholders but especially those in a position to influence national policy. This theme was developed at the flat glass workshop organised by Glass For Europe in Brussels on October 1, 2008 and on November 3, 2008 at the GMIC parallel session to the Glass Problems Conference, "Building a Sustainable Global Glass Industry". The chairman and Mr Tackels also made presentations at the Energy Intensive Industry Conference in Brussels on "carbon leakage" on November 26, 2008.

PLANS AND DELIVERABLES FOR 2008

The main deliverables for 2008 have been:

- Consolidation of the committee and objectives through two meetings and on-line exchange of information
- Presentations to glass industry stakeholder representatives at events at Trencin, Columbus and a flat glass industry workshop in Brussels
- Presentation to industry and policy makers at the Brussels Conference on Energy Intensive Industries and Climate Change
- Regional interactive workshop with industry and local government; Harrogate UK October
- TNO were approached and responded with an estimate of the cost of delivering a report on the carbon impact of upgrading glazing on a global basis similar to that carried out for the European Flat Glass trade association

ACTIVITIES in 2008

Members were asked to look in their own area of work for relevant material and to forward it to the Chairman for consideration by the Committee. Members were asked to consider and recommend what similar or other initiatives could be carried out and what subjects should be included.

PLANS FOR 2009 AND DELIVERABLES

- Continue to consolidate the Committee
- Develop TC12 web pages within ICG website and as TC12 stand alone
- Develop website for posting and receiving information
- Generate documentation describing purpose of TC12 and the need for industry support
- Continue progress with the TNO study

- Request companies to provide information on standardized elements of LCAs
- Seek funding for promotional activity
- Encourage and participate in promotional events and opportunities
- Participate in Glassman Europe and PacRim 2009

PUBLICATIONS AND OTHER CONTRIBUTIONS

Available presentations:

EII Conference: "The positive side of the equation. How industry can be part of the solution."

GMIC Parallel Session - Building a Sustainable Global Glass Industry: "Glass & Environment: Spreading Good News"

Glass For Europe Workshop: "Glass For Europe and the International Commission on Glass"

4.5.3 EDUCATION & TRAINING (TC23)

Chair: *Reinhard Conradt, RWTH Aachen University, Germany*

Vice-Chair: *Ales Helebrant, Inst. of Chemical Technology, Czech Republic*

Members: *Carolina Brillante, GMAPI, the Philippines*

Petru Balta, Univ of Bucharest, Romania

Charles Drummond III, The Ohio State University, USA

Alicia Duran, Instituto de Ceramica y Vidrio, Spain

Clara Goncalves, Instituto Superior Técnico, Portugal

Hiroyuki Inoue, Institute of Industrial Materials, Japan

Marek Liska, Trenchin University, Slovak Republic

Angelo Montenero, Univ of Parma, Italy

Morsi M. Morsi, National Research Center, Egypt

Jean-Pierre Pagnac, Institut du Verre Prover, France

John Parker, Univ of Sheffield, Great Britain

Carlos Solier, INTEMIN/CIDEMAT, Argentina

Alev Yaraman, Sisecam, Turkey

Xiujian Zhao, Wuhan Univ of Technology, China

Candidates for membership: *N. Papadopoulos, Greece, Candida, Brasil*

SUMMARY

It is the mission of TC23 to support education and training within the glass community by encouraging the organisation of workshops and tutorials, by organising workshops and tutorials, as well as by providing information on education sites, courses, and teaching materials in the field of glass science and technology. The EFONGA project was extended for a further year and this year has generated a number of activities in its closing stages. One of these events was the **road-mapping exercise** held at Brig, Switzerland. It yielded valuable **recommendations for future teaching activities**. As a result, TC23 has supported TC01 in preparing a workshop planned for 2009 in Montpellier, France. Another workshop has been prepared by TC23 for 2009 to take place in Vancouver, Canada. A start has been made on the database of universities involved in teaching glass.

PLANS AND DELIVERABLES FOR 2008

The specific goals and deliverables of TC23 for the year 2008 have been:

- Support the organisation of workshops for young scientists and technologists.

- Contribute to a road mapping exercise being undertaken by ICG.
 - Produce a database of European universities offering courses in glass science and technology.
 - Revive and update the ICG book list (originally initiated by Akio Makishima).
- During the TC23 meeting in June 2008 at Trenčín, priority was given to the first two objectives; the latter two were postponed to early 2009.

ACTIVITIES IN 2008

A TC23 meeting was held on Sunday, June 22 at the ESG-ICG conference in Trenčín, Slovak Republic. A format for the **database of international glass courses** was adopted. Each entry to the list should provide the following information: a short summary of the typical profile of the institution offering the course, a thesis list (MSc, PhD) if available, the language of instruction, the course level, the e-mail address of a contact person, a web link of the institution offering the course and, if possible, to the course itself.

Several TC23 members contacted university teachers within their reach to request a list of the top 5 to 8 **most important topics in materials science** of glass to be addressed at an international students workshop in Montpellier 2009. The following topics were identified:

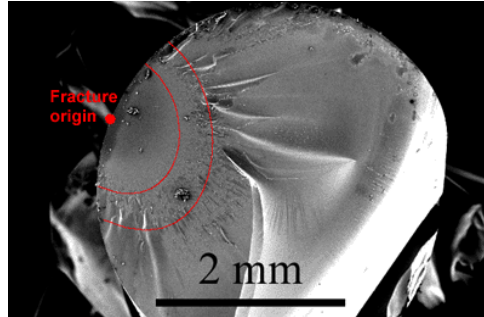
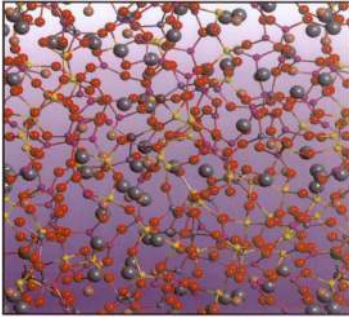
1. Composition – property relationships
2. Glass strength and mechanical properties
3. Thermodynamics of the glassy state, relaxation, and rheology / the glass transition
4. Glass structure and thermodynamic aspects of glass formation
5. Glass surface
6. Crystallisation
7. Glass chemistry

In two telephone conferences, the topical scope of an **EFONGA workshop** scheduled for May 4-8 in Montpellier was fixed (this workshop is prepared and run by TC01 jointly with TC23).

A second workshop, a “**Tutorial on Thermodynamics & Chemical Technology in Glass Melting**” was scheduled for the annual ICG meeting, June 2009, in Vancouver, Canada. The anticipated contents of the tutorial follows a recommendation from the “International Workshop on Advanced Materials and Innovative Glass Technology in the Year 2020” held during March 26 – 29, 2008 under the sponsorship of EFONGA in Brig, Switzerland.

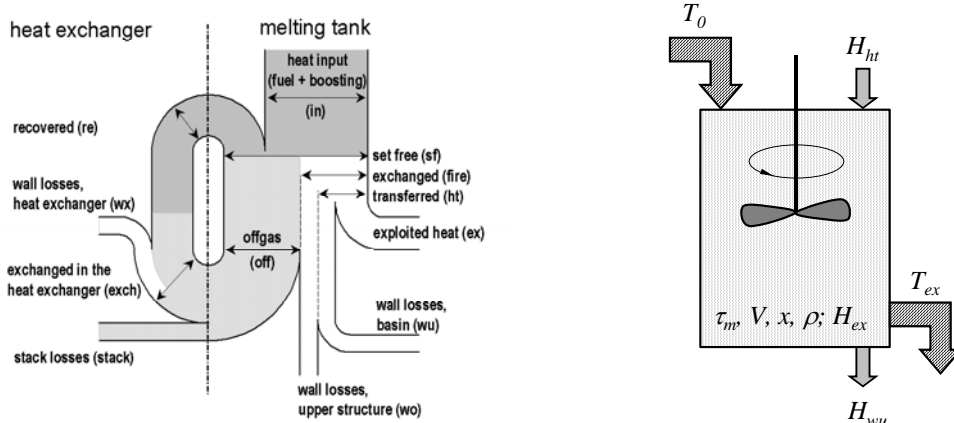
Alicia Duran volunteered – and was authorised by TC23 – to organise, establish, and coordinate an **ICG training team**. The team shall give courses organised by ICG in developing countries (core team members: A. Duran, H.Schaeffer, F.Nicoletti, H.de Waal). The activity is in progress, although it is very difficult to recruit active university teachers or active researchers from industry.

PLANS FOR 2009



- A “**Workshop for New Researchers in Glass Science and Technology**” will be held in Montpellier, France, during May 4 – 5, 2009. The workshop is organised under the auspices of EFONGA (European Forum on New Glass Applications) funded by the EU. A series of 17 lectures on current understanding of the fundamentals of structure-property relationships in glass will be presented by 11 world experts from industry or university. New research student studying for a PhD or have recently joined a glass manufacturer as a research worker will also have the opportunity to see their own research in the context of current gaps in our knowledge, in discussion with the panel of experts. Local expenses will be paid (i.e. meals and accommodation) but participants will need to cover their transport costs to Montpellier. Participants will be limited to 60; preference will be given to applicants from Europe but others may apply.

Address for application: Dr J M Parker, e-mail: j.m.parker@sheffield.ac.uk



- At the “International Workshop on Advanced Materials and Innovative Glass Technology in the Year 2020” held during March 26 – 29, 2008 under the sponsorship of EFONGA in Brig, Switzerland, a group of international experts recommended to strengthen the knowledge in thermodynamics and chemical technology within the glass community. As a result of this recommendation, a “**Tutorial on Thermodynamics & Chemical Technology in Glass Melting**” will be organised for the annual ICG meeting, June 2009, in Vancouver, Canada. The tutorial addresses Master level or 1st year PhD students with a focus on glass science and technology. Students may have acquired a background in materials science of glass and an overview over glass fabrication processes, but often feel a lack of instruction in the general concepts of industrial high-T processes. The tutorial aims at closing this gap by offering 4 sessions taught by well-known experts in the fields of (1) thermochemistry of raw materials, glasses and glass melts, (2) combustion technology, (3) technical thermodynamics of high-T processes, (4) chemical technology of high-T processes.

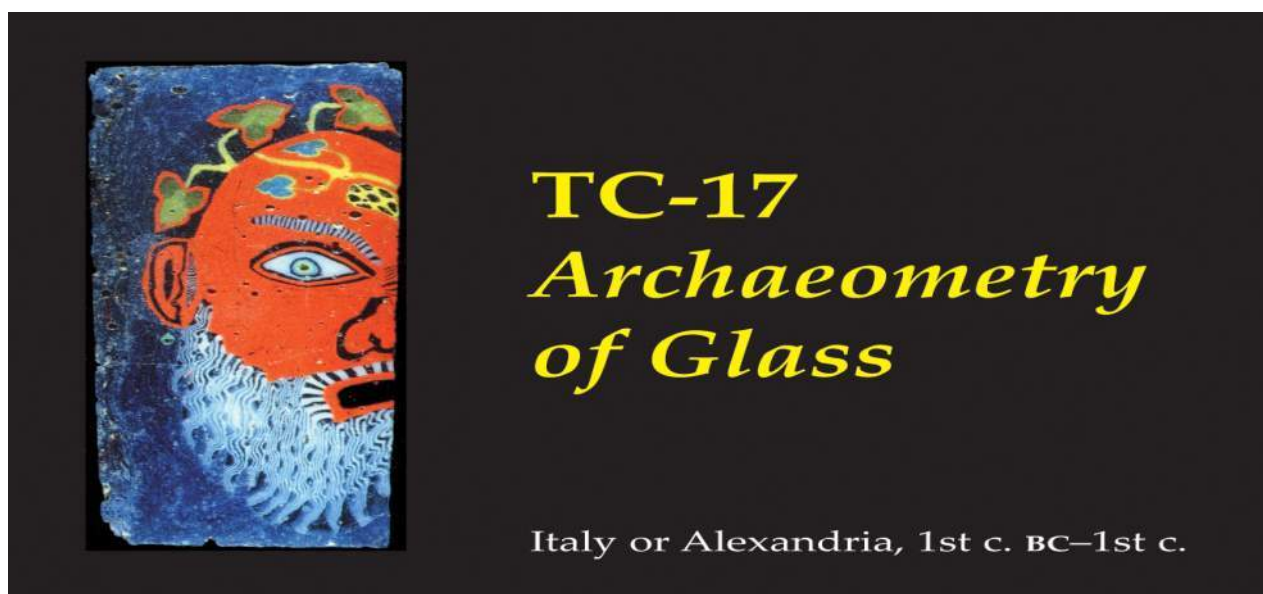
- Completion of a first draft of a database of international and European universities offering courses in glass science and technology.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- Glass DVD, copies available from the Society of Glass Technology (contact details at www.sgt.org)
- Lecture slides from the workshop for young glass scientists held at the Hameln, Germany, are available on request at DGG-HVG, Offenbach, Germany. See: info@hvg-dgg.de

Co-chairing the plenary session and round table discussion “Glass – The Challenge for the 21st Century“. This event was meant to contribute to the road mapping being undertaken by ICG. It focused on the prospects for glass and the glass industry in this century. The event was organised in the framework of the 9th ESG conference in Trenčín, Slovakia on 23. June 2008 on request by the organisers and International Commission on Glass.

4.5.4 THE ARCHAEOLOGY OF GLASS (TC17)



Chair: *Stephen P. Koob, Corning Museum of Glass, USA*
Vice-Chair: *Robert H. Brill, Corning Museum of Glass, USA*
Members: *Abdugani Abdurazakov, Nat. Inst. of Arts and Design, Uzbekistan*
H. C. Bhardwaj, Chandua Chittupur, India
Catarina Carvalho, Museu do Vidro, Portugal
Christopher R. DeCorse, Syracuse University, USA
Gan Fuxi, Shanghai Institute of Optics and Fine Mechanics, China
An Jiayao, Chinese Academy of Social Sciences, China
Takayasu Koezuka, Nara Nat. Cult. Properties Res. Inst., Japan
Alok Kumar Kanungo, Dept of Archaeology, Deccan College, India
David Martlew, Society of Glass Technology, United Kingdom)
E. Edwards McKinnonm, Pentlands Science Park, Scotland
Patricia Pongracz, American Bible Society, USA
Rainer Richter, Staatliche Kunstsammlungen, Germany
Manfred Schreiner, Institut fur Farbenchemie, Austria

Colleen P. Stapleton, Mercer University, USA
Norman Tennent, Glasgow, UK
Marco Verità, Stazione Sperimentale Del Vetro, Italy
Elzbieta Greiner-Wronowa, Univ. of Mining & Metallurgy, Poland

Consultative

Members: Jerzy Kunicki-Goldfinger, Inst. of Nucl. Chem. and Tech., Poland
In-Sook Lee, Busan Museum, Korea
Carlo G. Pantano, Materials Science & Engineering Dept., USA

Members

Emeriti: Kazuo Yamasaki, Mizuko, Nagoya, Japan
Shi Meiguang, China Building Materials Academy, China

SUMMARY

The purpose of TC17, unchanged since its beginning in 1982, is to bring together glass scientists, archaeologists, museum curators, and conservators to present and discuss the results of research on early glass and glassmaking, and on the conservation of historical glass objects. Ordinarily, TC17 meets only at the International Congresses and centers its programs in an ad hoc manner on the research and glass problems of the regions where the Congresses are held.

Two very important aspects of TC17 are that it promotes collaboration among glass specialists in widely-separated countries and it serves as a stimulus and encouragement for glass scientists and historians in developing countries.

ACTIVITIES in 2008

Meetings

None.

PLANS AND DELIVERABLES FOR 2009

At this point TC17 is not planning any involvement with the 2009 Annual Meeting of the ICG, in Vancouver, Canada, but is looking ahead to planning a program for the XXII International Congress on Glass, to be held 15-19 September, 2010 in Salvador, Brazil.

Membership

No new members were added in 2008. However in 2009 we are planning to invite Dr. M.O. Kozlova of the State Hermitage, St. Petersburg to join TC17.