COORDINATING TECHNICAL COMMITTEE
ANNUAL REPORT
2010

January 2011

CTC Chair

René Vacher

Université Montpellier II
CC 069 - 5 Place Eugène Bataillon
34095 Montpellier cedex, France
Phone: +33-467143449 or +33-608869333
Fax: +33-467143498
Email: rene.vacher@univ-montp2.fr

CTC Members

Volker Rupertus
Gülcin Albayrak
Richard Brow
Jun Matsuoka
John Parker
Ruud Beerkens
Jianrong Qiu
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>3</td>
</tr>
<tr>
<td>Summary of R&amp;D Activity Fields &amp; TC Activities</td>
<td>5</td>
</tr>
<tr>
<td>2.1 Basics and Properties</td>
<td>5</td>
</tr>
<tr>
<td>2.2 Glass Melting</td>
<td>6</td>
</tr>
<tr>
<td>2.3 Surfaces and Interfaces</td>
<td>8</td>
</tr>
<tr>
<td>2.4 New Applications</td>
<td>9</td>
</tr>
<tr>
<td>2.5 Information, Education, History</td>
<td>10</td>
</tr>
<tr>
<td>Organizational issues</td>
<td>12</td>
</tr>
<tr>
<td>Activities of the Technical Committees in Detail</td>
<td>14</td>
</tr>
<tr>
<td>4.1 R&amp;D Activity Field “Basic Glass Science”</td>
<td>14</td>
</tr>
<tr>
<td>4.1.1 Glass Structure (TC03)</td>
<td>14</td>
</tr>
<tr>
<td>4.1.2 Atomistic Modeling and Simulation of Glass (TC27)</td>
<td>17</td>
</tr>
<tr>
<td>4.1.3 Vibrations and Glass Structure (TC26)</td>
<td>18</td>
</tr>
<tr>
<td>4.1.4 Structure-Property Relationship (TC22)</td>
<td>21</td>
</tr>
<tr>
<td>4.1.5 Relaxation Phenomena in Glasses (TC08)</td>
<td>23</td>
</tr>
<tr>
<td>4.1.6 Nucleation, Crystallization &amp; Glass-Ceramics (TC07)</td>
<td>26</td>
</tr>
<tr>
<td>4.2 R&amp;D Activity Field “Production”</td>
<td>30</td>
</tr>
<tr>
<td>4.2.1 Glass Melting (TC18)</td>
<td>30</td>
</tr>
<tr>
<td>4.2.2 Modelling of Glass Melting Processes (TC21)</td>
<td>34</td>
</tr>
<tr>
<td>4.2.3 Materials for Glass Manufacturing (TC11)</td>
<td>37</td>
</tr>
<tr>
<td>4.2.4 Sensors and Advanced Control (TC15)</td>
<td>41</td>
</tr>
<tr>
<td>4.2.5 Gases in Glass (TC14)</td>
<td>42</td>
</tr>
<tr>
<td>4.2.6 Environment (TC13)</td>
<td>47</td>
</tr>
<tr>
<td>4.3 R&amp;D Activity Field “Characterization”</td>
<td>54</td>
</tr>
<tr>
<td>4.3.1 Glass Surface Diagnostics (TC19)</td>
<td>54</td>
</tr>
<tr>
<td>4.3.2 Mechanical Properties of Glass (TC06)</td>
<td>57</td>
</tr>
<tr>
<td>4.3.3 Optical Properties and Characterization (TC10)</td>
<td>59</td>
</tr>
<tr>
<td>4.3.4 Glass Durability and Analysis (TC02)</td>
<td>61</td>
</tr>
<tr>
<td>4.4 R&amp;D Activity Field “Applications”</td>
<td>64</td>
</tr>
<tr>
<td>4.4.1 Nanostructured Glass (TC16)</td>
<td>64</td>
</tr>
<tr>
<td>4.4.2 Coatings on Glass (TC24)</td>
<td>68</td>
</tr>
<tr>
<td>4.4.3 Glasses for Medicine and Biotechnology (TC04)</td>
<td>68</td>
</tr>
<tr>
<td>4.4.4 Nuclear and Hazardous Waste Vitrification (TC05)</td>
<td>75</td>
</tr>
<tr>
<td>4.4.5 Glass for Optoelectronics (TC20)</td>
<td>78</td>
</tr>
<tr>
<td>4.5 R&amp;D Activity Field “Information, Education and History”</td>
<td>83</td>
</tr>
<tr>
<td>4.5.1 Information and Communications (TC01)</td>
<td>83</td>
</tr>
<tr>
<td>4.5.2 Education &amp; Training (TC23)</td>
<td>85</td>
</tr>
</tbody>
</table>
1 Executive Summary

CTC Actions in 2010
The telephone conferences among CTC members and the traditional CTC business meetings which took place on March 11, 2010 in Mainz, Germany and on September 22, 2010 in Salvador, Brazil, focused on the:

- Organization of special events, such as expert workshops and the initiation of new actions,
- Preparation for the reorganization of the clusters,
- Discussions on financing future activities such as expert meetings, monitoring the work and output of the TCs,
- Motivating and supporting the TCs to improve the quality and effectiveness of their work.

Features of the year 2010 have been:

- Some decrease of meeting frequency as a consequence of the global credit crisis, but an increased use of teleconferencing
- Growing interactions between pairs of TCs where their interests are complementary
- Growing interest in the road mapping process to develop research programmes
- Developing education actions
- More committees developing their own web sites and using Blogs as communication tools

Turner Award
The WES Turner Award 2010 was presented in Salvador to Klaus Bange in recognition for his invaluable contribution to TC work as a TC Chair and as CTC Vice-Chair and Chair. Klaus Bange started his activity in the ICG as Chair of TC19 “Surface Diagnostics”. From 1998 to 2004 he was Vice-Chair of the CTC and became Chair of the CTC in 2004, a position that he kept up to 2009. As Vice-Chair and Chair of the CTC during more than 10 years, he was one of the main actors, and often the main actor of the considerable improvements in ICG activity. He reorganized completely the way of working of TCs, in order to increase their efficiency and professionalism. He created the cluster structure, that we call now R&D fields, to promote the interactions between TCs in the same field. He established the “Speed Project”, the telephone conferences within the CTC, and he put much effort into improving the quality of the CTC annual report. He was one of the main contributors to the recent revision of the ICG Constitution. More recently, he organized expert meetings and he developed roadmapping activity within the ICG.
ICG Glass Technology Roadmaps

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 focusing future R&D efforts and ICG directions for congress topics and expert meetings, and in defining new technical committees. One of the most promising tools for the ICG is the expert meeting that focuses on trends in different fields to create clearer pictures (roadmaps) and more precise perspectives on important topics for the glass community. Since the start of the roadmapping activities at ICG2007 in Strasbourg, France and the successful workshops in 2008 in Brig, Switzerland on “Advanced Materials and Innovative Glass Melting Technology in the Year 2020” the procedure and the technique has matured and is more accepted in the glass community. In 2010, the following meetings were organized under the auspices of the ICG with the aim of creating new roadmaps and improving existing ones:

- Expert meeting on “Atomistic Modeling and Simulation” on 18 May 2010 in Corning N.Y., USA during the GMOC conference, guided by TC27,
- Expert meeting “Surfaces and Thin Films”, Paris, France, August 26 - 27, 2010,
- Expert meeting on “Advanced sensors and process control in High Temperature Processes ”, Maastricht, The Netherlands, October 4-6, 2010, organized by TC15 and TC18.

A summary of roadmapping activities had recently been produced as a book “Making Glass Better” authored by Klaus Bange and Marion Weissenberger-Eibl.

ICG Glass Courses

In 2010, the Technical Committee on “Education & Training in Glass Science & Engineering” (TC23) increased the visibility of the ICG among students and younger scientists in the field of glass by offering two special events:

- The “Montpellier Student Workshop”, was organized this year in collaboration with TC01 from July 26 to July 30 on the theme: “Glass, the fourth state of matter?”
- The “Workshop on Glass Surfaces”, part of the “Clear as Glass” series, was held during the ESG meeting in Magdeburg, Germany on 1 June, 2010.

In addition, an ICG Training Team list (“rent a Prof”) was prepared, and includes 15 teachers that can offer training courses in different fields of glass.

2010 International Congress on Glass

The core event of the year was the International Congress on Glass which took place in Salvador from 20-25 September. 300 participants from 30 countries joined ICG2010 and presented 380 papers. During the opening session of the meeting, the current and future activities of the TCs were presented. The sessions on: Education; Structure and Vibrations; Waste Management; Bubbles; and Bioglasses were specifically allocated time slots and these were much appreciated by the audience. During the course of the event, 10 TCs organised sessions, some working as pairs to examine particular issues from different points of view. Good examples of such cooperation are: Blister formation at the Glass-refractory interface (TC11 and TC14), Structural aspects of glass crystallization (TC03 and TC07), and Modeling of bubbles and gases in the glass melt (TC14 and TC21). TC04, TC05, TC16, TC22 and TC26 also helped to organize sessions covering glasses for medical and dental applications, vibrations and structures, nanostructured glass coatings by sol-gel, immobilisation processes for nuclear and hazardous waste, glass structure-property relations, and vibrations and structure.
**Reorganisation of R&D fields**

As a consequence of the creation of three new TCs in the field of Basic Glass Science, the R&D field “Basics and Properties” has become too large. Furthermore, some of the TCs in this cluster were working on fundamental mechanisms, while some were more concerned by characterization. The following new structure was decided at the Steering Committee and Council meetings in Salvador:

- Basic Glass Science, TC03, TC07, TC08, TC09, TC22, TC26, TC27
- Characterization: TC02, TC06, TC10, TC19
- Applications: TC04, TC05, TC16, TC20, TC24
- Glass Production: TC11, TC13, TC14, TC15, TC18, TC21, TC25
- Information, Education, Communication: TC01, TC17, TC23

**Plan 2011**

- The Annual Meeting will be held in Shenzhen, China, from March 31 to April 2, 2011,
- CTC Technology meeting and business meeting planned in November 2011,
- The annual Montpellier Student Workshop will be held on July 4-8, 2011,
- A textbook “Bio-glass: an Introduction” will be published,
- An “Expert Meeting on Structure and Vibration in Oxide Glasses” will be held in Montpellier, 24-25 March 2011,
- TC18 and TC15 will organize from 12.-13. April 2011 in Eindhoven an expert meeting on “Fining, Redox Chemistry and Color Control in Glass Manufacture”,
- A meeting ”Bringing together Academia & Glass Industries” will be organized by Glass Trends in collaboration with ICG,
- The summary of roadmap activities “Making Glass Better” will be updated.

2 Summary of R&D Activity Fields & TC Activities

As described above, the structure of the R&D fields was changed in September 2010. In this summary, we have followed the “old” cluster structure, while the new one is used for the presentation of results in Section 4.

2.1 BASICS AND PROPERTIES

**Coordinator: R. Vacher**

The main lines of activities in this field are:

- Increasing understanding of the mechanisms of glass formation (TC08), glass stability and recrystallization (TC07), and of the microscopic structure of glasses (TC03, TC26, TC27),
- Improving the physical and chemical properties of glasses: chemical durability (TC02), mechanical (TC06), and optical properties (TC10),
- Understanding the structure-properties relationship (TC22).

Reorganisation in TCs:

Basic glass science is one of the important axes that we want to develop. Three new TCs were created last year in this direction. The main goal of TC27 “Atomistic simulation” is to increase our knowledge of the microscopic structure of glass by numerical simulations. TC26 “Structure and vibrations” concentrates on the investigation of the glass structure at the nanometric scale by analysis of
the vibrational spectra, and also on the understanding of collective vibrations in glasses. TC22 aims at defining more precisely “Structure-property relationships”. As a consequence of the creation of these TCs, TC03 will concentrate its activity on the experimental investigations of glass structure. Its title was changed in “Glass structure”.

**Expert meetings:**
- TC27 organized a roadmapping session on “Atomistic Modeling and Simulation”, chaired by Ulrich Fotheringham at the GOMD meeting in Corning, N.Y., USA in May 2010,
- TC08 organized a topical session on “Rheology of glass-forming melts” at the same conference in Corning.

**Symposia at the 2010 International Congress on Glass in Salvador, Brazil:**
- Structural aspects of glass crystallisation (TC03 and TC07),
- Nanostructured glass coatings by sol-gel (TC16),
- Vibrations and structures (TC26),
- Glass structure-property relations (TC22).

### 2.2 GLASS MELTING

*Coordinator: Ruud Beerkens*

*Within this cluster, is has been recognized that there is a need for new technical committees or task forces on the following subjects:*
- Glass furnace designs
- Energy efficiency & Combustion Processes
- Glass quality
- Thermodynamics and thermo-chemistry of glass melting

**Topics & meetings within this cluster in the period 2008-2012:**
- TC11, TC14, TC15, TC18, TC21: BRIG roadmap process (3 meetings in 2008 and 1 in 2009) → organisation of 4 seminars in 2010-2012
- TC11 & TC14 Test procedure for blistering from tank refractories in contact with molten glass
- TC11, TC14 and TC21 sessions at XXII ICG congress in Bahia, Brazil, September 2010
- TC13 Dust characterization in flue gases of glass furnaces
- TC13 Testing availability of dangerous compounds from glass (leaching tests) in framework of REACH.
- TC14 New methods for determination of water in glass
- TC14 Characterization of deposits in blisters in glass
- TC15 Project proposal for BRIG projects on Sensors and Advanced Control
- TC15 Seminar on Advanced Sensors & Process Control, Maastricht 2010
- TC18 Start of new RRT on Thermodynamic Modelling
- TC21 Round Robin test 5

TC25 did not meet in 2010 because of discussions on the continuation of TC25 activities and chairmanship. A new candidate chair for TC25 has been nominated at the end of 2010. TC25 will try to re-start in 2011 activities under a newly appointed chair person.
TC11 met in Magdeburg and they organized a seminar in co-operation with the DGG and GlassTrend in June 2010 on Glass Furnaces and Refractory Materials. TC11 met with TC14 to discuss the joint project on blistering from glass melt - refractory interfaces. TC11 members presented several papers (13) at the ESG conference in Magdeburg in June 2010.

The joint TC11 - TC14 meeting was held on 31 May. Topics: Impurities in AZS refractory materials, blistering from refractory-glass melt contact, analysis of gases in closed pores in AZS refractory.

TC11 and TC14 organized sessions at the XXII. ICG congress in September in Salvador de Bahia: session on Refractory blisters (TC11+TC14), Saturday, 25 Sept. On 20 September a joint TC11-TC14 meeting was planned in Bahia.

TC14 and TC21 organized a session in Bahia at the XXII ICG congress on Thursday 23. September 2010: Modeling of bubble behavior, fining and refining.

TC14 will meet from 12-14 April 2011 in Eindhoven for a seminar (Fining, Redox and Color Control in Glass Melting) and annual meeting.

TC13 met in 2010, two times in Murano, Italy (15 & 16 June 2010) and in Sheffield (16 and 17 November 2010). The meetings covered a range of subjects, with a focus on environmental legislation associated with the leaching of heavy metals from glass. TC13 also discussed the novel Cercat air pollution control plant installation at St. Gobain’s factory at Arboç, in Spain, and TC13 discussed the IPPC re-cast and BREF revision with its controversial BAT-AELs. There were also discussions of different emission monitoring techniques, with emphasis on measuring ammonia and mercury and on the American methods for distinguishing filterable and condensable particulate matter. TC13 also drafted a vision, a mission statement and an action plan for the next ten years work. TC13 published results of the particle size distribution measurements of flue gas dusts and leaching tests (availability of dangerous compounds from glass) in 2009 and 2010. TC13 next meeting will be on 5-6 April 2011 in Eindhoven. The TC13 fall meeting will be in Belgium or Italy in October 2011.

With emission limits becoming tighter and more expensive there is a critical need for better and more reliable measurements methods. In the next 5 - 10 years, TC13 will help providing the glass industry with adapted and affordable standard protocols, and finding new monitoring and emission control technologies.

TC15 and TC18 organized a joint seminar on “Advanced Sensors & Process Control in High Temperature Processes” in Maastricht, Netherlands from 4-6 October. Focus was on requirements for new types of sensors for combustion processes and glass melts, and process control of glass furnaces. The seminar concluded with discussion sessions and focused on a first draft roadmap for 2020-2030 concerning sensors & process control in glass production. TC15 held their annual meeting on Monday 4 October 2010 in Maastricht.

The title of TC18 changed from “Properties of Glass Forming Melts” into “Glass Melting”. TC18 stimulates co-operation between different Technical Committees operating within the cluster “Glass Production” and strives for further actions within the 4 main topics identified and described during the 2008-BRIG expert meeting “Innovative Glass Melting for the year 2020”.

Page 7
TC18 organized in co-operation with TC11 (Materials for Glass Manufacturing), a seminar of 25 papers on “Glass Furnaces & Refractory Materials” at the 10th ESG Conference in Magdeburg from 1-2 June 2010. About 100-120 people attended these sessions. On 31 May, 2010, TC18 held its annual meeting in Magdeburg (G).

From 4-6 October 2010, a seminar and roadmap workshop on “Advanced Sensors & Process Control in High Temperature Processes” was organized in co-operation with TC15 and GlassTrend in Maastricht, The Netherlands. The seminar included 15 technical papers on different types of sensors for Combustion, Flue Gases, Melting and Raw Materials. TC18 continues a Round Robin Test on Thermodynamic Modeling of Multi-Component Silicate Glass (Melts).

TC21 organized in co-operation with TC14 a session at the XXII ICG congress in Brazil. The Round Robin test RRT5 was continued in 2010. Results of a few modeling groups have been compared with measured data of the furnace (in operation in 2004). The furnace was a TV panel glass furnace with measured data available for validation of the modeling exercises.

TC21 is working on a publication of the results of their Round Robin test 4. Furthermore, TC21 plans a seminar and meeting on furnace modeling on 21-23 June 2011, in Velke Karlovice in the Czech Republic.

TC25 did not meet in 2010 and no activities have been pursued.

2.3 SURFACES AND INTERFACES
Coordinator: Volker Rupertus

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 the most important added value topics on glasses and films. The ICG road mapping session on “Glass Surfaces&Thin Films on Glass” on 26th and 27th August, 2010 in Paris was the central event of that cluster. The three TC chairs were member of the advisory board of that meeting and supported the preparation with many ideas and some members of the 3 TCs attended at the meeting and gave presentations and participated at the discussion with the external experts.

Nanostructured Glass (TC16) is working on glasses and coatings obtained by chemical nanotechnology. The main activities concentrated on a new topic. A study had been carried out for sol-gel derived nanostructured coatings for energy savings in buildings which have simultaneously solar control and photocatalytic properties. Most of the results have been obtained by TC members working parallel in Lisbon, Madrid and Padua. TC16 had a meeting in Madrid on April 23, 2010 and at the ICG congress in Salvador, Brazil, 20-24 September, 2010, TC16 organized a Symposium on Nanostructured Glass Coatings by Sol-gel, which included one invited and seven contributed talks, and presented a poster.

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 technical committee’s activities during the year have focused on three areas:
• Completion of the work on self cleaning / reduced maintenance coatings. This work area has now been completed with a hand over of all information to the CEN committee TC129 who are now progressing a standard in this area.
• Testing of pyrolytic coated transparent conductive oxide films (TCO).
• Identification of the forward route for TC24 and new areas of interest. Following reduced activity in 2009, the TC24 committee has this year been more active with three technical meetings held during the year (23 Feb, 2010 at AGC headquarters Brussels; 8 June, 2010 at ICCG 8 Braunschweig; 23 Sept., 2010 at AGC headquarters Brussels) along with the completion of a round robin and a second round robin established. Other activities had been participating on the ICG Road mapping session on Glass Surfaces & Thin Films on Glass - 26 and 27 August, 2010 and presentation of a poster at the 2010 ICG Congress in Salvador, Brazil, 20-24 September, 2010.

Glass Surface Diagnostics (TC19) establishes 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. In 2010 TC19 was strongly involved in the organization of an ICG expert panel on “Glass Surfaces & Thin Films on Glass” (Paris, August 26th-27th 2010) with 18 experts to work on a road-map for that field. In addition a XRD-round-robin was carried out, which deals with the determination of the crystallite size, the crystalline composition, glass/crystalline ratio as well as the lattice parameters of glass ceramics. The status of this activity is available in a report. Since TC19 is coming to the end of its current Road-Map, which was started over five years ago, TC 19 member-surveys were carried out to prepare the discussion on the future works of the TC. 12 TC members participated and gave strong indication for future actions. A TC19 group meeting took place on June 11th 2010 in Mainz.

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 of very high importance. Product cost, and issues related to large-scale manufacturing processes are generally not of significant priority in this cluster.

Each of the three technical committees in this cluster were very active, each with at least one business/technical meeting in 2010 and each developing some collaborative activity within the respective TC.
The Technical Committee Glasses for Medicine and Biotechnology (TC04) carried out round robin testing of commercial bioactivity of glasses (provided by five companies) and their variants and assessed the applicability of the protocol devised by the committee in 2009. Ten labs participated on this activity. In addition, the textbook “Bio-glass: an Introduction” was making progress and is close to the final state. Actions were started to obtain funding for the biomedical glass area, via a European Framework 7 COST action, to enable international meetings and roadmapping to take place in 2011 and beyond.

The Technical Committee on Nuclear and Hazardous Waste Vitrification (TC05) organized a symposium and conducted technical programming at the International Congress on Glass meeting in Salvador, Brazil. These technical programming efforts (starting in 2007) were highly successful so a continued programming effort was deemed to be worthwhile to further communicate the activities of TC05 members and the work of the waste vitrification community to a broader audience. The symposium was
successfully organized and was well attended. A total of 18 oral presentations and poster presentations were presented in the symposium. Papers were presented by six TC05 members. Moreover, presentations were made by representatives from 7 countries.

The Technical Committee Glass for Optoelectronics (TC20) organized and met at the 3rd International Workshop on Photoluminescence on Rare Earth: Photonic Materials and Devices (PRE’10) during 29 and 30 April at Firenze, Italy. Many of TC20 members contributed to the organization of the workshop. TC20 focuses on optoelectronic glasses and also on New Materials for Lighting and Solar Energy in addition to the present activities.

**INFORMATION, EDUCATION, HISTORY**

*Coordinator: J M Parker*

This cluster includes 3 TCs responsible for communications, education and history. To achieve these goals TC17 coordinates international activity in glass history and organizes conference sessions on archeometry, TC23 arranges student workshops and has created a database of teachers and glass courses, while TC01 is responsible for publicity and information, running the ICG web site and assisting in the publication of a wide range of literature and press releases.

This year has been unusually busy for this cluster with the publication of two important new volumes, numerous press releases, and changes in the web site, particularly organising a move to a new host. All these have taken place alongside the day-to-day tasks of production of CTC minutes and maintaining lists of committee members.

The main deliverables of TC01 in 2010 have been:

- Continuing revision and updating of the ICG and EFONGA Web sites
- Revision of the leaflet listing ICG officers
- Assisted in the 2<sup>nd</sup> Student workshop in Montpellier with TC23
- Minutes of CTC and EFONGA management board meetings
- The editing of News Briefs
- Assisting in the publication of two new ICG volumes

As in 2009, the main focus of TC23 activities during the year 2010 was the organization and support of workshops, among which were the Montpellier Student Workshop 2010, and the Workshop on Glass Surfaces as part of the “Clear as Glass” series, held during the ESG meeting in Magdeburg, Germany on 1 June. Prof. Duran continued the development of an International Training Team but had found the recruitment of younger academics and people from industry difficult. Additionally, plans include the generation of a new format for the ICG Book List, and a compilation of available courses on glass. TC23 met in Salvador jointly with TC01 on 20 September.

The second Montpellier Student Workshop was organized by TC01 and TC23, specifically Prof R. Conradt, Prof J Parker and Prof B Hehlen, who made the local arrangements. The workshop, like the previous event, was motivated by the idea to establish an international network among future glass scientists and technologists by exposing them to a series of attractive and excellent lectures and giving them ample opportunity to
interact both academically and socially. Lectures were given by 9 academics, including 4 from the University of Montpellier. In spite of the charge for accommodation and a small conference fee the event was still able to attract 26 young people from 10 different European Countries, Canada, USA, India, Japan and Thailand. The programme was run over an extended period of 5 days from 26-30 July and under the general title: ‘Glass: the fourth state of matter?’

The organizing committee decided to hold future workshops at the same location, thus establishing the “Montpellier Student Workshop” as a regular international event with a hopefully wide recognition.

TC17 did not meet in 2010 and no activities have been pursued.
3 Organizational issues

The following table depicts the current situation (Dec. 2010) for members of the CTC and chairs of the TCs.

<table>
<thead>
<tr>
<th>CTC/Coordinator/TC</th>
<th>Name</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTC-chair</td>
<td>R. Vacher</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>CTC-Vice Chair</td>
<td>R. Beerkens</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTC-Secretary</td>
<td>J. Parker</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTC</td>
<td>V. Rupertus</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>CTC</td>
<td>G. Albayrak</td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTC</td>
<td>R. Brow</td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>CTC</td>
<td>J. Qiu</td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>CTC</td>
<td>J. Matsuoka</td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>Information</td>
<td>J. Parker</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basics &amp; Properties</td>
<td>R. Vacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InterFaces</td>
<td>V. Rupertus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melting</td>
<td>R. Beerkens</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Applications</td>
<td>D. Brow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC01</td>
<td>J. Parker</td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>TC02</td>
<td>S. Jamieson</td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2d TE</td>
</tr>
<tr>
<td>TC03</td>
<td>F. Muñoz (acting)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC04</td>
<td>J. Jones</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC05</td>
<td>J. Marra</td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>TC06</td>
<td>R. Hand</td>
<td>Start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
</tr>
<tr>
<td>TC07</td>
<td>E. Zanotto</td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC08</td>
<td>L. Wondraczek</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2d TE</td>
</tr>
<tr>
<td>TC09</td>
<td>M. Ciccotti</td>
<td>Start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
</tr>
<tr>
<td>TC10</td>
<td>C. Anderson</td>
<td></td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC11</td>
<td>M. Dunkl</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2d TE</td>
</tr>
<tr>
<td>TC12</td>
<td>J. Stockdale</td>
<td>Start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
</tr>
<tr>
<td>TC13</td>
<td>G. van Marcke</td>
<td></td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC14</td>
<td>D. Koepsel</td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>TC15</td>
<td>W. Linz</td>
<td></td>
<td></td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC16</td>
<td>R. Almeida</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>TC17</td>
<td>S. Koob</td>
<td></td>
<td></td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC18</td>
<td>R. Beerkens (acting)</td>
<td></td>
<td></td>
<td>3rd TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC19</td>
<td>V. Rupertus</td>
<td></td>
<td></td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC20</td>
<td>S. Tanabe</td>
<td>2nd TE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC21</td>
<td>E.Muijsenber</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2d TE</td>
</tr>
<tr>
<td>TC22</td>
<td>G. Calas</td>
<td>Start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
</tr>
<tr>
<td>TC23</td>
<td>R. Conradt</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td></td>
<td>2nd TE</td>
</tr>
<tr>
<td>TC24</td>
<td>K. Sanderson</td>
<td>Start</td>
<td></td>
<td></td>
<td>1st TE</td>
<td></td>
<td></td>
<td>2d TE</td>
</tr>
<tr>
<td>TC25</td>
<td>C. Berndhäuser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3rd TE</td>
</tr>
<tr>
<td>TC26</td>
<td>B. Hehlen</td>
<td>Start</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
</tr>
<tr>
<td>TC27</td>
<td>J. Mauro</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st TE</td>
</tr>
</tbody>
</table>

The following CTC members started their **first 3-year term** in 2010:
- Ruud Beerkens (CTC Vice-Chair)

The following 3 chairs started their **second 3-year term** in 2010:
- John Parker (TC01)
- Rui Almeida (TC66)
- Reinhard Conradt (TC23)
The third term started in 2010 for:
- Edgard Zanotto (TC07)
- Guy van Marcke (TC13)
- Stephen Koob (TC017)

For 2010, decisions on the following persons/functions have to be prepared:
- Following Officers have agreed to continue: L Wondraczek, Kevin Sanderson as TC Chairs.
- In 2011 successors have to be selected and installed for Gülcin Albayrak, John Mauro, Christoph Berndhäuser, Ruud Beerkens, S. Tanabe.

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 2011 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 organization of expert meetings
- 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.
4 Activities of the Technical Committees in Detail

4.1 R&D ACTIVITY FIELD “BASIC GLASS SCIENCE”

4.1.1 GLASS STRUCTURE (TC03)

Chairman: Francisco Muñoz Fraile, Ceramics and Glass Institute, Spain
Vice-Chair: Akira Takada, Asahi Glass, Japan
Members: Joe Zwanziger, Dalhousie University, Canada
Adrian C. Wright, Reading University, U.K.
Natalia Vedishcheva, (Institute Silicate Chemistry, Russi)
Ondrej Gedeon, Institute of Chemical Technol., Czech Republic
Doris Ehrt, Otto-Schott Institute, Germany
Liu Qiming, Wuhan University of Technology, China
Hiromichi Takebe, Ehime University, Japan
Efstratios Kamitsos, Nat. Hellenic Research Foundation, Greece
Laurence Galoisy, IMPMC CNRS 7590, France
Lionel Montagne, Lille University, France
Alex Hannon, Rutherford Appleton Laboratory, U.K.

SUMMARY
2010 has been a transition year for TC03. Josef Zwanziger has been the interim Chair of TC03 since 2009 until Sept. 2010. However, in order to carry out new TC03 commission, Francisco Muñoz Fraile (Spain) and Akira Takada (Japan) were appointed as acting Chair and Vice-chair, respectively, after the last ICG Congress held in Brazil during September. Due to the quite broad scope of topics covered by the former TC03 (Basic Glass Science) and, as a consequence of the recent formation in 2009 of 3 new TCs focused on computer modelling, structure and vibrations and structure-properties relationships, the Technical Committee TC03 has changed its objectives to a group mainly devoted to the study of the structure of glasses. Thus, TC03 has been renamed Glass Structure. Approximately half of the members (before September 2010) have shown their availability to continue collaboration within new TC03 objective. New members have also been contacted to ask for their participation and they accepted to be involved. They are Lionel Montagne (University of Lille, France), Laurence Galoisy (IMPMC CNRS 7590, France) and Alex Hannon (Rutherford Appleton Laboratory, UK).

ACTIVITIES in 2010
Meetings
There have not been formal meetings of TC03 members during 2010. However, informal discussions were held during the 11th International Conference on the Structure of Non-Crystalline Materials (Paris, France) and the ICG Congress in Salvador, Brazil by the few members present in either of the conferences, in order to solve the organisational issues and define the new working lines for the near future.

NMR Round Robin Test
Samples of four sodium borosilicate glasses, whose composition and properties can be found in reference [“Electrical conductivity and viscosity of borosilicate glasses and melts”, D. Ehrt and R. Keding, Physics and Chemistry of Glasses, 50(3), (2009), 165-171] and were prepared by Doris Ehrt in the Otto-Schott Institute (Jena, Germany), were distributed to several Laboratories for NMR characterisation. Table 1 shows the nominal composition of the studied glasses.
### Table 1. Composition of investigated NBS glasses.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Na&lt;sub&gt;2&lt;/sub&gt;O (mol %)</th>
<th>B&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt; (mol %)</th>
<th>SiO&lt;sub&gt;2&lt;/sub&gt; (mol %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBS-A-1</td>
<td>12.5</td>
<td>62.5</td>
<td>25</td>
</tr>
<tr>
<td>NBS-B-2</td>
<td>3</td>
<td>48.5</td>
<td>48.5</td>
</tr>
<tr>
<td>NBS-C-3</td>
<td>15</td>
<td>42.5</td>
<td>42.5</td>
</tr>
<tr>
<td>NBS-D-4</td>
<td>6.5</td>
<td>33.5</td>
<td>60</td>
</tr>
</tbody>
</table>

The Professors/Researchers in charge of this test were: Scott Kroeker (University of Manitoba, Canada), Randy Youngman (Corning, USA), Pierre Florian (CNRS, France), Mark Smith (University of Warwick, UK) as well as Josef Zwanziger (Dalhousie University, Canada). Results are complete from Zwanziger and Kroeker; reports are being completed by Youngman and Florian and measurements are underway at several other laboratories. While data have been collected on various aspects, one representative graph, of four-fold-coordinate boron fraction $N_4$, is shown in Figure 1.

![Figure 1. $N_4$ values in NBS glasses.](image)

In conjunction with the round robin test, Natalia Vedishcheva estimated the fractions of basic structural units, densities and $Q^n$ values successfully by modelling the chemical structure.

**Symposium**

Adrian Wright, Natalia Vedishcheva and Josef Zwanziger, from TC03, together with Edgar D. Zanotto of TC07, organised for the ICG 2010 Congress a session on the **Structural Basis of Glass Crystallisation** where an invited talk and five more papers were presented. Both technical committees affirmed the success of collaborative discussions and the continual exchange of discussion after this symposium.

**Education**

During a stay at the University of Trento (Italy) through invitation of Giuseppe Dalba, Adrian Wright presented a 6-lecture course on “X-Ray and Neutron Amorphography”.

**PLANS FOR 2011**

In order to continue the work of TC03 within the topic of Glass Structure, it has been decided to keep running the activities planned in the former Basic Glass Science committee that would best fit in the newly organised one. Thus, the main objectives to be carried out during 2011 are the following:
**Round-robin test**
Once all results of the Round Robin Test on the four samples of Na$_2$O-B$_2$O$_3$-SiO$_2$ glasses can be completed, an analysis of the influence of the NMR experimental parameters on the speciation of the borate and silicate structural units will be carried out. All four borosilicate glasses present subliquidus phase separation. It has been discussed that it would be more suitable for a start to perform a characterization based on a single-phase homogeneous glass sample; nevertheless it will be interesting to standardize and complete the structural characterisation in the sodium borosilicate glasses that is already running in the mentioned laboratories. As more laboratories continue to join the TC03 committee, the round robin test will be extended to other potential characterization techniques that could better fill the gaps that Nuclear Magnetic Resonance could not achieve by itself. This will be a chance to properly combine NMR with diffraction techniques, for example.

**Computer modelling of glass structure**
The previous activities in TC03 were to perform a “round robin” test to evaluate the various computer simulation codes currently used to investigate the vitreous states. However, in order to cooperate more with the experimental round-robin tests, the objective will be changed. First, the present state of advanced NMR simulation will be investigated. If the techniques have applicability they will be evaluated using round-robin results. Second, results of atomistic modelling will be compared with those of the chemical structure modelling.

NMR round robin test results on the structure of the borosilicate glasses under study will also be used in comparison with the modelling of the chemical structure through a purely thermodynamic model of associated solutions, a model developed by N. Vedishcheva and coworkers [more information: ref. N.M. Vedishcheva et al., J. Non-Cryst. Solids 345&346 (2004) 39-44].

**Glass microstructure**
It has been proposed to extend the subjects under study to glass microstructure and the relationship between atomic structure and phase separation behavior.

**Education**
The objective was established to act in collaboration with TC23 to improve students' training, from a general point of view related to Glass Science, and as a consequence of the fact that inadequate students' training might be occurring. Despite future collaboration with TC23 within this subject, the intention is that a series of workshops/seminars can be planned with the topic “Glass Structure”, not only for students but also for glass researchers in general who need to specialize in structural characterization techniques of glasses.

**Meeting and symposium**
At the moment, a TC03 meeting is planned for 2011 in Oxford (UK) within the framework of the International Conference on the Chemistry of Glasses and Glass forming Melts in celebration of the 300$^{th}$ anniversary of the birth of Mikhail Vasilievich Lomonosov. At the same place, a session on the Chemical Aspects of Glass Structure will be organised by the members of TC03.
4.1.2 ATOMISTIC MODELING AND SIMULATION OF GLASS (TC27)

Chairman: John Mauro, Corning Incorporated, USA  
Ulrich Fotheringham, SCHOTT AG, Germany  

Members: Douglas Allan, Corning Incorporated, USA  
Richard Catlow, University College London, UK  
Dipak Chowdhury, Corning SAS, France  
Alastair Cormack, Alfred University, USA  
Phong Diep, Corning Incorporated, USA  
Jincheng Du, Univ. of North Texas, USA  
Neville Greaves, Aberystwyth Univ., UK  
Liping Huang, Rensselaer Polytechnic Institute, USA  
Ben Leimkuhler, Univ. of Edinburgh, UK  
Roger Loucks, Alfred Univ., USA  
Matthieu Micoulaut, Univ. Pierre et Marie Curie, France  
Yunfeng Shi, Rensselaer Polytechnic Institute, USA

SUMMARY
The Technical Committee on “Atomistic Modeling and Simulation of Glass” was founded in 2009 and officially approved by ICG during the PACRIM conference in Vancouver, Canada. The focus of the new TC is on developing the theoretical foundation for advancing the modeling and simulation of glassy systems. The scope includes both the development of accurate interatomic potentials for multi-component glass-forming systems, as well as the development of new theoretical approaches and algorithms for overcoming the intrinsic time and length scale limitations of existing simulation techniques. The TC set off to a running start with the “Theory and Modeling” session organized by John Mauro and Ulrich Fotheringham at PACRIM in Vancouver. Topics covered during the session included energy landscape techniques, topological modeling approaches, thermodynamic modeling, statistical mechanics, as well as advances in traditional molecular dynamics. Later Matthieu Micoulaut and John Mauro organized the “International Workshop on Topology, Structure, and Dynamics in Non-Crystalline Solids,” in September, 2009 in Paris (together with Normand Mousseau of Université de Montréal). Ulrich Fotheringham also chaired a preliminary roadmapping session for atomistic modeling of glass during an EFONGA workshop in Montpellier. We followed up on this roadmapping session at the American Ceramic Society Glass and Optical Materials division meeting in May, 2010, in Corning, NY. Emphasis is on bringing the application-oriented glass simulation community together with the community working on the basic numerics for dynamic systems in order to establish a common strategic research agenda in the long run.

DELIVERABLES FOR 2010

- Glass and Optical Materials Division (GOMD) Meeting of the American Ceramic Society, Organized and Chaired by John Mauro in Corning, NY. The meeting drew double the attendance of the previous GOMD meeting and set a new record for
number of presentations and participants. A total of 387 registered attendees participated at this year’s GOMD meeting.

- Roadmapping session on “Atomistic Modeling and Simulation,” chaired by Ulrich Fotheringham at the GOMD meeting.
- Technical session on “Atomistic Modeling of Glass” at GOMD 2010, organized and chaired by Ulrich Fotheringham and Jincheng Du. Invited speakers include Walter Kob, Andreas Heuer, Neville Greaves, and Guillaume Ferlat.
- Technical session on “Topology and Rigidity” at GOMD 2010, organized and chaired by Matthieu Micoulaut and Normand Mousseau. Invited speakers include David Drabold, Carlo Massobrio, and Punit Boolchand.

PLANS FOR 2011 AND DELIVERABLES

The focal point for our TC activities during 2011 will be a workshop on “Pushing the Limits in Glass Modeling and Simulation,” organized by Ben Leimkuhler, Richard Catlow, and Ulrich Fotheringham. This meeting will bring together industry glass experts with chemists, physicists, and mathematicians interested in exploring novel multiscale modelling techniques for glasses, beginning from the molecular level. Numerical methods, model development, fast force computations, and parallel computing methods are to be considered. Specific themes to be addressed include:

- The force field of 2030
- Coarse graining from Atomistics to Mesoscale Models
- Towards O(N) Simulation Algorithms
- Scalable Parallel Algorithms

ORGANIZATIONAL CHANGE

John Mauro has accepted a new position at Corning and needs to resign as chair of TC27. Jincheng Du has graciously agreed to take over in John’s role. Ulrich Fotheringham will continue to co-chair the European side of our activities.

4.1.3 VIBRATIONS AND GLASS STRUCTURE (TC26)

Chairman: Bernard HEHLEN, Univ. Montpellier 2, France
Vice-Chairs: F.J. Bermejo, Instit. de Estructura de la Matiera, Madrid, Spain
Members: E.I. Kamitsos, TPCI/NHRF, Greece
A. Chumakov, ESRF, France
P. Simon, CNRS, France
D. Massiot, CNRS, France
I. Farnan, Univ. Cambridge, UK
M. Dove, Univ. Cambridge, UK
S.R. Elliott, Univ. Cambridge, UK
L. Cormier, Univ. Paris 6, France
A. Pasquarello, EPF Lausanne, Switzerland
W. Schirmacher, T.U. Munich, Germany
SUMMARY

This TC focuses on the nature of the vibrations in glasses and on the structural information that can be gained using inelastic spectroscopy techniques: infrared absorption, light scattering, neutron and X-ray scattering, etc, as well as numerical simulations of the vibrational properties. We will mainly concentrate on i) the origin of the boson peak and its relation with the end of acoustic branches ii) the understanding of the optic modes of oxide glasses and their relation to the structure, and iii) the contribution of inelastic spectroscopies to the characterization of the structural properties of technological glasses.

PLANS AND DELIVERABLES FOR 2010

1. Annual TC26 meeting at ICG conference in Salvador de Bahia

This was the first meeting of this young TC. Six members were present. B. Hehlen made a brief summary of the scientific objectives of workgroup. A discussion followed on the better methods to be operated to get the higher efficiency in the group. The members also proposed a list of researchers that could join the TC.

2. Enlargement of the workgroup

Following the suggestions of the members, 4 researchers have accepted to participate to the workgroup: M. Ramos (Madrid, Spain), D. Neuville (Paris, France), G. Henderson (Toronto, Canada), J. Horbach (Mainz, Germany).

3. Organization of an expert meeting in Montpellier.

The date of the meeting has been fixed to the 24th-25th March 2011. The participants will all be invited. The funds arise from the Region Languedoc Roussillon and the University of Montpellier II. Most of the TC members have accepted the invitation.

The objective of this meeting will be to make an inventory of the state-of-the-art of what is known and still under discussion on the vibrations in glasses, from an experimental, numerical, and theoretical point of view. In order to reach this objective, a series of questions have been sent to the members that will be addressed during their talk.

A preliminary program is given below:
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Thursday, March 24&lt;sup&gt;th&lt;/sup&gt;</strong> (Chairman B. Hehlen)</td>
<td></td>
</tr>
<tr>
<td>8h30</td>
<td>Opening : B. Hehlen</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Round Table 1 : Optic modes in oxide glasses - simulations -</strong> <em>Moderator : S.R. Elliott</em></td>
<td></td>
</tr>
<tr>
<td>9h00</td>
<td>A. Pasquarello</td>
<td>Structure of Oxide Glasses through the First Principles Simulation of Vibrational Spectra</td>
</tr>
<tr>
<td>9h30</td>
<td>S.R. Elliott</td>
<td>VDOS SiO₂, ...</td>
</tr>
<tr>
<td>10h00</td>
<td>Coffee break</td>
<td></td>
</tr>
<tr>
<td>10h30</td>
<td>S. Ispas</td>
<td>VDOS SiO₂, binary silicates, pressure</td>
</tr>
<tr>
<td>11h00</td>
<td>J. Horbach</td>
<td>MD, VDOS SiO₂, binary glasses, localisation</td>
</tr>
<tr>
<td>11H30</td>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>12h30</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Round Table 1 : Optic modes in oxide glasses - spectroscopy -</strong> <em>Moderator : G. Henderson</em></td>
<td></td>
</tr>
<tr>
<td>14h00</td>
<td>L. Cormier</td>
<td>Structure of silicates</td>
</tr>
<tr>
<td>14h30</td>
<td>D. Neuville</td>
<td>Structure and vibrations in silicates</td>
</tr>
<tr>
<td>15h00</td>
<td>E. Kamitsos</td>
<td>IR of silicates and borates</td>
</tr>
<tr>
<td>15h30</td>
<td>Coffee break</td>
<td></td>
</tr>
<tr>
<td>16h00</td>
<td>P. Simon</td>
<td>Vibrations silicates + high temp.</td>
</tr>
<tr>
<td>16h30</td>
<td>G. Henderson</td>
<td>Vibrations silicates, germanates + High temp.</td>
</tr>
<tr>
<td>17h00</td>
<td>B. Hehlen</td>
<td>Vibrations and glass structure</td>
</tr>
<tr>
<td>17h30</td>
<td>Discussion and Summary</td>
<td>Inputs to the roadmap</td>
</tr>
<tr>
<td></td>
<td><strong>Round Table 1 : Closing</strong></td>
<td>Dissemination of information</td>
</tr>
<tr>
<td></td>
<td><strong>Friday, March 25&lt;sup&gt;th&lt;/sup&gt;</strong> (Chairman B. Hehlen)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Round Table 2 : The boson peak of glasses - Theory and simulations -</strong> <em>Moderator : U. Buchenau</em></td>
<td></td>
</tr>
<tr>
<td>8h30</td>
<td>B. Rufflé</td>
<td>Introduction</td>
</tr>
<tr>
<td>9h00</td>
<td>W. Schirmacher</td>
<td>BP: Theory 1</td>
</tr>
<tr>
<td>9h30</td>
<td>H. Schober</td>
<td>BP : Theory 2</td>
</tr>
</tbody>
</table>
PLANS FOR 2011 AND FORESEEN DELIVERABLES

The main event for 2011 is the “Expert Meeting on Structure and Vibration in Oxide Glasses” which will held in Montpellier, 24-25 March 2011.

This will start the roadmap process, and define short, medium and long range actions.

The conclusions of this meeting will be part of an ICG press release, but we could also envisage to publish this work e.g. in “Review of Modern Physics” or in “Physics Reports”.

4.1.4 STRUCTURE-PROPERTY RELATIONSHIPS (TC22)

Chairman: Georges Calas, Univ. Paris, France
Members: Bruce G. Aitken, Corning, USA
Harald Behrens, Univ. Hannover, Germany
Richard K. Brow, Univ. Missouri-Rolla, USA
Marie-Hélène Chopinet, Saint-Gobain Recherche, France
Manoj Choudhary, Owens Corning, USA
Giuseppe Dalba, Univ. Trento, Italy
Laurence Galois, Univ. Paris, France
Neville Greaves, Univ. Wales, Great Britain
Scott Kroeker, Univ. Manitoba, Canada
Chuck Kurkjian, Rutgers, USA
In 2010, we have organized two meetings/sessions, which will have allowed most members of the TC to gather:
1. The 11th conference of the series "Structure of non-crystalline materials". We achieved 250 participants, and several members were actively involved in the meeting, as members of the International Advisory board, as Session chairs and as invited speakers. The main novelties presented at the meeting, which are interesting in showing emerging trends in the investigation and in the concepts relative of glass structure, are:
   - new tools: high-energy X-ray diffraction, high-T and high-P spectroscopic and diffraction, *ab initio* modeling of multicomponent glasses
   - theoretical aspects: glass rigidity, nano-cluster agglomeration, new statistical codes
   - influence of external forcing: high pressure with polymorphism investigated both experimentally and numerically and with P-induced amorphization; external irradiation with both electronic and ballistic effects investigated
   - emerging properties: memory effects, new generation of waste glasses, properties from nano-particles in glasses, photo-structural properties, control of the formation of glass ceramics.

This long list is in fact very informative and shows that more realistic conditions and compositions are now taken into account, even with advanced experimental and numerical tools.
Presently, G. Calas is editing, with Neville Greaves (Aberystwyth) and Joe Zwanziger (Dalhousie), a special issue of JNCS dedicated to NCM11. The activity of TC22 will be mentioned in the foreword of the special issue, ensuring a broad diffusion of the existence and activities of the TC. With the new editorial line of JNCS, the editing is requiring a high standard for the accepted manuscripts. As a consequence, among the 71 manuscripts received, probably only about one half will be published, the lowest rate in the NCM conference series. The positive sponsoring from French public and international industrial groups is supporting the edition and we will thank the sponsors in showing the complementary action between NCM11, a conference organized every 3 years, and TC22, a group with a permanent existence.

2. We have managed a TC22 session at ICG2010, scheduled by the organizing committee. 8 talks have been presented, mainly outside the TC committee. It was the occasion to raise the importance of this topic. In the future, it will be interesting to work in advance with the organizing committee to seek an information exchange between the content of the sessions dealing with glass properties.

3. TC meeting: it was held during the ICG congress, with a special room reserved for that occasion. It was the occasion for the members to know more about the activities of every one. Among the topics discussed, some emerging topics are: glass surface structure and properties, influence of thermal history, or significance of the chemical control of the glass properties.
During the TC meeting, we discussed the possibility of making available to the glass community the important sets of glasses left by some industrial laboratories. Similarly, there exist a few databases (e.g. at NIST), which could be completed and which may be
used for the correlation between glass composition and some physical properties. The financial cost of establishing and maintaining such repositories and databases does not allow further progress at the moment. In addition, the stability of the structure in charge of each of these repositories/databases needs to be permanent and not to rely on a single person. However, we will approach the Society of Glass Technology to get their opinion on that topic. Presently SGT proposes, with a minor financial contribution, some reference samples to the glass community. We want to know if they think it is wise to enlarge their catalog.

In 2011, TC22 "Structure-property relationships in glasses" will hold its meeting on the occasion of the International Conference on the Chemistry of Glasses and Glass-Forming Melts, which will be organized by Adrian Wright in Oxford, September 4th - 8th, 2011. The conference will be held together with the annual meeting of the Society of Glass Technology, which will ensure a good attendance. We will be involved in two events:
- We will have a TC business meeting in Oxford on Sunday September 4th, probably at Lady Margaret Hall, where a room will be reserved (to be confirmed).
- We will organize a session on "Structure-properties relationships in glasses and melts", the title of TC22. The deadline for the abstracts is February 28th.

Until this date, we have a proposition from Chuck Kurkjian to think how to share glass samples and physical/chemical data on glasses. Samples and data are available, but among the question are the repository and the data handling on the web. On the other hand, as discussed in Salvador, we explore the possibility of round robin measurements of glass structure and properties and we will approach other TCs to seek cooperation.

Preliminary contacts on organizing a summer school on our topic in 2012 have been taken. In case of a positive feedback, a proposal will be prepared for late Spring 2011.

4.1.5 RELAXATION PHENOMENA IN GLASSES (TC08)

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

In 2010, TC08 started preparations for the third international workshop on glass and entropy which is planned for 2012. This workshop is anticipated to temporarily conclude the focus of glass and entropy issues (started in 2007). As a new focus, rheology of glass forming liquids and relaxation processes close to $T_g$ were identified, and activities beyond 2012 will cluster around this topic.

ACTIVITIES in 2010

In the following, the main activities which were conducted in 2010 are briefly summarized:

(A) organization of a topical session on rheology of glass-forming melts at GOMD conference in Corning, US

A technical session and TC meeting was held at the GOMD conference in Corning, US. The following presentations were given:

- **Rheology of heterogeneous liquids** J. Deubener*, Clausthal University of Technology, Germany
- **Viscosity of Glass-Forming Liquids** J. C. Mauro*, Corning Incorporated, United States; Y. Yue, Aalborg University, Denmark; A. J. Ellison, Corning Incorporated, United States; P. K. Gupta, The Ohio State University, United States; D. C. Allan, Corning Incorporated, United States
- **Modeling the Nonequilibrium Viscosity of Glass** D. C. Allan*, J. C. Mauro, M. Potuzak, Corning Incorporated, United States
- **Viscosity and softening behaviour of alkali zinc phosphosulphate glasses** N. Da*, L. Wondraczek, Universität Erlangen-Nürnberg, Germany
- **Progress in the Rheology of Inorganic Glass-Forming Melts** Y. Yue*, Aalborg University, Denmark
- **Boson peak, inhomogeneity and pressure experiments in SiO$_2$ and GeO$_2$ glasses** B. Champagnon*, D. Thierry, M. Christine, Université Lyon1-CNRS, France
- **Pressure-assisted flow of glass melts in narrow capillaries** M. Schmidt*, L. Wondraczek, P. Russell, Max Planck Institute for the Science of Light, Germany
- **On the Origin of the Mixed Glass Former Effect: Varying Coulomb Traps of Network Forming Units** P. Maass, Universität Osnabrück, Germany; C. R. Müller*, Technische Universität Ilmenau, Germany; M. Schuch, Universität Osnabrück, Germany
- **Viscosity of Tellurite Glass: 75TeO$_2$-20ZnO-5Na$_2$O** A. Belwalkar*, W. Z. Misiolek, J. Toulouse, Lehigh University, United States

(B) EFONGA summer school in Montpellier

TC08 contributed two lectures to the summer school “2nd Workshop for New Researchers in Glass Science and Technology” which was held in Montpellier, France on 26-30 July 2010).
Preparation of the third Glass & Entropy workshop has started. As with the two previous workshops, this event will be another high-level symposium with strong focus on discussion. Although general aspects of the glass transition and the quest for zero-point entropy will remain the focus of this meeting series, this time, we would like to further highlight applications (after nomenclature and definitions in the first meeting in Trenčín, SK, and experiments in the second meeting in Aberystwyth, UK), not meaning (primarily) applications in the engineering sense, but specific examples where entropy-related problems of glassy systems are relevant. This covers practically all topics of the first two meetings, but we are hoping (and confident) that there will be various actual proceedings, results and follow-ups of the experiment-related discussions back in April '09.

Some rough facts at present are:
- date will be somewhere between April and July 2012, depending on overlap with other conferences; 3-5 days
- location will be in Germany; two options: Nuremberg metropolitan area OR "Wildbad Kreuth", http://www.kreuth.de/
- the symposium will be a high-level event with 30-40 invited speakers, this time eventually broadened by additional poster presentations; maximum - 70-80 attendees
- it is an objective to design the program so that, on average, 15 min are available for discussion after each presentation
- an agreement has already been obtained from Elsevier for a special issue of J. Non-Cryst. Solids, published as a regular volume, and paper submission is already possible
- we are trying to obtain funding from various sources so that a significant part of the symposium can be sponsored by the organizing committee. In general, it is my goal to reduce cost to not more than a total of 200,-EUR for conference fees, lodging, meals, proceedings volume, eventual bus transfer from Munich airport to Kreuth.

Up to now, about 40 scientists have confirmed their concrete interest in active participation.

Cooperative actions

As the main objective of the workshops on glass and entropy, some concrete cooperative actions were started, e.g.:

"Development of electrochemical methods for the determination of the thermodynamic properties of vitreous non-metallic and metal / metalloid systems"

(presently involving University of Erlangen and Bulgarian Academy of Science, financially supported by the German Academic Exchange Office for the period 2010-2011)

"The configurational Prigogine-Defay ratio"

(involving University of Grenoble, Institute Neél / CNRS, University of Erlangen)

Review on "Glass and Entropy"

(Wondraczek/Conrat/Mauro, delayed in 2009, and again delayed in 2010; anticipated submission date late 2011)
PLANS FOR 2011 AND DELIVERABLES

(A) The feature article on “Glass and Entropy” shall be finalized as a summary of the 2007, 2008 and 2009 workshops.

(B) Preparation of the third workshop on glass and entropy in finalized, including acquisition of sponsors/funding.

(C) New topical focus on rheology of glass forming liquids

(D) Evaluate synergies of merging TC08 with other TC(s).

4.1.6 NUCLEATION, CRYSTALLIZATION & GLASS-CERAMICS (TC07)

Chairman: Edgar Dutra Zanotto, Fed. Univ. São Carlos, Brazil
Vice-Chair: W. Höland, Ivoclar Vivadent, Liechtenstein
Members: A. Sakamoto, NEG, Japan
T. Komatsu, Nagaoka Univ., Japan
R. Hill, Imperial College, UK
R. Müller, BAM, Germany
M.J. Pascual, ICV, Spain
J. Deubener, TU Clausthal, Germany
G. Querel, St-Gobain, France
M.J. Davis, Schott, USA
F. Gabel, SCHOTT AG, Germany
M.O. Prado, CNEA, Argentina
M. Budd, consultant, Norway
J. Sestak, Science Academy, Czech Republic
V.M.Fokin, Vavilov Optics Institute, Russia

SUMMARY
Two successful business meetings (in USA and Brazil) demonstrate that the TC07 chair and most members have been quite active in 2010. The new focus of the TC07 - the study of crystallization of multi-component glass forming systems and properties of glass-ceramics - initiated in 2008 was continued. We successfully organized an important congress - The XXII International Congress on Glass - with special one-day workshops on “Glass-ceramics” and on “Structural aspects of glass-crystallization”. Last, but not least, various crystallization related publications were co-authored by TC07 members and/or with members of other TCs.

PLANS AND DELIVERABLES FOR 2010
The TC07 had planned to organize the XXII International Congress and two dedicated satellite workshops, and such meetings were indeed successfully organized. In the ICG2010, in Salvador de Bahia, Brazil, from 20-24 September 2010, about 370 oral and poster presentations were delivered from authors of approximately 30 countries. The ICG2010 was a relatively small congress compared to previous editions, but of high scientific and technological level, as indicated by some relevant facts listed below:
- All 22 invited speakers were carefully selected and presented insightful talks;
- 20 of the 100 most prolific glass researchers of this planet (as shown by the Scopus database) attended the ICG 2010!
- 13 Gottardi awardees were present!
- A most useful and enjoyable short course was nicely delivered by Prof. Arun Varshneya to 37 professionals and students.
- 2 round table discussions captured the attention of hundreds of attendees.
- 21 of the ICG2010 International Advisory Board were TC chairs or from the ICG board. For more details please check www.icg2010.com.br

TC07 & TC03 successfully co-organized a one-day symposium on “Structural basis of glass crystallization” during ICG2010. TC07 also organized a special one-day session on “Glass-ceramics” and presented a poster on its activities and focus at the same Congress.

Two annual business meetings took place in 2010 during important congresses, which allowed an optimized participation of TC members from several countries.

TC07 Meeting in Corning, USA, May 2010
Attendees: Wolfram Höland, (vice-chair), Mark Davis, USA, Joachim Deubener, Taka Komatsu.

Details of their oral presentations are summarized in the Appendix. As an example we show below a figure with Vickers hardness and (indentation) fracture toughness versus volume fraction of Ba$_2$TiSi$_2$O$_8$ nanocrystals in a multi-component glass-ceramic (source T. Komatsu).

Please check a more detailed report in the Appendix.

TC07 meeting in, Salvador, Brazil, September 2010

Please check a report in the Appendix.

**PLANS AND FORESEEN DELIVERABLES FOR 2011**

We continued to discuss the future of the TC07. There has been a dynamic process in the development of the TC07 strategy in the last 5 years. We started to study the complex nano-crystallization process of photo-thermo refractive glass (a multi-
component oxy-fluoride glass); and we are now committed to focus on several other types of complex multi-component glass-ceramics. The planned strategy is to tackle both fundamental and applied research. The following topics are being focused, and the TC07 members that are already working or intend to be actively working in the next three years on one or more of these topics are listed below:

On going topics which started in the last decade:
- Sintering and crystallization of glass powders - Ralf, Edgar, Miguel, Maria, Joachim, Wolfram, Akihiko, Michael and Gilles have been actively working on this subject for several years and will continue.
- Nano crystal formation in GC - Wolfram, Edgar, Fokin, Maria, Akihiko, Komatsu, RH

Relatively new topics:
- Relationships between micro and nanostructure, strength and toughness of GC at low and high temperatures: Wolfram, Joachim, Ralf and Gilles are already actively working on this subject. Others will probably join.
- Sealing different materials to GC - Ralf, Wolfram, Michael, Joachim, Michael
- Interfaces between glass/crystal or GC/other materials - Mark, Ralf, Wolfram, Akihiko
- Rheological behavior of GC (at high temperature) - Ralf, Joachim, Gilles.

Research topics proposed for possible interaction with other committees:
- with TC03 (Basic Science/ Structure) “Structural aspects of glass crystallization” TC07 members that are interested: Edgar, Robert, Fokin
- with TC04 (Biomaterials) / “Microstructure, strength and toughness of bio GC” TC07 members that are, in principle, interested: Wolfram, Joachim, Edgar / TC04 members: Julian Jones, Aldo Boccaccini

Possible deliverables for next year will be:
  i) One business meeting in Oxford, September 2011
  ii) Joint publications on the above listed research topics between TC07 members and also with members of other committees.

JOINT PUBLICATIONS in 2010
J. Sestak has submitted for publication a new book that includes chapters written by other TC07 members: “Thermodynamic, structural and behavioral aspects of amorphous materials”

Papers co-authored by TC07 members and members of other TCs
“GLASS FORMATION FROM IRON-RICH PHOSPHATE MELTS”

“THERMAL STABILITY OF GLASSES FROM THE FE4(P2O7)3-FE(PO3)3 SYSTEM”

“CORRELATION OF NETWORK STRUCTURE WITH DEVITRIFICATION MECHANISM IN LITHIUM AND SODIUM DIBORATE GLASSES”
“IMPACT OF NETWORK TOPOLOGY ON CATIONIC DIFFUSION AND HARDNESS OF BORATE GLASS SURFACES”
JOURNAL OF CHEMICAL PHYSICS Volume: 133 2010

“CRYSTALLIZATION OF NIobiaUM GERMANOSILICATE GLASSES”

“SYNTHESIS OF BIOACTIVE CLASS II POLY (GAMMA-GLUTAMIC ACID)/SILICA HYBRIDS FOR BONE REGENERATION”

“DEVELOPMENT AND PERFORMANCE OF DIOPSIe BASED GLASS-CERAMIC SEALANTS FOR SOLID OXIDE FUEL CELLS”

“LASER CLADDING OF BIOACTIVE GLASS COATINGS”
ACTA BIOMATERIALIA Volume: 6 Issue: 3 Pages: 953-961 2010

“CRYSTALLIZATION AND PROCESSING OF SOFC SEALING GLASSES”
S.T.Reis, M.J.Pascual, R.K.Brow, C.S.Ray, T.Zhang, W.M.Pontuschka
JOURNAL OF NON-CRYSTALLINE SOLIDS (in press 2010)

“DESIGN OF OXY-FLUORIDE GLASS-CERAMICS CONTAINING NALAF₄ NANO-CRYSTALS”

Papers co-authored by 2 or more TC07 members
“HOW DO CRYSTALS FORM AND GROW IN GLASS-FORMING LIQUIDS: OSTWALD'S RULE OF STAGES AND BEYOND”,

“ON THE THERMODYNAMIC DRIVING FORCE FOR INTERPRETATION OF NUCLEATION EXPERIMENTS”

“STRESS INDUCED PORE FORMATION AND PHASE SELECTION IN A CRYSTALLIZING STRETCHED GLASS”

Conclusion: Most TC07 members have been quite active regarding TC activities; they substantially helped the ICG with the organization of the ICG2010, and collaborated in several research projects within the TC07 and with other TCs.

4.2 R&D ACTIVITY FIELD “PRODUCTION”

4.2.1 GLASS MELTING (TC18)

Chairman: Ruud Beerkens, TNO, Eindhoven, Netherlands
Vice-Chairs: Reinhard Conradt, RWTH, Aachen (TC23)
Members: Hande Sengel, Sisecam, Turkey
Hayo Mueller-Simon, HVG, Germany
Detlef Koepsel, Schott AG, Germany (TC14)
Masataka Kawaguchi, NEG, Japan
Shige Oaki, NEG, Japan
Oleg Prokhorenko, Russia
Ulrich Roger, HVG, Germany
Yasushi Kii, NEG, Japan
Satoshi Yoshida, University Shiga Prefecture, Japan
Neill McDonald, Saint Gobain, France
Leena Hupa, Åbo Akademi University, Finland
Alix Clare, Alfred University, USA
Wilfried Linz, Schott AG, Germany (TC15)
Wolfgang Muschick, Schott AG, Germany (TC21)
Erik Muijsenberg, Glass Service, Czech Republic (TC21)
Thomas Pfeiffer, Schott AG, Germany
Marie-Helene Chopinet, Saint Gobain Recherche, France
Gulcin Albayrak, Şişecam, Turkiye
Christina Stålhandske, Glafo, Sweden
Christopher Berndhäuser, Schott AG, Germany (TC25)

SUMMARY

The title of TC18 changed from “Properties of Glass Forming Melts” into “Glass Melting”. TC18 stimulates co-operation between different Technical Committees operating within the cluster “Glass Production” and strives for further actions within
the 4 main topics identified and described during the 2008-BRIG expert meeting “Innovative Glass Melting for the year 2020”.

TC18 organized in co-operation with TC11 (Materials for Glass Manufacturing), a seminar of 25 papers on “Glass Furnaces & Refractory Materials” at the 10th ESG Conference in Magdeburg from 1-2 June 2010. About 100-120 people attended these sessions.

On 31 May, 2010, TC18 held an annual meeting in Magdeburg (G).

From 4-6 October 2010, a seminar and roadmap workshop on “Advanced Sensors & Process Control in High Temperature Processes” was organized in Maastricht, The Netherlands. The seminar included 15 technical papers on different types of sensors for Combustion, Flue Gases, Melting and Raw Materials.

TC18 continues a Round Robin Test on Thermodynamic Modeling of Multi-Component Silicate Glass (Melts).

At the ICG Congress in Salvador, Brazil, 20-24 September, TC18 presented a poster.

PLANS AND DELIVERABLES FOR 2010 OF TC18

Plans & Activities in 2010 have been:


2. Annual TC18 meeting on 31 May in Magdeburg, Germany. Minutes are available (ruud.beerkens@tno.nl). See also annex 1.

Summary of annual TC18 meeting in Magdeburg

The participants (12 persons) introduced themselves. Activities in 2009 have been reviewed and progress on Round Robin: Thermodynamic Modelling of Chemical Activities of Components in Multi-component Silicate Melts and the new role of TC18 in Cluster “Glass Production (TC11, TC13, TC14, TC15, TC18, TC21, TC25)”, has been discussed.

Actions:

A new chair should take over from Ruud Beerkens, but a selected candidate did not accept the chairmanship.

- Organization of a seminar on Innovation in Batch Preparation and Raw Materials for 2011/2012 is recommended.
- Continuation of Round Robin Thermdynamic Modelling of Multi-Component Silicate Glass (Melts)
- Future topics: Viscosity models for silicate melts

3. TC18 presented a poster on the actual activities and focus of TC18 at the ICG Congress in Salvador de Bahia in Brazil from 20-24 September 2010.
4. TC18 organized in collaboration with TC15, Deutsche Glastechnische Gesellschaft (DGG), AgentschapNL, TNO and Nationaal Comité Nederlandse Glasindustrie (NCNG), a seminar and roadmap meeting on “Advanced Sensors & Process Control in High Temperature Processes” (a BRIG topic*), from 4-6 October 2010 in Maastricht, the Netherlands. 65 Experts attended the seminar. Annex 3 shows the program of presented papers. More information can be obtained on request: ruud.beerkens@tno.nl or may.rietjens@tno.nl.

After the seminar a workshop identified the most important sensors to be developed for optimizing high temperature processes. It includes sensors for combustion/flue gases, foam formation, cullet quality, refractory wall thickness, and inclusions in melts. The need for, and demonstration of, model based control systems for controlling processes in glass furnaces have been discussed as well.

5. A Round Robin Test on Thermodynamic Modelling of Multi-Component Glass Melts is progressing but more scientists are required to participate in modelling thermodynamic properties of binary, ternary and commercial silicate melt compositions.

![Chemical activity Na$_2$O in Na$_2$O.2SiO$_2$](attachment:image.png)

**Thermodynamic modelling result for a binary sodium-silicate melt**

6. Apart from the focus of TC18 on properties of glass forming melts, this TC has a co-ordinating role on glass melting issues in the cluster Glass Production.

**Erreur ! Des objets ne peuvent pas être créés à partir des codes de champs de mise en forme.**

**Cluster Glass Production with co-ordinating role of TC18**

It has been noticed, that today, in the cluster **Glass Production**, technical committees on:
- Thermodynamics and Glass Chemistry,
- Combustion Processes and Energy,
- Furnace Design
are missing. These items may launch new ICG-Technical Committees.

PLANS FOR 2011 AND FORESEEN DELIVERABLES

- TC18 and TC15 intend to organize from 12-13 April 2011 in Eindhoven at TNO an expert meeting on “Fining, Redox Chemistry and Colour Control in Glass Manufacture”. New technical issues and scientific questions will be discussed concerning alternative fining methods, fining of ultra-clear glasses, fining performance depending on glass furnace designs.

- TC18 plans an annual meeting in Europe in summer (May or June)

- Continuation of Round Robin Test on Thermodynamic Modelling of Multi-Component Glass Melts. Foreseen deliverable in 2011, a report of results of this Round Robin Project.

- In 2011 or 2012 organization of an expert meeting & roadmap workshop on Batch Pretreatment / Routing and Alternative Raw Materials for Glass Production (BRIG topic 2*)

PUBLICATIONS AND OTHER CONTRIBUTIONS

Collections of powerpoint presentations of the following TC18 seminars can be ordered on request (may.rietjens@tno.nl), see annexes 2 and 3:


4. Preparation of catalogue of experimental facilities (worldwide) for glass melt property measurements (2008-2011)

* BRIG topics (identified in BRIG 2008 workshop):

1. Innovative glass melting concepts

2. Batch Pretreatment / Routing and Alternative Raw Materials for Glass Production

3. Waste heat recovery from flue gases of glass furnaces

4. Advanced Sensors & Process Control in Glass Productions

5. Textbook on Thermochemistry and Chemical Engineering in Glass Manufacture Processes

6. Characterization of Glass Quality

4.2.2 MODELLING OF GLASS MELTING PROCESSES (TC21)

Chairman: Erik Muijsenberg, Glass Service, Vsetin, Czech Republic
Members: Wolfgang Muschick, Mainz, Germany
Uwe Krieger, University of Ilmenau, Germany
Lale Onsel, Sisecam, Istanbul, Turkey
Sanjay Somany, HNG, India
AC Jain, HNG, India
Aaron Huber John Manville, USA
Bob Kosymna, OI, USA
Fabrice Fasilow, AGC, Belgium
Laurent Pierrot, Saint Gobain, France  
Christian Müller, Schott AG, Germany  
Stanislav Kasa, ICT Prague, Czech Republic  
Menno Eisenga, Glass Service, Netherlands  
Graham Unwin, Pilkington, UK  
Adriaan Lankhorst, TNO, Netherlands  
Dries Hegen, TNO, Netherlands  
Gerd Philipp, JSJ-Jodeit, Germany  
Otto Hofmann, Jena, Germany  
Wolf Kuhn, Stein Heurtey, France  
Robert Markiewicz, Videocon, Poland  
Matthias Lindig, Sorg, Germany  
Camille Moukarzel, Stein Heurtey, France  
Klaus Jochem, Schott, Germany  
Zeynep Eltutar, Şişecam, Turkey  
Ozel Sinem, Şişecam, Turkey  
Fabien Bouillet, Saint Gobain, France  
Didier Bessette, Fluent, France

SUMMARY

The main activity of TC21 is to improve the quality and reliability of glass furnace simulation modeling and optimization of software packages of different suppliers and glass producing factories that describe heat transfer, flows and temperatures in glass furnaces (melt, batch & combustion space).

The most effective way to understand the strong and weak points is by simulating with the different participants the same well defined existing glass melting furnace and ideally with actual measured and validated data. This allows the different participants to compare and validate results with each other and also with real measured data. Such a comparison activity is usually referred to as a Round Robin Test (RRT). In the past, TC21 has used several different so called RRTs and has now reached definition RRT5 for a formerly existing furnace with detailed measured data.

PLANS AND DELIVERABLES FOR 2010

1. Preparation of report on the RRT 4-4a results;
2. Gather and discuss the results of different (4) participants on RRT5 (combustion, batch blanket and glass melt modeling for TV glass furnace) and improve definition and boundary condition information;
3. General discussion about the future of modeling of glass melting processes and future TC21 activities.
3D picture of TV panel melting furnace RRT5
Input data gathered and supplied by TNO

ACTIVITIES in 2010

1. TC21 annual report has been delivered;
2. Discussions with core members during ESG/DGG 2010 in Magdeburg;
3. TC21 meeting during ICG meeting in Salvador, Brazil. Discussion and comparison of updated results of RRT5 during TC21 meeting
4. Presentation of TC21 poster at ICG congress in Salvador de Bahia.

4 participants submitted results for the RRT5. The agreement in 2010 is quite good and closer to each other than what was achieved with RRT4. It was concluded that some of the input conditions seem incorrect, for instance especially the actual cooling level in the 2nd part of the furnace probably should be increased to make all results closer matching with reality.

The 4 active participating parties are: TNO, Glass Service, Dr. Muschick (retired Schott) and Şişecam.

5. Discussed further improvement of definition* of the RRT5 exercise.
6. Draft report on RRT4-4a prepared (former chair person Lale Önsel is in charge of writing the final RRT4-4a report)

*definition means the boundary conditions that include furnace design, energy consumption, cooling levels, insulation, type of glass, glass properties, batch properties, fuel properties etcetera. These are required input data for each of the applied models.

In RRT5 we have complete temperature profiles over the depth of the furnace at 5 positions along the length of the furnace. In general the comparison of participants and measured data is within about 25 °C.

See below figure of one such comparison
PLANS FOR 2011 AND FORESEEN DELIVERABLES

1. Organize TC21 meeting during specialized glass melting and forming modelling seminar in June in Velke Karlovice Czech Republic, usually attended by over 100 glass modelling specialist from all over the world.
2. Discuss further and more results of RRT5 with adapted and well defined input conditions;
3. General Lecture during an ICG meeting about activities and results of TC21;
4. Continuation of discussion of the future of TC21 and lack of activity.

PUBLICATIONS AND OTHER CONTRIBUTIONS

1. Lecture by TC21 chair about TC21 activities over last years and at present during 10th conference of simulation of glass melting processes to be organized in June 2011 in Velke Karlovice, Czech Republic.

IMPORTANT ISSUES

New and increasingly important aspects of glass furnace modeling include:
- modeling of radiation in combustion space and glass melt (important for optically thin melt layers, e.g. ultra-clear glasses);
- modeling of behavior of bubbles in glass melting tanks;
- modeling of processes in batch blankets.

TC21 activities are mainly carried out by three or four parties. Unfortunately contributions from industries are diminishing, although industry very much needs validated and detailed simulation models for furnace designs, process operation, troubleshooting (glass defects, energy efficiency improvement) and advanced process control.

Engagement of members, especially glass industry contributions should be improved to guarantee continuation of TC21.

TC21 members need to be re-activated to deliver their parts to TC21 projects.
### 4.2.3 MATERIALS FOR GLASS MANUFACTURING (TC11)

**Chairman:** Michael Dunkl, Dr. M. Dunkl Consulting, Germany  
**Vice-Chairs:** Nobuyuki Kido, AGC CERAMICS CO., Ltd, Japan is retired  
Jean-Pierre Meynckens, AGC Flatglass Europe, Belgium is elected  
**Members:** Esref Aydin, Şişecam, Turkey  
Janusz Zborowski, SCHOTT AG, Germany  
Michel Gaubil, Saint Gobain CNEE-SEFPRO, France  
Rongxing Bei, RHI AG, Germany  
Chris Windle, DSF, UK  
Anne Jans Faber, TNO, The Netherlands  
Bernhard Fleischmann, DGG, Germany  
Simon Petro di Pierro, Saint Gobain Recherche, France  
Stefano Sanchetti, Stazione Sperimentale del Vetro, new member  
Roel van Herten, Philips Lighting, The Netherlands  
Detlef Köpsel, SCHOTT AG, Germany  
Wilfried Linz, SCHOTT AG, Germany  
Dietrich Messerschmitt, NARCO is a new member  
Gerhard Schmitt, NARCO is a new member  
Brian Harris, Pilkington, UK  
Amul Gupta, RHI MONOFRAX  
Mathi Rongen, TNO, The Netherlands  
Mustfa Oran, ŞİŞECAM, Turkey  
Samir Tablouli, FIVES STEIN  
Beyhan Bozdemir, KÜMAS is a new member  
Toshio Ishino, AGC Ceramics is a new member

**SUMMARY**

During the 10th ESG Conference & 84th Annual Meeting of the DGG & GlassTrend Seminar: Glass Furnaces and Refractory Materials & Plansee Session: Refractory Metals for the Glass Industry in Magdeburg, 1 - 2. June 2010, several TC11 members contributed to different papers.

**TC11 and joint TC11/TC14 meetings** were organized during the 10th ESG CONFERENCE in conjunction with the 84th Annual Meeting of the German Society of Glass Technology (DGG), on 31 May in Magdeburg, Germany.

*During the ICG 2010 Congress in Salvador Bahia (Brazil) a joint TC11/TC14 half day symposium took place with the topic: “Blister formation from refractory - glass melt interfaces”, organized by: Detlef Köpsel, Jean Pierre Meynckens, Michel Gaubil and Michael Dunkl.*

**PLANS AND DELIVERABLES FOR 2010**

1. **TC11 MEETING MAGDEBURG**
   
   During the 10th ESG Conference, 84th Annual Meeting of the German Society of Glass Technology, on 31 May, a **TC11 meeting and a joint TC11/TC14 meeting** took place in Magdeburg.
TC11 meeting in Magdeburg - important issues:

- The vice chairman Nobuyuki Kido retired from AGC Ceramics and is no more available for the TC11. The new vice chairman Jean-Pierre Meynckens from AGC Europe was elected.
- History of TC11 from 1987 till now was presented by Michael Dunkl, see File: dgg-tagung-2010-Dunkl-ICT-TC11[1].pdf
- Recommendation and publication proposal for the “TC11 Exudation test - guidelines, results interpretation and limits” will be prepared by M. Dunkl /J. Zborowski/J.-P. Meynckens and submitted for the next meeting.
- Open discussion on the limitation of the laboratory tests to be in line with the refractories procurement and the furnace construction schedule. Several tests such as the corrosion and exudation tests are used by some glassmakers to judge quality and select the refractories. However, these tests need a lot of time to get the final results. Whilst it has been underlined that the limitation of the test time could lead to false results or misinterpretation for the refractory selection of unknown products, the glassmakers are continuously pressed to reduce the glass furnace interruption for cold repairs.
- The discussion is still open but the TC11 could offer some guidelines for quick tests (including sampling) in the frame of the quality assessment of a refractory product already known by the glassmaker; keeping in mind the particularity of the glass produced.
- Corrosion behavior of refractory material for regenerators.
  This topic finds interest by members from the companies Şişecam, RHI and AGC Europe, specifically for the basics bricks vs various atmospheres and carryover materials.

1.1. Meeting report (Magdeburg TC11/TC14)

1.1.1. RRT on refractory blisters (dynamic blister test)

Two different laboratories participated in the RRT on refractory blisters. The blisters in the early stages (up to 50h) are primarily formed due to surface impurities. Hence, the observed deviations at relatively short times could be explained by non-uniformly spread impurities on the surface and by the “soft” cleaning procedure (refractory samples are only boiled in water). The result of both laboratories show now the same tendency as a function of time and are now reproducible.

Actions:
- The guideline for the next static (crucible) blister test has to be finally compiled (M.Dunkl, D.Koepsel)
- A comparison of the dynamic blister test with the quartz glass crucible test should be discussed at the next meeting.

Analysis of impurities in AZS (co-operation with TC02)

Samples had been taken from different positions of an AZS-32 block provided by AGCC.

First results of 3 different participating laboratories were discussed. The detection limits of a third analytical techniques (ToF-SIMS) have been not sufficient for the determination of the impurities. The RRT will be continued at least with one more analytical method. The impurities of concern were: sulfur, nitrogen and carbon. The state of nitrogen (gaseous or bonded) has to be found out.
Analysis of gases in closed pores of AZS refractory

The AZS refractory used in the corrosion test was examined by Computer Tomography (CT).

Inspection of the refractory structure contains many tiny pores. It was thought that gas release from these pores may be an important contributor to bubbles generated by the refractory. It was therefore decided to conduct research into the gas content of the pores.

The amount of hydrogen and methane in some pores is unusual high. The origin of these gases is still not clear. Two sources might be possible:

- the gases are formed mechanically due to contact of the needle in the vacuum chamber of the mass spectrometer with the refractory sample during the breaking procedure (“fake gas”)
- the gases are formed and entrapped in a pore during the casting of the refractory block

Therefore, it is important to evaluate not only the relative gas composition (partial pressures) but the absolute volumes of each gas in the pore.

Next Action:
Analysis of the gas content in pores in other laboratories (Glass Service, Şişecam, NEG, ZGU)

2. TC11 PAPERS/PRESENTATIONS IN 2010

During the combined 10th ESG Conference & 84th Annual Meeting of the DGG & the GlassTrend Seminar on Glass Furnaces and Refractory Materials & Plansee Session: Refractory Metals for the Glass Industry, in Magdeburg, 1 - 2 June 2010, TC11 members contributed many different papers.


TC11 members presented papers with the following titles:

M. Dunkl: Refractory materials for glass melting at high temperature.

B. Fleischmann: Electrochemical behavior of molybdenum in glass melts.

H.P.H. Muijsenberg, H. Larcher: Studying the effect of molybdenum glass tank reinforcement and its interaction with the electric field created by electric boosting in a gas fired container glass furnace with simulation models.


B. Fleischmann: AZS refractory materials - structure, testing and structural changes during application

B. Schmalenbach, R. Bei, S. Postrach, G. Heilemann: Monolithics in glass melting furnaces: state of the art.

B. Schmalenbach, R. Bei, S. Postrach, G. Heilemann: Refractories based on chrome-alumina: advantages and limitations.

E. Aydin, M. Oron: The behavior of cord making material in F/H channels as depicted by physical and mathematical modeling.

M. Dunkl: Quality characterization and specifications of refractory materials for glass melting furnaces.


R. Beerkens: Corrosion & Performance of glass melting tanks.


J. Ullrich: Studying bubble glass defects that are caused by refractory materials.

3. CONTRIBUTIONS TO THE ICG2010 CONGRESS IN SALVADOR, BAHIA, BRAZIL

Within the ICG2010 Congress, a half day TC11/TC14 symposium took place with the topic: “Blister formation from refractory - glass melt interfaces.” organised by: Detlef Köpsel, Jean Pierre Meynckens, Michel Gaubil and Michael Dunkl.

TC11 members presented papers, with the following titles:

D. Koepsel; M. Dunkl: Mechanisms of blister formation at refractories.

M. Dunkl: Overview on blister tests and necessary improvements.

A. Gupta; K. Selkregg; R. Heidrich: Risk in testing and selection of fusion-cast AZS and Aumina refractories for Glass melting furnaces.

E. Muijsenberg at al: Studying bubble glass defects caused by refractory materials.

I. Cabodi; M. Gaubil, et al.: New high Zirconia fused cast material having a high electrical resistivity for alkali free glass melting.

TC11 PLANS FOR 2011 AND TARGETED DELIVERABLES

a combined TC11/TC14 ansd two TC11 meetings in 2011:
To continue running projects and start new activities selected in 2009 and 2010.
Continuation of TC11/TC14 Round Robin for “Blisters in Glass from Refractories”.

FORESEEN TC11 OUTPUT/ACTIVITIES

- Recommendations and publication of proposal for the “TC11 Exudation test

- → guidelines, results interpretation and limits" will be prepared.

- Offering some guidelines for tests (including sampling) in the frame of the quality assessment of a product already known by the glassmaker; keeping in mind the particularity of the glass produced.

- Corrosion behavior of refractory materials for regenerators.

- TC11 and TC14 intend to co-organize meetings after the Glass Trend seminar:
  - “Fining, Redox Chemistry and Colour Control in Glass Manufacture” in April 2011
SENSORS AND ADVANCED CONTROL (TC15)

Chairman: W. Linz, SCHOTT AG, Germany
Members: A. Huber, Johns Manville, USA
P. H. Guering, St. Gobain, France
I. Solis, Vitro, Mexico
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
A.M. Kondurin, Novocherkassk Polytechnic Inst., Russia

SUMMARY

TC15 met twice: as a Core group in June in Magdeburg (G) and for all TC members in October in Maastricht (NL).

From 4-6 October 2010, a seminar and roadmap workshop on “Advanced Sensors & Process Control in High Temperature Processes” was organized in collaboration with TC18, DGG (Deutsche Glastechnische Gesellschaft), Agentschap NL, TNO and NCNG (National Committee Netherlands Glass industry) in Maastricht, The Netherlands. The seminar included 15 technical papers on different types of sensors for Combustion, Flue Gases, Melting and Raw Materials.
Prior to this seminar, TC15 members met in Maastricht to discuss the needs for sensors in glass industry sectors in a regular TC15 meeting.
After the seminar, a workshop identified the most important sensors to be developed for optimizing high temperature process control and operation.

PLANS AND DELIVERABLES FOR 2010

Organization of and preparation for a seminar/workshop/expert-meeting on:
“Advanced Sensors & Process Control in the Glass Industry” with experts and their input also from outside glass industry (cement, steel, ceramics, refractory).
A TC15 core group meeting is planned during the ESG-/DGG-Conference and Glass Trend Seminar in Magdeburg (Germany) from May 30th to June 2nd, 2010.
A TC15 meeting will take place in connection with the planned seminar/workshop/expert-meeting in Maastricht (Oct. 2010).

ACTIVITIES in 2010

A TC15 core group meeting was held during the ESG-/DGG-Conference and Glass Trend Seminar in Magdeburg (Germany) from May 30 to June 2, 2010.
A TC15 meeting took place in connection with the meeting in Maastricht.

TC15 organized in collaboration with TC18, Deutsche Glastechnische Gesellschaft (DGG), AgentschapNL, TNO and Nationaal Comité Nederlandse Glasindustrie (NCNG), a seminar and roadmap meeting on “Advanced Sensors & Process Control in High Temperature Processes” (a BRIG topic*), from 4-6 October 2010 in Maastricht, the Netherlands. 65 Experts attended the seminar.
Annex 1 shows the program of presented papers. More information can be obtained on request: may.rietjens@tno.nl.
After the seminar, a workshop identified the most important sensors to be developed for optimizing high temperature processes. It includes sensors for combustion/flue gases,
foam formation, cullet quality, refractory wall thickness, and inclusions in melts. The need for, and demonstration of, model based control systems for controlling processes in glass furnaces have been discussed as well. Exchange of information from other sectors (steel industry, ceramics industry, cement industry, sensor industries) was essential in this workshop.

**PLANS FOR 2011 AND DELIVERABLE**
Meeting of TC 15 members together with additional experts and delegates from process industry and institutes to select the most important topics and activate a roadmap on “Advanced Sensors and Process Control “. Continue the collaboration with TC18 / Ruud Beerkens on this topic. Next regular TC15 meeting is planned for Oct. 2011 in Columbus/OH (Glass Problems Conference).

**PUBLICATIONS AND OTHER CONTRIBUTIONS**

### 4.2.5 GASES IN GLASS (TC14)

**Chairman:** Detlef Koepsel, Schott AG, Germany  
**Vice-Chair:** Noriyuki Yoshida, NEG, Japan  
**Secretary:** Sean Marsden, Pilkington Group Limited, UK  
**Members:** Marie-Hélène Chapinet, St. Gobain Recherche  
Yukihito Nagashima, NSG, Japan  
Jaroslav Klouzek, ICT Prague, Czech Republic  
Hayo Müller Simon, HVG-DGG, Germany  
Jan Hermans, Philips, Netherlands  
Ruud Beerkens, TNO, Netherlands  
Stefano Maurina, SSV, Murano, Italy  
Martin Gaber, BAM Berlin, Germany  
Ralf Mueller, BAM Berlin, Germany  
Jiri Ulrich, Glass Service, Vsetin, Czech Republic  
Lubomir Nemic, ICT Prague, Czech Republic  
Harald Behrens, University of Hannover, Germany  
Juergen Daniel, ZGU Ilmenau, Germany  
Mustafa Oran, Şişecam, Turkey  
Leonid Glebov, University of Florida, USA  
Hande Sengel, Şişecam, Turkey  
Wolf S. Kuhn, Stein-Heurtey, France

**SUMMARY**
The main lines of activities are:
- **RRT on refractory blisters with two goals:**
  1. comparison of methods for the experimental determination of the blistering rate:
     - the dynamic blister RRT is successfully finished; a recommendation will be ready in 2011
     - **RRT on the static blister test has to be carried out in 2011**
(2) analysis of the gas content of refractory blisters formed at AZS refractories and classification of blister formation mechanisms:
- gases in closed pores in AZS refractory have been determined
- impurities of C, N, S, which might be one source of blisters, have been analyzed with the support of TC02
- the gas content of blisters in the corrosion layer of the refractory has to be determined in 2011
- a draft report on blister formation mechanisms at AZS refractories has been compiled and presented at the XXII ICG Congress in Salvador (Brazil)

- Preparation of a new activity concerning the nucleation of new bubbles in glass melt with focus on:
  (1) comparison of experimental methods: direct observation methods as well as other methods (e.g. evolved gas analysis) will be compared in 2011/2012
  (2) understanding of blister nucleation mechanisms

In 2010 two meetings and two seminars were organised:
- TC14 meeting (7 participants, 4 guests) and joint meeting of TC11 and TC14 in Magdeburg (14 participants, 4 guests) during the 10th ESG conference
- Joint meeting of TC11 and TC14 (5 participants, 3 guests) in Salvador (Brazil) during the XXII ICG congress
- Session on “Modeling of fining, refining and bubble behavior” organized by TC14 and TC21 at the XXII ICG congress in Salvador (Brazil)
- Session on “Refractory blisters” organized by TC11 and TC14 at the XXII ICG Congress in Salvador (Brazil)

PLANS AND DELIVERABLES FOR 2010

1) Blistering rate of AZS refractories in contact with low-iron soda-lime silica glass

The RRT on the determination of the blistering rate of AZS with the dynamic blister test has been finished. The results are shown in fig. 1.

Fig.1: Blistering rate determined with the dynamic blister test.
The results of 2 participants agree more or less after reaching a quasi-stationary blistering rate. Since the dynamic blister test is very time consuming and expensive, a RRT with the static blister test will be carried out in a next step. A recommended guideline for the dynamic blister test will be completed and published in 2011.

2) Classification of blisters formed at AZS refractories
In order to better understand the mechanisms of blister formation, the gas content of closed pores in AZS has been analyzed with mass spectrometry. Samples for the gas analysis have been taken from different parts of a big AZS block (fig.2) in order to check whether there are differences between the outer layer and the inner part of the block due to the manufacturing process of the block. The location of the analyzed voids within the samples has previously been determined with Computer tomography (CT). Even in AZS samples, which seemed to be void-free by visual inspection, a lot of tiny closed pores with diameters in the micrometer range have been detected (fig.3).

![Fig. 2: Location of samples within the AZS block taken for gas analysis of the voids](image)

![Fig. 3: CT slides showing the voids in different depths of the sample](image)

The gas content of the pores is shown in table 1.
The presence of CH4 and H2 might be explained either by analytical problems (mechanical impact of the needle in the vacuum chamber of the MS during the breaking process) or by manufacturing problems (reaction of the binder of the mould with the liquid material during the casting process). In order to better understand the origin of CH4 and H2 the absolute gas volumes have to be compared. If possible, other analytical methods have to be used.

3) Impurities of carbon, nitrogen and sulphur in the AZS (support of TC02)
Impurities in the AZS might be one source of refractory blistering. Therefore, they have been analyzed in samples taken from different parts of the refractory block (fig.2). Results are shown in table 2.

<table>
<thead>
<tr>
<th>Lab</th>
<th>Position</th>
<th>Sample ID</th>
<th>C (mg / kg)</th>
<th>N (mg / kg)</th>
<th>S (mg / kg)</th>
<th>Analytical Technique</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Bottom</td>
<td>A1</td>
<td>620</td>
<td>&lt; 5000</td>
<td>&lt; 10</td>
<td>Leco (C, S)</td>
<td>Ground in ZrO2 mill, results are mean of 6 determinations</td>
</tr>
<tr>
<td></td>
<td>bulk</td>
<td>B1</td>
<td>250</td>
<td>&lt; 5000</td>
<td>&lt; 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X1</td>
<td>160</td>
<td>&lt; 5000</td>
<td>&lt; 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>W1</td>
<td>460</td>
<td>&lt; 5000</td>
<td>&lt; 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bottom</td>
<td>H1</td>
<td>&lt; 10</td>
<td>--</td>
<td>&lt; 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>K2</td>
<td>&lt; 10</td>
<td>--</td>
<td>&lt; 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bulk</td>
<td>R1</td>
<td>23</td>
<td>--</td>
<td>&lt; 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2</td>
<td>12</td>
<td>--</td>
<td>&lt; 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>bottom</td>
<td>D2</td>
<td>15</td>
<td>1400</td>
<td>5.3</td>
<td>Glow Discharge MS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>G2</td>
<td>22</td>
<td>1400</td>
<td>3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bulk</td>
<td>Y2</td>
<td>&lt; 10</td>
<td>1200</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z2</td>
<td>34</td>
<td>2100</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is still questionable, whether the differences are caused by inhomogeneities in the AZS or by analytical problems. Therefore, a relative large amount of AZS material has to be ground into fine powder and homogenized, before splitting into smaller samples for analysis by different labs afterwards.

4) Preparation of the next activity
Prof. Nemec suggested the problem of blister nucleation as a next activity. The blister nucleation can be directly observed with hot stage microscopy or with the so called HTO
test (High temperature observation of glass in a silica glass crucible). These tests can be undertaken for different conditions (with/without undissolved sand particles or cords, different redox conditions etc). This suggestion has been discussed at the meeting in Salvador. Several extensions to the direct observation have been proposed:
- The direct observation of blister nucleation can be combined with the determination of the bubble growth rate
- In order to understand the blister nucleation evolved gas analysis can be performed for the same conditions
- The glass used for test should be accurately characterized (residual gases, \( \text{pO}_2 \) or \( \text{Fe}^{2+}/\text{Fe}^{3+} \) ratio)

**PLANS AND FORESEEN DELIVERABLES FOR 2011**
1) Publication of a guideline for the dynamic blister test (support of TC11)
2) RRT on blister formation with the static blister test (joint activity with TC11)
3) RRT on the gas content of blisters in the corrosion layer of AZS
4) Further test of analytical methods for impurities in AZS (support of TC02)
5) First results on blister nucleation

**PUBLICATIONS AND OTHER CONTRIBUTIONS**
The extended abstracts of the contributions presented at sessions organized at the XXII ICG Congress in Salvador (Brazil) will be published in the Congress proceedings:
- 1) Modeling of fining, refining and bubble behavior (TC14+TC21) with 6 contributions
- 2) Refractory blisters (TC11+TC14) with 4 contributions

**MEETINGS IN 2011**
The next TC14 meeting will be held in Eindhoven, April 13, after the Glass Trend meeting organized by R. Beerkens (TNO).

**4.2.6 ENVIRONMENT (TC13)**

**Chairman:** Guy Van Marcke, AGC, Belgium  
**Secretary:** Simon Slade, NSG, England  
**Vice-Chairs:** Andreas Kasper, St. Gobain, Germany  
**Members:** Petr Beranek, Glass Services Inc, Czech Rep.  
Dilek Bolcan, Şişecam, Turkey  
Karlheinz Gitzhofer, HVG, Germany  
Denis Lalart, Arc Intl., France  
Nicola Favero, SSV, Italy  
John Stockdale, British Glass, England  
Thomas Hunlich, Schott, Germany  
Hans Van Limpt, TNO, The Netherlands  
Phil Ross, GICI, USA  
Hugues Abensour, St. Gobain, France  
Etienne Senechal, Arc Intl. France  
Zsuzsa Varga, GE, Hungary  
Ruud Beerkens, TNO, The Netherlands  
Anne Rasneur, AGC Glass Europe, Belgium  
Mike Turnbull, Guardian, USA
After around 20 years of active involvement in TC13 work Mr Tackels has retired and is replaced by Mr Abensour. All TC members thank Mr Tackels for his huge contribution.

Mr. Senechal and Mrs Rasneur have joined the TC13 as full permanent members and Mrs. Varga had replaced Mr. Liptak who had retired from GE in Hungary. Mr. Lucien Belmonte had previously expressed his interest to join and had been invited to the meeting although he had not responded. He was contacted by Mr. Stockdale during the meeting and stated that he will not join the committee even though he is interested in TC13 work. Michael W. Turnbull of Guardian Industries Corp, US has expressed his interest in becoming a member.

Summary

Since the last annual report the TC13 has met twice:
- 15/6/2010 at SSV in Murano, Italy, with 13 participants.
- 16/11/2010 at British Glass in Sheffield, United Kingdom, with 19 participants.

As usual the meetings were interesting, useful and informative. A range of subjects were discussed covering: global environmental regulations; emission formation and emission characterisation; primary emission control; and both existing and emerging secondary pollution control plant. Two briefing papers have been written on the potential leaching of selenium and of antimony from certain flat glass products. These have been made available to the European Chemicals Agency in Helsinki to support discussions over whether certain glasses can be exempt from REACH. Related work on leaching from glass sheets is underway in support of the Construction Products Directive. This work is being done in conjunction with ICG TC02.

TC13 Activities

Mission and Vision

At the request of ICG CTC, TC13 has produced its vision and mission statement:

<table>
<thead>
<tr>
<th>TC13</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vision</strong></td>
</tr>
<tr>
<td>Protecting the planet and making glass.</td>
</tr>
<tr>
<td><strong>Mission Statement</strong></td>
</tr>
</tbody>
</table>
The mission of TC13 is to achieve best practice by exchange of information concerning current and developing techniques for reducing the environmental impact of glass during its production, use and disposal. This shall include the comparison of the results of different control techniques and the determination of best practice for measuring pollutants (primarily total particulate, NOx, SOx, HCl, HF & heavy metals) by means of parallel measurements, material balances, and round robin tests.

Action plan for the next 5 to 10 years
With emission limits becoming tighter and more expansive there is a critical need for better and more reliable measurements methods. TC13 will help provide the glass industry with adapted and affordable standard protocols, and it will help the industry benefit from new monitoring and emission control technologies.

Activities
The meetings covered a range of subjects, with a focus on environmental legislation associated with the leaching of heavy metals from glass. The results of the previous studies on antimony and selenium leaching from broken end-of-life flat glass were discussed and plans for future work were agreed. Further assessment of selenium leaching from different non-flat products will be conducted. It is expected that this will take place in parallel to the start of next phase of the work to address the leaching of components from glass during its working life. This TC13 work will first study glass for photovoltaic cells and tinted windows and provide timely data in support of the CEN work on the Construction Products Directive. Close links to the work of ICG TC02 will be maintained.

The committee also heard about the novel Cercat pollution control plant installation at St. Gobain’s factory at Arboç, in Spain, and discussed the IPPC re-cast and BREF revision with its controversial BAT-AELs. The committee also drafted a vision, a mission statement and an action plan for the next ten year’s work.

Cercat operation in the glass industry
Two Cercat system are now in operation in the glass industry one in Arc International, in France, and one in Saint-Gobain in Arboç, Spain. Cercat is Maguin’s integrated pollution control plant based on a catalytic ceramic filter supplied. There had been some problems with the construction of the outer casing of the Cercat unit but that had been easily fixed. Problems were also mentioned with the alkali dosing (calcium hydroxide) but that too had been remedied. It is said that the equipment was now working very well indeed and some results of analyses done by St. Gobain’s analytical team and by the consultant TüV were shown. These results were very impressive. Very low NOx emissions were achieved without any measurable ammonia slip, even when using stoichiometric amounts of urea as the reductant. There was also no measured increase in CO emission. Dust and SOx emissions were very low and HCl and HF were at the level of detection. The system is based on 1700 ceramic candles from Cerafil and operates at up to 350°C. The measurements were taken at 280°C.
The new BAT-AEL’s being considered by the Technical Working Group (TWG) for the BREF revision under the IPPC did not adequately take account of ammonia slip from SCR units when low NO\textsubscript{x} limits are imposed. Data collected from various installations show that high level of NO\textsubscript{x} can be achieved by SCR installation (up to 90%) however the limiting factor is the ammonia slip.

The study concluded that for a standard SCR unit used in the glass industry, the NO\textsubscript{x} reduction is linearly proportional to the NH\textsubscript{3}:NO\textsubscript{x} ratio, up to ~90%. Ammonia slip is
exponentially proportional to the $\text{NH}_3$:$\text{NO}_x$ ratio. With a maximum allowed $\text{NH}_3$ slip of 30 mg/Nm$^3$ the maximum $\text{NO}_x$ reduction possible is about 80%. This means that large or double-layer catalysts will be required and many existing SCR units will not be able to meet low emission limits without excessive slip. Additionally, low ammonia slip is not easily possible because of the confounding effect of furnace firing reversals, during which time there is a low $\text{NO}_x$ concentration in the waste gases. The figure below, shows the effect of reversals on $\text{NO}_x$ concentration.

The committee then discussed the methods for ammonia analysis and it was clear that not all techniques are equally good. TC13 will compare the existing methods for sampling and analysing ammonia emissions and to decide which were best.

**REACH and leaching tests**

TC13 prepared a paper assessing the leaching of antimony from rolled glass for the photovoltaic market. The work was done to demonstrate that no constituents of potential concern were “available” at any stage of the glass’ life cycle, thus supporting the exemption of the glass from the requirements of the REACH directive. This paper has been made available to CPIV and will be placed on the TC13 website. A key figure from the paper is reproduced below.
An equivalent paper on selenium leaching from tinted flat glass is also being drafted. A round-robin assessment was conducted as before, but in this case statistical analysis of the results was inappropriate because no selenium was found in any of the leachate samples.

**Construction Product Directive and leaching tests**

Leading directly from the discussion of the REACH-related leaching study, the work of CEN TC 351 (*Comité Européen de Normalisation*) and the Construction Products Directive was discussed. All glass sold with a CE mark is covered by CEN rules and there are over 100 standards relating to glass. A company’s product must comply with “essential requirements” to get a CE mark. These cover many areas such as fire safety, security, and HSE impacts, and one will now deal with release of dangerous substances during the product’s use. TC129 is a product TC dealing with glass. TC127 covers all building products’ response to fire. TC351 is a horizontal TC covering release of substances from building products. The horizontal TCs develop methods and analytical techniques for assessing products’ compliance with the standards developed by the other TCs.

The ICG TC13 committee consider its work is thus very timely and the results of its studies should be made available to CEN. The results of the TC13 work may mean that some, or all, glass products can be placed in the “without testing” classification of the TC351 listing. TC13 will work into this important and growing area of the scientific understanding of the interaction between glass and the environment. The committee agreed that such work for CEN would follow well its end-of-life leaching studies that are currently underway. The current work addresses the Construction Product Directive’s demolition and recycling stages and the proposed work will address the service life stage. These are demonstrated in the figure below.
Assessment of component availability throughout a product’s life cycle.

The monolithic tank test described in the Dutch standard NEN7375 has been accepted by various authorities as a suitable method for assessing leaching from building products in use. The CEN TC351 is developing a method based on the United Kingdom’s Environment Agency’s 2005 translation of that standard: EA-NEN-7375. This method uses water to leach the product and only tests surfaces exposed to consumers during its normal use. The test assesses leaching over 64 days and the associated documentation explains how to interpret the results and thus understand the processes by which the leachable components may come out of the glass.

<table>
<thead>
<tr>
<th>Life Cycle Stage</th>
<th>Area of use</th>
<th>Exposure conditions</th>
<th>Suitable characterisation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service life</td>
<td>Facades, Roof</td>
<td>Rain water, splash water</td>
<td>Tank test with modified conditions, DSLT, special test methods</td>
</tr>
<tr>
<td></td>
<td>After demolition</td>
<td>Soil/rain</td>
<td>Granular test</td>
</tr>
<tr>
<td></td>
<td>Disposal (End of life)</td>
<td>Ground/percolating rain water</td>
<td>Granular test</td>
</tr>
</tbody>
</table>

Examples of leaching scenarios for flat glass used in buildings.

The method does not relate to a leachable “limit”, but could be used in the future to classify products by their leachability.
The committee agreed to use the EA NEN 7375 monolithic tank test to assess the antimony leached from photovoltaic glass and selenium leached from grey tinted glass. As well as Sb and Se, the conductivity (E.C.) and acidity (pH) of the eluate should be measured. The committee then discussed the best way to seal the glass surfaces that are not exposed during normal use of the product. From previous experience of similar work, some members said that commercially-available laboratory grade paraffin wax could be used. It was agreed that molten wax should be painted over the edges and over the rear face of the plate to be assessed so that when it cools it seals the surface. Control samples of glass should be painted with the wax to ensure that the wax did not leach any relevant components and to provide an analytical test blank.

An extensive round-robin assessment of Sb leaching from intact pieces of flat glass is underway, with the involvement of 13 laboratories around the world. This study of glass for photovoltaic cells will provide timely data in support of the CEN work on the Construction Products Directive. Close links to the work of ICG TC02 are being maintained.

**TC13 website**

A preview of the updated website was presented; additional papers will be added such as the TC13 papers on Sb and Se leaching. The secretary had already received permission from GLASS INTERNATIONAL to put the particulate size paper on the website; the “Glass Problems” Conference paper (2009) will also be added.

The website now contains a substantial amount of information but it is still not available to the public on a hosted site. Sheffield University seems no longer be able to accommodate TC13 website. A new host is needed.

**Participation to the ICG meeting in Brazil**

Mr. Favaro and Mr. Van Limpt attending the meeting in Brazil and Mr Van Limpt presented a poster with a summary of TC13 activities.
Plans for 2011 and Deliverables

TC13 will meet twice in 2011. The first will be held on April 5 & 6 at Eindhoven by invitation of TNO, and the second will be on October 12 & 13 in Brussels by invitation of AGC.

As usual, the broad range of subjects covering all aspects of environmental technology will be covered. The focus will be on completing the round robin monolithic tank test and reporting the results. The performance of novel emission control techniques will also be a key focus for TC13 work.

Publications and other contributions in 2010.

As noted above, two briefing papers were sent to ECHA assessing leaching of Se and Sb from cullet and supporting the exemption of glass from REACH. The TC13 website has been initiated and contains many useful documents.

4.3 R&D ACTIVITY FIELD “CHARACTERIZATION”

4.3.1 GLASS SURFACE DIAGNOSTICS (TC19)

Chairman: Volker Rupertus, Schott AG, Mainz, Germany
Vice-Chairs: Mark Farnworth, Pilkington Technology, UK
Herve Montignaud, Saint Gobain Recherche, France
SUMMARY

In 2010 TC19 was involved in the organization of:

1. an ICG expert panel on “Glass Surfaces & Thin Films on Glass” with 18 experts to work out a road-map. The activity ran in Paris, August 26th - 27th 2010
2. a TC19 group meeting, located in Mainz, June 11th 2010.
3. a member survey about the future work of TC19 with participation of 12 members.
4. an XRD-round-robin, which deals with the determination of crystallite size.

TC19 was also represented at CTC meetings in Mainz (11 March 2010 and Salvador (21 Sept. 2010) as well as in the surface cluster meeting 20 Sept 2010)

PLANS AND DELIVERABLES FOR 2010

- Survey results TC19
- Developing new strategy
- Press release about the ICG expert panel workshop “Glass Surfaces & Thin Films on Glass”
- Submission of the “EDS-paper” to a Journal

ACTIVITIES in 2010

1) “Glass Surfaces & Thin Films on Glass” workshop
18 experts gave 30 minute presentations on various topics. In the final ‘road-mapping’ discussion the topics of a fundamental and quantitative understanding of adsorption phenomena on different types of glass surfaces were ranked high but also the aspects of adhesion and interfacial strength on atomistic scale and chemical durability in different environments were seen as important for future applications of glass. Further research on selected glass surfaces is necessary to create a broader experimental database and link these with atomistic modeling activities, i.e. better coordination between the experimental and modelling activities is essential. For the long term, predictable models on atomistic scale were seen as the tools of the future.

2) TC19 member-survey
TC19 is coming to the end of its current Road-Map, which was started over five years ago. The aims of the meeting were to review what has been achieved over the last 5 or so years and to discuss the next steps. To involve all the members a survey was prepared, dealing with the following topics:

- Areas of Expertise
- Used Analytical Equipment
- Interests of Collaboration

Some of the results are shown in Figures 1 and 2:
3) **New strategy for future work of TC 19**

- The future work of TC19 should be more oriented as a market place for exchange of expertise. The members discussed the preparation of individual working groups, which present their work once a year. A time-line for participants to be agreed prior to the start of an activity.

- There is a need to understand the reasons behind differences in measured data since through this understanding improved data quality can result. The current XRD round robin is a good example where the crystallite size differences between laboratories need to be understood.

- TC19 provides networking opportunities with other members and with other Technical Committees. Links with other TCs could be strengthened.

- All TC19 members have SEM and AFM and most have ToF-SIMS. These core techniques provide the means of engaging most participants although individual collaborations around other techniques could also take place.

- Round robins are a tool to help with collaborations.

**Planned Issues for 2011:**
- Finishing the round robin “Glass-ceramic determination via XRD”
- Start of a new round-robin
- Starting a new format of TC19 meetings according to the ‘strategy’ discussion

PUBLICATIONS AND OTHER CONTRIBUTIONS
Press release about the ICG-workshop.

4.3.2 MECHANICAL PROPERTIES OF GLASS (TC06)

Chairman: Russell J. Hand, Materials Sci & Eng, Uni. of Sheffield, UK
Vice-Chairs: Paul D. Warren, Pilkington, UK
Members: Reha Akcakaya, Türkiye Şişe ve Cam Fabrikalari A.S., Turkey
Dr. Matteo Ciccotti, LCVN, Université de Montpellier II, France
Dr Suresh Gulati Corning, Inc., USA
Dr. Rene Gy, Saint-Gobain Recherche, France
Dr. John Helfinstine, Corning, Inc., USA
Dr. Jun Matsuoka, School of Eng, Uni of Shiga Prefecture, Japan
Dr. Kurt Nattermann, Schott. Germany
Prof. V. Pukh, A. F. Ioffe Physical Technical Institute, Russia
Prof. Jim Varner, NYS College of Ceramics, Alfred Univ., USA
Jorma Vitkala, Glaston, Finland
Prof. Lothar Wondraczek, Univ. Erlangen-Nürnberg, Germany
Dr. Jian Yang, Civil Engineering, Univ. of Birmingham, UK

SUMMARY

Overall although it has not proved possible to have a physical meeting this year TC06 has made progress and has agreed a programme of actions via two teleconferences. Committee members have been involved in the GMIC programme of working towards stronger glass. It is unclear currently exactly how this programme is going to move forwards but clearly it is an important external factor in determining future activity in the area of glass strength. TC06 will continue to maintain links with this GMIC activity with the intention of making a positive contribution.

PLANS AND DELIVERABLES FOR 2010 (from 2009 AR)

- Agree projects to be worked on. Possible projects include
  - Agreeing best practice for edge strength measurements
    - Deliverable: follow-up publication to ICG Kyoto CD proceedings publ.
  - Hot strength of glass and the origin of strength controlling defects
  - Possible joint activity with GMIC in the form of a specialist meeting
  - Possible joint activity with TC09 in the form of a specialist session
  - Quality of glass data
  - Definition of glass strength to enable meaningful discussions of glass strengthening
- Agreement on projects to be delivered via
  - Teleconferences (1 or 2)
  - Face to face meetings to be held at ESG, Magdeburg, Germany (30.5.-2.6.2010) and ICG, Salvador, Bahia, Brazil (20.9.-25.9.2010)
    - Deliverables - meeting minutes; programme of work
- Revamp TC06 website
ACTIVITIES in 2010

- Two TC06 teleconferences have been held since the last annual report. The first involved 6 members of TC06 (Baikova representing Pukh, Ciccotti, Gulati, Hand, Matsuoka and Varner) and the second 9 members (Baikova representing Pukh, Gulati, Hand, Helfinstine, Matsuoka, Nattermann, Varner, Warren and Yang). These were successful and the second one has led to a number of projects being agreed (detailed below). It has not proved possible to get significant numbers of the committee members to meet face to face during the year.
- TC06 members have been involved with the GMIC activity on producing stronger glass. Hand has been involved in teleconferences with the Core Group for this activity and was involved in discussions with the GMIC group at ICG2010. A workshop is being organised as an outcome from the ICG discussions in which TC06 members will be involved. Other members of TC06 (Gulati, Varner) attended and contributed to the GMIC organised workshop on glass strength at the GOMD meeting.
- Revamping of TC06 website. This has been discussed with JM Parker but is awaiting clarification from Parker as to how the website is to be run in future.

PLANS FOR 2011, 2012 AND DELIVERABLES

- Undertake a 2nd round robin to establish best practice for edge strength measurements. Pilkingtons have agreed to supply samples for this activity.
  - Deliverable: Recommendations for good practice for edge strength testing resulting in a follow-up publication to ICG Kyoto proceedings CD publication
- Participation in GMIC workshop - some committee members will be directly involved in this activity
  - Definition of glass strength to enable meaningful discussions of glass strengthening
- Meetings
  - Teleconferences (1 or 2) plus face to face meeting to be held at FFAG5, St. Malo, France
    - Deliverables - meeting minutes; programme of work
- Revamp TC06 website (see comments above)
- Compilation of a list of strength related glass standards together with a critical evaluation of the standards.
  - We are currently seeking involvement in an ASTM programme of work to define a solar glass standard.
- 2012 ICG Advanced Course on Strength of Glass (held jointly with the DGG) provisionally arranged. This will be held either immediately before or immediately after ESG2012.

PUBLICATIONS AND OTHER CONTRIBUTIONS

There were no TC06 publications in 2010. Work has started on compiling a bibliography of papers related to glass strength.

Gulati and Helfinstine have prepared a paper on the vertical 4 point bend test that references the first TC06 round robin edge strength data.
4.3.3 **OPTICAL PROPERTIES AND CHARACTERIZATION (TC10)**

**Chairman:** C. Anderson, Saint-Gobain Recherche, France  
**Vice-Chair:** P. van Nijnatten, OMT Solutions bv, The Netherlands  
**Minutes Secretary:** H.R. Wilson, Fraunhofer, Germany  
**Members:**  
Scott Aldrich, Corning, USA  
Fehiman Akmaz, Turkiye Şişe ve Cam Fabrikalari, Turkey  
Joachim Breitschneider, Pilkington, Germany  
Antonio Daneo, Stazione Sperimentale Del Vetro, Italy  
Alexander Dotsenko, Corning Scientific, Russia  
James Farmer, Pilkington Technology Centre, England  
Gille Flamant, BBRI, Belgium  
Giovanni Gagliardi, Pilkington Italia Spa, Italy  
Thomas Hofmann, Centrosolar Glas GmbH & Co, Germany  
Michael G Hutchins, Sonnergy Ltd, England  
Jacob Jonsson, Lawrence Berkeley Laboratory, USA  
Olivier Kappertz, Interpane, Germany  
C. Kermel, INISMa, Belgium  
T. Kinoshita, Nippon Sheet Glass, Japan  
Ingrid Marenne, AGC flat glass Europe, Belgium  
M.Mika, VSCHT, Czech Republic  
Francois Olive, CSTB, France  
Clemens Ottermann, Schott AG, Germany  
Arne Roos, Uppsala University, Sweden  
Giuseppe Rossi, I.N.Ri.M., Italy  
T. Saito, ASAHI GLASS Co. Ltd, Japan  
I. Stemmler, Perkin Elmer, Germany  
P. Veiga, Guardian Llodio, Spain  
Guests:  
A. Nilsson, Uppsala University, Sweden

**SUMMARY 2010**

TC10 changed its name from “Optical Properties” to “Optical Properties and Characterization”. This change was due to the fact that the most of the activities of the committee are based around different optical measurements of glass and coated glass products. However, it was decided to organize a sub-group to study basic optical properties.

TC10 welcomed Mr. James Farmer, Mr. Antonio Daneo, and Ms. Christine Kermel as new members replacing others from the same organizations. In addition Ms. Pilar Veiga became a member, practically completing the membership of TC10 concerning producers of glass coated products. Finally, Mr. Ivo Stemmler became a member, becoming the first producer of commercial optical measurement instrumentation.

The main goals of TC10 have not changed. They are to answer the needs of characterization of optical properties for commercial products with available commercial instrumentation, to disseminate this information to relevant standards bodies and the public in general. This is accomplished with the cooperation of members from producers, independent research laboratories (both educational and national), and now a producer of optical measurement instrumentation. The results of these studies
define techniques allowing building energy balance simulations which allow minimal energy consumption. Finally, a new goal for TC10 is to work on optical properties such as determining the effects of glass composition on optical properties.

For the year 2010, the project to measure optical transmission and reflection of highly diffusing and patterned glass products using commercially available optical instrumentation continued. This has been an extremely ambitious project but the year 2010 has produced results that indicate a technique that produces similar results among different measurement instrumentation for a variety of such products for transmission measurements. Basically, the technique is to diffuse the incident beam before impinging on the sample. This is because, especially for patterned glass, the integrating sphere designs are not adapted to measure samples where the transmitted beams are also structured. Following are illustrations that show the structure of the glass patterns and the resulting transmitted light beams.

Photos provided courtesy of T. Hofmann, HR Wilson and A. Roos

A new inter laboratory comparison was started to validate methods of measuring transmission and reflection of specular glass products at oblique angles. Samples were produced, measured for homogeneity between samples and distributed to participants. In addition, instructions and Excel worksheets were developed to organize the project. This project was instigated to improve input to building energy balance simulations. While standards generally refer to normal transmission and reflection, the following illustrates the actual average distribution of the angle of incidence of solar radiation for Madrid and Stockholm.

Angular dependence of direct total solar transmittance for Madrid and Stockholm.
Finally, it was agreed to form a subgroup to study optical properties per se of glass compositions to be organized by Martin Mika. Mr. Mika explained that remaining within TC10 was preferable as optical measurements will always be a necessity for such studies and that the infrastructure of TC10 such as the website would be of great value to such a subgroup.

There were two TC10 meetings in 2010. The first was held in Murano, Italy hosted by SSV on the 12 March. The second was held at Uppsala University on 10 September.

Dissemination of results of the project concerning optical measurements of diffusing and patterned glass products included a presentation at PVSat6 24 and an OTTI article. A TC10 poster was presented in Salvador, Brazil that outlined the basic work of TC10.

PLANNING for 2011

As it appears that some progress has been made on the project to measure optical transmission and reflection of highly diffusing and patterned glass products, a new inter laboratory comparison will be organized among the full membership using a specific measurement technique. Results from these new measurements will be compared to results of earlier measurements.

For the inter laboratory comparison to validate methods of measuring transmission and reflection of specular glass products at oblique angles we hope to accumulate sufficient data to determine the status quo of such measurements and provide recommendations for these measurements.

The new subgroup on optical properties will be organized at the next TC10 meeting to be held in March. We will determine who within TC10 would like to be part of the new subgroup and try to determine a list of others to invite to join this subgroup. A list of possible research topics will be presented with a selection of priorities determined. The subgroup will then organize a more detailed plan of activity for each priority topic.

As usual two TC10 meeting will be held in 2011. The first will be in March in Murano, Italy and the second will be in Paris in September.

4.3.4 GLASS DURABILITY AND ANALYSIS (TC02)

Chairman: Stuart Jamieson, NSG Pilkington, UK
Vice-Chair: Vacant
Secretary: Peter Sundberg, Glafo, Växjö, Sweden
Members: Sylvie Abensour, St Gobain Recherche, France
Ayse Kerestecioglu, Şişe ve Cam, Turkey
Tepiwan Jitwatcharakomol, Ministry of Sci & Technol, Thailand
Martina Scarpa, SSV, Italy
Pascal Marque / Philippe Pradeau, Corning, France
Andreas Kasper / Eike Chorus, Saint Gobain, Germany
Leos Bauer, Glass Institute, Czech Republic
Isabelle Lesieur, St Gobain ISOVER, France
Ralf Eiden / Christine Strubel, Schott, Germany
Dominique Michiels, AGC Europe, Belgium
Jose Simons / Jean Marc Carpentier, INISMa, Belgium
TC02 continues to provide analytical solutions to complex issues facing the glass industry. This includes raw material supply through to final product testing. The Committee operates within the “Characterization” cluster group but provides ad hoc support to other TCs (e.g. TC13) and specially selected external bodies upon request e.g. certified reference material producers.

The committee is committed to the pursuit of analytical excellence through the standardization and harmonization of analytical methodology throughout the glass and associated industries.

TC02 committee members continue to actively promote and participate in a wide range of proficiency testing schemes and undertake investigations to explain complex differences in measurement response by different analytical procedures.

The committee has established close working links with The Society of Glass Technology and The Bureau of Analyzed Samples (both UK based) and has been instrumental in providing expert commentary in the development of new National and International standards for analysis and the development of a range of CRMs the production of which is deemed critical to the development of accurate instrumental analytical methodology across the glass industry.

Individual committee members have also published related articles within The Society of Glass Technology Journal with TC02 technical support.

PLANS & ACTIVITIES FOR 2010 included:

FINALISATION OF 2009 TOPICS:

- Mercury in glass project concluded; looking into options for developing a “mercury in glass” reference material via an external organisation.
- Sulfide / Sulfur level in amber glass project has been closed. Sulfur analysis deemed consistent; problems persist with sulphide measurement, although issues re sample homogeneity were a concern.
- Proficiency testing work on new, low iron, glass making sand has been completed. Wide range of analytical protocols evaluated, all deemed suitable for this type of analysis.
BAM CRM examined for major components following work on traces concluded in 2004 / 2005. Work package now closed.

At the request of TC11 / TC14, TC02 looked into options for the determination of C/S/N in a refractory material. Results have been forwarded to the relevant committee members.

NEW TOPICS FOR 2010:

- Analysis of DB 2009-1 Novatec Glass ceramic to be used as working standard - material was sourced from a Chinese supplier and subjected to analysis by 16 laboratories of which only 2 manufactured this product type. Results were generally considered acceptable although concerns over the wide spread in reported values for the alkali metals and other minor components are subject to further review.
- Low iron measurements in limestone and dolomite - possible method dependency or variation in inherent geology of materials which adversely affect the measured outcome reported by TC02 member. Committee has entered into an extensive review of applicable methodology and working with a raw material supplier looking into determining an appropriate “best practice” approach to low iron measurement for such materials.
- TC02 is working with TC13 to develop / measure antimony leaching rates from low iron glass samples using EA NEN 7375:2004 to provide information regarding CEN TC351 supporting the Construction Products Directive. This builds on work done last year looking at gaining exemption from REACH for glass. Programme is ongoing. Results should be available for our Spring Meeting in April / May 2011.

Full details of all TC02’s activities in 2010 are appended in Annex 1 and 2.

FUTURE TOPICS / DELIVERABLES FOR 2011:

- Determination of fluorine (~25%w/w) in optical glasses.
- Assessment of glass durability, particularly in humid environments.
- Determination of arsenic leach rate in pharmaceutical containers.
- Conclusion of low iron measurement for dolomite / limestone systems.
- Conclusion of TC02 / TC13 joint study into the leaching of Sb from low iron glass.
- Characterisation of a new, low iron, float glass for use as a CRM in association with the SGT and BAS. (This material may also be used as an optical standard in association with TC10).
- Characterisation of a new, high purity silica material for use as a CRM in association with SGT and BAS.
- Committee is looking to hold two European meetings in Belgium (April / May) and Italy (October / November). The committee also has a long standing invitation to Thailand for 2012.
- Cluster Chairman to be invited to address TC02 to provide a greater understanding of the ICG’s longer term role for Technical Committees under the revised structure.

PUBLICATIONS AND OTHER CONTRIBUTIONS

1. ICG/TC02/10-1561 Report - Proficiency Test in Chemical Analyses: Analysis of Glass Ceramic.
2. ICG/TC02/10-1562 Report - Proficiency Test in Chemical Analyses: Low iron glass sand.
3. ICG/TC02/10-1563 Report - Mercury in Glass - Preparation of Samples and Proficiency Test in Chemical Analysis.
4. ICG/TC02/10-1566 Report - Collaboration in chemical analyses of glass raw materials: iron quantification in dolomite.

4.4 R&D Activity Field “Applications”

4.4.1 NANOSTRUCTURED GLASS (TC16)

Chairman: Rui M. Almeida, IST / ICEMS, Portugal
Vice-Chair: Alex Martucci, Univ. Padova, Italy
Members: Alicia Duran, ICV/CSIC, Spain (core group)
          Sidney Ribeiro, Univ. Araraquara, Brazil
          Kiyoharu Tadanaga, Osaka Pref. Univ., Japan
          David Levy, ICMM-CSIC, Spain
          M. Clara Gonçalves, IST/ICEMS, Portugal
          Mario Aparicio, ICV, Spain
          Yolanda Castro, ICV, Spain
          Marcos Zayat, ICMM-CSIC, Spain
          Luis Fortes, IST/ICEMS, Portugal
          Nathan Mellot, Alfred Univ., USA
          Gang Chen, Univ. Ohio, USA
          Jian Xu, Univ. Ningbo, China

SUMMARY

TC16 during 2010 concentrated mostly on new activities related to the study of sol-gel derived nanostructured coatings for energy savings in buildings simultaneously with solar control and photocatalytic properties, where most results have already been obtained by TC members working in Lisbon, Madrid and Padua.

TC16 had a meeting in Madrid on April 23.

At the ICG congress in Salvador, Bahia, Brazil, 20-24 September, TC16 organized a Symposium on Nanostructured Glass Coatings by Sol-gel, which included one invited and seven contributed talks and presented a poster.
PLANS AND DELIVERABLES FOR 2010

The main goal of TC16 at present is to perform collaborative research focused around the development of a nanostructured functional coating on glass, simultaneously with solar control and self-cleaning properties, based on TiO$_2$ or on ZnO:Al (AZO). In particular, the goal is to use sol-gel processing for the purpose of combining solar control and photocatalytic activity on a single nanostructured glass coating, by using Bragg mirrors (BMs), which are photonic bandgap-type coatings with high reflectivity in the near-UV and NIR, further coated with mesoporous TiO$_2$ with photocatalytic properties. Another strategy could be the realization of an AZO coating starting from already formed nanoparticles to eventually combine with a TiO$_2$ self-cleaning coating.

For 2010, the plan was to work on the solar control development in Lisbon and Padua, with the self-cleaning development being done in Madrid. A second goal was the organization of a Symposium on Nanostructured Glass Coatings by Sol-gel in the ICG congress in Salvador (Brazil) in September.

Activities in 2010:

A solar control coating reflects near-infrared radiation from the sun, while transmitting the visible portion. The sol-gel method is a low-cost coating technology for this purpose, in particular, for the deposition of BMs on glass substrates. Multilayer quarter-wave BMs have been modelled by the Transfer Matrix method, designed to have near-UV and near-IR reflectivity, but visible transparency, based on alternating silicate glass / titania quarter-wave stacks. Good quality Bragg Mirrors were prepared by sol-gel processing (spin-coating) on borosilicate glass and other types of substrates. Their optical behavior was measured by absorption and reflection spectroscopies. The optical reflectivity characteristics of these multilayer coatings revealed solar control properties.

Example of reflection spectrum for a long-wavelength BM for the near infrared on a borosilicate glass substrate, at near-normal incidence and corresponding TMM simulation (red line).

The photocatalytic activity of TiO$_2$ coatings has been evaluated. In particular, for mesostructured anatase coatings with photocatalytic properties including the elimination of air borne toxic and corrosive compounds. In particular, ICV has deposited a two-layer TiO$_2$ mesoporous coating to give the Bragg mirror additional photocatalytic behavior.
Photocatalytic oxidation of MEK

Photocatalytic reactor and results on TiO$_2$ mesoporous coatings prepared with different surfactants.

The work performed included also the photocatalytic characterization of TiO$_2$ coatings prepared from TiO$_2$ nanocrystals (Padua) and photonic crystal (BM) coatings (IST).

In order to develop a high refractive index coating at low temperature, a film composed of already formed TiO$_2$ nanoparticles has been synthesized. Below is an example of the sol-gel synthesis of clear and well dispersed anatase TiO$_2$ NC colloids, from titanium isopropoxide in alcohol medium, which led to anatase TiO$_2$ NCs with a diameter of ~ 4 nm. Starting from these NPs, TiO$_2$ anatase coatings have been obtained at room temperature:

Sol-gel synthesis of clear and well dispersed anatase TiO$_2$ NC colloids (dia. ~ 4 nm).

The combination of multiple types of coatings on a common glass substrate, e.g. a Bragg mirror and a photocatalytic (self-cleaning) titania coating, offers an interesting
possibility for obtaining multi-functional optical coatings on window glass with solar control/low-E and other properties, while the sol-gel technique is a potential low-cost method to deposit such coatings on large area glass substrates. Possible applications include architectural, automotive, or microwave oven windows.

Rui Almeida and Alicia Duran have also participated in the ICG Roadmap Workshop on Surfaces & Interfaces & Thin Films on Glass organized by Klaus Bange at the Institut du Verre in Paris, on August 26 and 27, where two presentations were made of TC16-related work: Photonic Bandgap coatings for solar control (R. Almeida) and Mesoporous nanostructured coatings produced from soft chemistry (A. Duran).

Summary of the TC16 meeting in Madrid on April 23:

Rui Almeida described the Transfer Matrix simulation and sol-gel spin-coating deposition of Bragg mirrors on Si or borosilicate glass substrates, composed of alternating silica and titania layers, designed with stop bands of high reflectivity both for the near-UV and the near-IR.

Alicia Duran described the successful preparation of mesoporous titania coatings based on the addition of surfactants to a TiCl$_4$-based sol followed by dip-coating on window glass substrates, with good photocatalytic performance in terms of the oxidation of methyl ethyl ketone (MEK). A pore size distribution peaking at ~ 4 nm was obtained by spectral ellipsometry measurements with humidity control.

Alex Martucci described in detail the problems he has encountered to prepare Al-doped ZnO nanoparticles (NPs).

Finally, Marcos Zayat briefly described the work going on at ICMM, namely on sol-gel derived hybrid, photochromic and liquid crystal coatings.
Minutes are available (rui.almeida@ist.utl.pt).

Summary of the TC16 meeting in Salvador on September 20:

Rui Almeida described the simulation and sol-gel spin-coating deposition of Bragg mirrors on Si or borosilicate glass substrates, composed of alternating aluminosilicate glass and titania layers, designed with stop bands of high reflectivity both for the near-UV (peaking at ~ 300 nm) and the near-IR (peaking at ~ 1000 nm).

Alicia Duran described the successful preparation of porous titania coatings on window glass substrates, with good photocatalytic performance.

Alex Martucci described the preparation of titania NPs ~ 4 nm in diameter, as well as the synthesis of titinate nanosheets, using tetramethyl ammonium hydroxide.
Minutes are available (rui.almeida@ist.utl.pt).

PLANS FOR 2011

Different complementary lines of work will be pursued, namely in Lisbon, Padua and Madrid.
In Lisbon, Bragg mirror sol-gel coatings will be further developed and optimized for solar control, since significant improvements are still needed in reproducibility and optical performance.
In Padua, the NP (bottom-up) approach will be continued, with samples being supplied to ICMM (in Madrid) for photocatalytic evaluation under illumination from a solar simulator. In Madrid (ICV and ICMM), it will soon be possible to measure the
photocatalytic activity of Bragg mirror type, as well as NP-based coatings, along with the new and more efficient TiO$_2$ coatings doped with W, Co, Ca and N. The main goal of this work should be achievable within the next couple of years. TC16 also plans to hold progress meetings in Madrid (around February-March) and in Hangzhou (China) at the end of August, during the Sol-gel 2011 Conference. During these meetings, TC16 will evaluate the possibility of opening up one or two additional lines of collaborative work, particularly involving the most recent members who have joined the technical committee from USA. In particular, N. Mellot is interested in thin film X-ray studies of the amorphous to nanocrystalline transition, including high temperature in-situ analysis, whereas G. Chen is interested in the structure of mesoporous films like titania, particularly in their atomic and electronic structure, as well as the study of the nanoscale morphology of nanostructured glasses using X-ray methods.

4.4.2 COATINGS ON GLASS (TC24)

Chairman: K. Sanderson, Nippon Sheet Glass, UK
Vice-Chairs: M. Andreassen, AGC, USA
Members: H. Weis, Interpane E&B, Germany
A. Piers, TNO, The Netherlands
A. Durandeau, Saint Gobain, France
A. Parlar, Sisecam, Turkey
E. Valentin, Saint Gobain, France
L. Hupa, Abo Academy University, Finland
P. Van Nijatten, TNO, The Netherlands
P. Bastianen, Vindico Surface Technologies BV, The Netherlands
T. Belgardt, Interpane E&B, Germany
P. Sonderkaer, Velux, Denmark
A. Roos, University of Uppsala, Sweden
D. Sheel, University Salford, CVD Technologies, UK
D. Coster, AGC, Belgium
J. Puetz, Zeiss, Germany
J. Vitkala, Tamglass Engineering, Finland
M. Hirata, NSG Group, Japan
K. Myli, Cardinal Glass, USA
M. Mitterhuber, ETC Products, Germany

SUMMARY

Following reduced activity in 2009, the TC24 committee has this year been more active with three technical meetings held during the year along with the completion of a round robin and a second round robin established.

The activities of the group during the year include:

- 23 Feb 2010 - One day meeting at AGC headquarters Brussels
- 8 June 2010 - One day meeting conducted at ICCG 8 - Braunschweig
- 23 Sept 2010 - One day meeting at AGC headquarters Brussels
Other Activities:

- ICG Road mapping session on Glass Surfaces & Thin Films on Glass - 26 and 27 August 2010 - Two members of the committee attended and presented material.
- ICG congress in Salvador, Brazil, 20-24 September; TC24 presented a poster.

The technical committee’s activities during the year have focused on three areas:

- Completion of the work on self cleaning / reduced maintenance coatings. This work area has now been completed with a handover of all information to the CEN committee TC129 who are now progressing a standard in this area.
- Testing of pyrolytic coated transparent conductive oxide films (TCO).
- Identification of the forward route for TC24 and new areas of interest.

PLANS AND DELIVERABLES FOR 2010

The key technical objectives for 2010 were:

- Agree the technical committee’s role in ongoing work in the Self Cleaning and Reduced Maintenance Areas. The key challenge being to establish the role of TC24 in the ongoing standardisation activities now being undertaken by CEN TC129.
- 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 into new areas of interest and importance to coating development going forward.

ACTIVITIES IN 2010

Self Cleaning Reduced Maintenance

- For several years TC24 has been undertaking ongoing testing of the Self Cleaning / Reduced Maintenance Glass test proposed initially by a Framework 6 funded European STREP project and subsequently by CEN TC129. In 2009 TC24 formally submitted a letter to CEN TC129 summarising the activities undertaken over several years by members of TC24 and raising a series of concerns related to the reliability and reproducibility of the test in its current format. CEN TC129 formally responded to the letter during 2010. The letter also highlighted on going development work being undertaken by CEN TC129 in order to address the committee’s concerns. These were discussed with TC24 and it has been agreed that formally TC24 technical activities in the area should now be stopped. TC24 have offered additional support to CEN TC129 if required but it was generally felt by all parties that activities in this area were now best undertaken by the standardisation bodies and that the concerns were being addressed.
- Discussions were held as part of the review of potential new work areas whether TC24 could undertake evaluation of such technology for other applications. After discussions and review of external work in this area it was generally felt that this area was being covered by other bodies. As such at this time it was felt that the committee would maintain a watching brief and only commence additional activities if felt appropriate at a later stage. The specific areas of development which the committee will monitor are:
- Use of this technology in Photovoltaic type applications and the differing demands which this places on the technology,
- Use of the technology in anti dew / condensation roles.

- In order to maintain a watching brief it is proposed that along with other areas of coating technology a short update will be provided annually on the technology by one of the committee members.

**Transparent Conductive Oxides**
- For the last 2 years TC24 has been evaluating the technical information provided on transparent conductive oxide films (TCOs). With the growing use of TCOs in technical applications such as photovoltaics in addition to the more traditional uses such as Low Emissivity coatings it was felt a study of the measurements being presented and standardisation of some of the new techniques being developed was warranted. Following an initial round robin on a transparent conductive oxide in 2008 and 2009 the committee highlighted significant variations in measurements which had been obtained by the institutes involved. Following evaluation of the results an expanded round robin tests was established in late 2009 and has run through the year using a single layer transparent conductive oxide.

The focus of the round robin was to address two key issues:
- Identify the root cause of variation in TCO analysis observed in the first round robin. The round robin therefore undertook across several institutes in Europe and Japan the following measurements
  - Traditional Optical Measurements - Transmission and Reflection
  - Haze
  - Thickness
  - Sheet Resistance
  - Hall Effect
    - Carrier Concentration
    - Mobility
- Undertake an evaluation of angular spectroscopy. The objective of the exercise was to look at a range of methods currently being used / presented for the measurement of angular values and identify a correlation between these. This was felt of importance as increasingly data are being presented in the literature on the spectral properties of TCOs with angular dependence. Studies have then been undertaken to identify the relationship with a range of properties such as:
  - Morphology of the TCOs
  - Performance of TCOs when used in PV devices

**Technical Results:-**

- The TC24 round robin confirmed that the key variation in measured properties in the first round robin was a result of variable thickness measurements between the institutes involved. This work highlights the importance of the etching technique used when looking at multiple layer TCO coatings. The second round robin utilising a single layer TCO confirmed that film thickness on a nominally 510nm thick film was measure to +/- 10nm showing good consistency between the measurement techniques utilised
• The round robin confirmed that as a result of the better consistency on the thickness measurement, the other key values derived showed good consistency between the three institutions which measured the values

<table>
<thead>
<tr>
<th>Test Laboratory</th>
<th>Carrier Concentration ((\times 10^{20}/\text{cm}^3))</th>
<th>Mobility ((\text{cm}^2/\text{Vs}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>4.09</td>
<td>23.98</td>
</tr>
<tr>
<td>Two</td>
<td>4.47</td>
<td>22.3</td>
</tr>
<tr>
<td>Three</td>
<td>4.17</td>
<td>22.7</td>
</tr>
</tbody>
</table>

Table 1: Hall Effect Comparison from three round robin participants on TCO Sample

• Interestingly, AFM analysis by two members was conducted on the samples. It is worth noting that these resulted in some variation in the RMS values seen on the two samples. This could be related to the different measurement systems utilised but with the increasingly links between morphology and performance in certain devices is an area for on going future investigation.

<table>
<thead>
<tr>
<th>Test Laboratory</th>
<th>RMS (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>16.05</td>
</tr>
<tr>
<td>Two</td>
<td>20.6 +/- 3.4</td>
</tr>
</tbody>
</table>

Table 2 - AFM RMS Analysis on TCO Sample

• Two methods of angular spectroscopy have also been evaluated as part of the round robin. These involve:
  1. The use of a traditional spectrometer with the measurement of spectra at different angles of incidence,
  2. A laser diode based system where angular measurements made with 90 degrees input and varying detector angle.
Figure 2: Angular Spectral Dependence of a TCO sample using a Traditional Spectrometer

Figure 3 - Angular Measurements made using a Laser diode based system

- Initial comparison work between the two systems is now underway and will be addressed in a further round robin focusing on this element of the program. It has been agreed between committee members and this will focus on the following:
  - Structured TCO from Universities covering the range of TCO morphologies currently available
    - \( \text{SnO}_2:F \) with a high haze >5% (high haze being felt critical to this exercise)
    - \( \text{A ZnO} \)
    - An etched \( \text{ZnO} \)
  - An extension to the round robin will then be to link AFM measurement and commercially available TCO samples into the program once techniques are established.

Other Areas of Interest

- A key objective of the year has been to expand the areas of interest of TC24 Coatings on Glass. In order to facilitate this, a questionnaire was run during the year with members to identify areas of interest / potential scientific collaboration.
- The general consensus if that the key focus of the group at present should be to continue investigations into TCOs whilst maintaining a watching brief on various new technologies. This will be achieved by regular updates in these coating development areas being provided by committee members or invited guests. Areas to be included are:-
  - Antibacterial coatings
  - Antimicrobial coatings
- Hybrid / polymer derived coatings.
- Anti condensation / Anti Dew
- Self cleaning / reduced maintenance for new areas
- Nucleation and Substrate effects on coating

- Expansion of the committee base beyond the current industrial bias of committee members is also felt crucial going forward.

PLANS FOR 2011 AND DELIVERABLES

- Conduct and report on a new round robin with specific emphasis on the relationship between angular spectroscopy and TCO characterisation. This work will focus on a wide range of TCOs but with emphasis on high haze samples which are being characterised using such techniques. As part of this exercise it is hoped to establish links with TC10 who have also undertaken a similar exercise with patterned glass and some low haze coatings.
- Expand committee membership to include more University members. It is hoped that this can be achieved through the round robin exercises.
- Conduct regular reviews of new technology areas and agree suitable fundamental scientific investigations in these areas as they become appropriate.

The work programs proposed for 2011 were discussed with the key challenges discussed at the Paris road mapping sessions in mind.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- Poster at the ICG Congress in Salvador, Bahia, Brazil, 20-24 September

4.4.3 GLASSES FOR MEDICINE AND BIOTEchnolOgy (TC04)

Chairman: Julian Jones
Vice-Chairs: Alexis Claire, Wolfram Holland
Members: Delbert Day
Enrica Verne
Aldo Boccaccini
Robert Hill
Carlo Pantano
Bob Baier
Sam Conzone
Alastair Cormack
Matthew Hall
David Greenspan
Akiyoshi Osaka
Leena Hupa
Larry Hench
Kai Karlsson
Matthew O’Donnell
SUMMARY
The aims for 2010 were to progress the TC04 book and to carry out round robin testing of bioactivity of glasses and their variants and to assess the applicability of the protocol devised by the committee in 2009. Another aim was to obtain funding for the biomedical glass area, via a European Framework 7 COST action, to enable international meetings and roadmapping to take place in 2011 and beyond.

PLANS AND DELIVERABLES FOR 2010

• Hold a meeting at the ICG meeting in Salvador, Brazil, September 2010
• Bio-glasses - An Introduction - chapters contributed by members of TC04
• Road-mapping activities related to biomaterials for the EFONGA project and beyond
• Round robin testing of bioactivity of glasses
• Obtain funding to replace the EFONGA project (COST)

ACTIVITIES in 2010
A TC04 meeting was held at the ICG meeting and was well attended. Discussion initially focused on the progress of the round robin testing. JR Jones reported that 8 groups have submitted their results. 4 further sets of results are expected. Jones will compile the results for publication in 2011. Initial results show that the protocol devised in 2009 is suitable as it does find differences in rate of the surface layer apatite formation for the different commercial glasses.

TC04 also organised a bioactive glass session at the ICG. The session was very well attended and discussion was extremely constructive. Attendees were from other fields in addition to those that work on biomaterials. Particularly popular was the invited keynote talk by Professor Mark Smith, University of Warwick, on the NMR characterization of bioactive glasses, particularly sol-gel derived bioactive glasses.

The progress of the TC04 book was discussed. A chapter of phosphate glasses was commissioned from Delia Brauer and delivered in a timely fashion. The editors are still waiting for two chapters but the decision was made to go ahead without them if they were not received by the end of 2010, following a final reminder. Larry Hench has agreed to write a forward.
The ICG has also agreed to co-finance the book to enable to keep the price of the book down and to allow ICG to offer it for sale.

The committee also addressed questions posted by René Vacher: What do you want to get from you participation to the TC, and what is your active contribution in this group? One of the main things was to improve education and awareness in bio-glasses. This includes increasing the number and quality of PhD students working in the field and the basic knowledge of PhD students once they begin. The committee will seek to achieve this by actively maintaining a visible website (to be constructed by ICG), which will include Streaming of content to entice students into the field (30s podcasts). Publication of the TC04 book will also help but we will look into creating online course and holding an international conference and workshop.

Jones/ Cormack/ Hupa gave an informal report of the Surfaces and Interfaces Workshop and Roadmap in Paris, August 2010. They highlighted that there are common problems, e.g. understanding the interaction of water and proteins at the glass surface, shared by researchers working in all areas of glass research.
An application was made by Julian Jones to the COST proposals for international collaborative research (£100k) in 2010. It application was ranked highly but unfortunately it was unsuccessful. No further applications are planned.

PLANS FOR 2011 AND DELIVERABLES

The deadline for the TC04 book is 1st April 2011.
The results for the bioactivity testing round robin experiments are due.
The data will be sent to Julian Jones for compilation and drafting of a publication.
The TC04 annual meeting will be in Cairns at the PACRIM meeting.
The bioactivity testing will then progress to in vitro cell culture experiments.

To collaborate with TC07 and review biomedical glass-ceramics led by Wolfram Höland and Joachim Deubener.
To produce a review of the latest coating technologies for coating prosthesis with bioactive glasses - led by Aldo Boccaccini.

PUBLICATIONS AND OTHER CONTRIBUTIONS

To come in 2011:
Bio-glasses textbook
Bioactivity testing of glasses and their variants, a journal article
A review of bioactive glass-ceramics

4.4.4 NUCLEAR AND HAZARDOUS WASTE VITRIFICATION (TC05)

Chairman: J. C. Marra, Savannah River National Laboratory, U.S.A.
Vice-Chair: C. Veyer, Areva, Inc., France
Secretary: D. K. Peeler, Savannah River National Laboratory, U.S.A.
Members: A. Boccaccini, University of Erlangen-Nuremberg, Germany
              W. Ebert, Argonne National Laboratory, U.S.A.
              C. Fillet, Commissariat à l’Énergie Atomique, France
              R. Hand, University of Sheffield, U.K.
              M. Harrison, National Nuclear Laboratory, U.K.
              M. Kovacova, Slovak Academy of Sciences, Slovak Republic
              M. LaRobina, Extreme Science Pty. Ltd, Australia
              C. Leonelli, University of Modena and Reggio Emilia, Italy
              R. Monteiro, Nova University of Lisbon, Portugal
              M. Ojovan, University of Sheffield, U.K.
              J. Rincon, Inst. E. Torroja de Ciencia y Tecnología de la Construcción, CSIC, Spain
              C. Scales, National Nuclear Laboratory, U.K.
              S. Stefanovsky, SIA Radon, Russia
              P. Stoch, Institut of Atomic Energy Swierk, Poland
              J. Vienna, Pacific Northwest National Laboratory, U.S.A.
              S. Weisenburger, Institut für Nukleare Entsorgung, Germany

HISTORY AND GOALS FOR TCO5

The Technical Committee on Nuclear and Hazardous Waste Vitrification was approved by the ICG Coordinating Technical Committee (CTC) and the Steering Committee (SC) in 2006. 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.

PLANS AND DELIVERABLES FOR 2010
In 2010, TC05 planned and executed two major activities. The first activity was to continue to sponsor technical programming at a major glass conference. This built on successful technical programming conducted in 2007, 2008 and 2009. In 2010, TC05 planned and conducted technical programming at the ICG International Glass Congress in Salvador, Brazil.

In 2008, TC05 members identified a common need for test method development as it related to waste glass properties. Liquidus temperature (T_L) is an important glass property for vitrification processing regardless of the melter technology being used or glass system being employed for waste immobilization and is, therefore, of worldwide interest. However, waste glasses are often opaque, making T_L measurements problematic. A need to develop and validate a T_L measurement procedure was identified. In 2010, TC05 completed round-robin testing to evaluate and validate T_L measurement protocols for waste-type glasses.

ACTIVITIES IN 2010
As noted, a primary objective for 2010 was to organize and conduct technical programming at the ICG International Glass Congress in Salvador, Brazil. Technical programming was conducted by TC05 in 2009 at the joint American Ceramic Society PacRim/ICG meeting in 2009 in Vancouver, Canada, in 2008 at the Materials Science and Technology conference in the U.S.A. and in 2007 at the ICG Congress in France and the Materials Research Society meeting in England. These technical programming efforts were highly successful so a continued programming effort was deemed to be worthwhile to further communicate the activities of TC05 members and the work of the waste vitrification community to a broader audience. The symposium was successfully organized and was well attended. A total of 18 oral presentations and poster presentations were presented in the symposium. Papers were presented by six TC05 members. Moreover, presentations were made by representatives from 7 countries.

The papers from the joint PacRim/ICG meeting in Vancouver were included in a Ceramics Transactions conference proceeding volume: Ceramics for Environmental and Energy Applications, edited by A. Boccaccini, J. Marra, F. Dogan, H-T. Lin and T. Watanabe.

In 2010, TC05 members supported publishing the book: Crystalline Materials for Actinide Immobilisation by B. E. Burakov, M. Ojovan and W. E. Lee. This book included process information and property data on glass-ceramic waste forms for actinide immobilization.
Isothermal $T_L$ determination techniques were developed at Pacific Northwest National Laboratory (under the direction of a TC05 member) that appeared to be repeatable and accurate. Round-robin testing was needed to verify and validate the experimental techniques with a goal for adoption of the methods as an ASTM procedure. Furthermore, comparison of the isothermal techniques to the more traditional gradient furnace (GF) method was needed. The isothermal techniques included a uniform furnace temperature method (UT) and a crystal fraction extrapolation method (CF). Three glasses (note most recent participants only tested two glasses) were sent to 10 laboratories for isothermal $T_L$ measurements. A procedure was sent to each laboratory for isothermal $T_L$ measurements using the two test method variations. The testing was completed by 8 laboratories and data was received in 2010 (Table I). The $T_L$ values of the round-robin unknowns ranged from ~950°C (Zr-9) to ~1230°C (AmCm-19) and the values depended on the method used. The values were most variable for the GF measurement which is to be expected due to the difficulty in making the measurements. For GF measurements, the crystallization front shape is often irregular leading to difficulties in determining $T_C$ and $T_a$ which is dependent on the viscosity of the melt at those temperatures. CF measurements seem consistent with the UT measurements, on average. The UT method was utilized by most of the participating institutions as the equipment requirements for this method are the most common. Due to difficulties experienced with measurement of Zr-9, only a few of the institutions were able to provide results for this glass.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Glass A: ARG-1</th>
<th>Glass B: Zr-9</th>
<th>Glass C: AmCm-19</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GF</td>
<td>UT</td>
<td>CF</td>
</tr>
<tr>
<td>PNNL</td>
<td>1033±2</td>
<td>1038±6</td>
<td>O.S.</td>
</tr>
<tr>
<td>SRNL</td>
<td>-</td>
<td>1024±5</td>
<td>-</td>
</tr>
<tr>
<td>INL</td>
<td>1065±2</td>
<td>1046±2</td>
<td>-</td>
</tr>
<tr>
<td>Monarch</td>
<td>-</td>
<td>1034±4</td>
<td>-</td>
</tr>
<tr>
<td>CEA</td>
<td>-</td>
<td>1036±2</td>
<td>-</td>
</tr>
<tr>
<td>NNL</td>
<td>-</td>
<td>1042±2</td>
<td>-</td>
</tr>
<tr>
<td>U. Modena</td>
<td>-</td>
<td>1035±5</td>
<td>1042±5</td>
</tr>
<tr>
<td>U. Sheffield</td>
<td>-</td>
<td>-</td>
<td>1035±5</td>
</tr>
<tr>
<td>ICT</td>
<td>-</td>
<td>O.S.</td>
<td>-</td>
</tr>
<tr>
<td>VSL</td>
<td>-</td>
<td>O.S.</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>1048.8</td>
<td>1036.3</td>
<td>1038.5</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>6.8</td>
<td>7.4</td>
<td>-</td>
</tr>
</tbody>
</table>

The technical committee held one “face-to-face” meeting and two teleconference meetings in 2010. The face-to-face meeting was held at the ICG Congress in Salvador, Brazil. At this meeting, the results of the round-robin testing were discussed and a status of the technical programming at the ICG Congress was provided. Plans for activities in 2011 as well as longer-range plans were also discussed. The teleconference meeting held in January 2010 focused on planning for the upcoming technical programming to be conducted at the ICG Congress. At the teleconference conducted in July, the focus was on developing the TC05 poster for the ICG Congress (Appendix A). During this teleconference call, the results of the round-robin testing were also discussed. During the year, several ad hoc telephone calls and e-mail exchanges occurred to discuss the round-robin testing.
PLANS AND DELIVERABLES FOR 2011
The primary objectives for 2011 will be to complete the liquidus temperature round-robin testing project and to continue technical programming. Plans are to publish the results of the round-robin testing in a peer-reviewed journal (the International Journal of Applied Glass Science is currently being targeted). In 2011, efforts to develop the isothermal liquidus temperature measurement protocols into ASTM procedures will be initiated.

TC05 is planning to conduct programming at the 2011 International Conference on the Chemistry of Glasses and Glass-Forming Melts to be held in Oxford, England in September 2011. The conference is sponsored by the Society of Glass Technology and is in celebration of the 300th anniversary of the birth of Mikhail Vasilievich Lomonosov. It is expected that TC05 will continue the successes of previous technical programming efforts.

4.4.5 GLASS FOR OPTOELECTRONICS (TC20)

Chairman: Setsuhisa Tanabe, Kyoto Univ., Japan
Vice-Chairs: Giancarlo C. Righini, CNR, Italy
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 Glas, Germany
         Jong Heo, Pohang Univ., Korea
         Daniel Hewak, Southampton Univ., UK
         Animesh Jha, Univ. of Leeds, UK
         Shibin Jiang, AdValue Photonics Inc, USA
         Peter Kazansky, Southampton Univ., UK
         Yasutake Ohishi, Toyota Technological Institute, Japan
         Guodong Qian, Zhejiang Univ, PRC
         Kathleen Richardson, Clemson Univ., USA
         Naoki Sugimoto, AGC America, USA
         Hisayoshi Toratani, Hoya Corporation, Japan
         V P Veiko, St Petersburg Inst of Prec Mech & Optics, Russia
         X. Zhang, Univ. of Rennes, France

SUMMARY
The year 2010 is the 50th anniversary of LASER invention, which impacts the present optoelectronics, the coming 2011 that of the first “Glass Laser” of Nd-doped silicate. TC20 focuses on optoelectronic glasses and also on New materials for Lighting and Solar Energy in addition to the present activities.

We had a business meeting on 20 September 2010 at Salvador, Brazil, where ICG2010 was held. We also organized and met at during the 3rd International Workshop on Photoluminescence on Rare Earth: Photonic Materials and Devices (PRE’10) during April 29 and 30th at Firenze, Italy. Many of TC20 members contributed to the organization of the workshop.
PLANS AND DELIVERABLES FOR 2010

ACTIVITIES in 2010

4.5 Meeting

As the third organization of a successful series since 2005 for every other year, we held the 3rd Workshop of PRE10 in Firenze on April 29 and 30. G.Righini, our vice chair, headed the organization, S.Tanabe cochairing and many members also cooperated as co-organizers.

Topics discussed there included:
- fundamental photoluminescence properties & spectroscopic measurements
- modeling, first-principles calculations, etc.
- rare-earth doped amorphous materials
- rare-earth doped glass-ceramic materials
- rare-earth-doped crystalline materials
- rare-earth optical amplifiers and lasers
- application-oriented materials investigations
- photonic and photovoltaic devices exploiting rare-earths’ characteristics.

Many of TC20 members were involved either as chairs (G.Righini, S.Tanabe) or as committee (J.Ballato, Y.Ohishi, J.Heo, S.Jiang, A.Jha), as well as other TC members of ICG such as R.Almeida (Chair of TC16) and Alicia Duran (CTC).

The next workshop PRE’12 will be organized by S.Tanabe in Kyoto during March 27-29 in 2012, which is the 5th continuing this good tradition.

Publication Activity in 2010:

The proceeding of the PRE’10 was published in December of the same year as a special issue of Optical Materials journal with the great effort and contribution of G.Righini.

This issue contains selected papers presented at the PRE’10, giving the broad spectrum of state-of-the-art on Photonic Materials.
PLANS FOR 2011 AND DELIVERABLE

In 2011 we will meet in mid July at Cairns, Australia, where the 9th PacRim Ceramics 2011 will be held. Kathleen Richardson is preparing organization of Symposium 22. Many of us will contribute to the glass symposium.

As for the Annual meeting of ICG2011 in March, that Jianrong Qiu is organizing at Shenzhen, some of the TC20 members are giving invited talks there, based on their excellent research activities.

In 2012, S. Tanabe is preparing the 5th PRE’12 workshop.

As research activities, TC20 focuses materials for “Green Photonics”.
In the next five years: The following research topics will be expected.

Glass Ceramic Phosphors for Solid-state Lighting
New glasses and fibers for fiber lasers and nonlinear optics,
New materials and process for infrared imaging and sensing.
Optical computing becoming more practical based on new materials.
Materials for solar cells show revolutionary increase in efficiency.

TC20 will focus also on New Materials for Lighting and Solar Energy in addition to the present activities.

PUBLICATIONS AND OTHER CONTRIBUTIONS


RCAPT in TTI succeeded in second and third harmonics and flattened supercontinuum generations in tellurite photonic crystal fibers for the first time.


**PbS Quantum Dots Controlled by Ag Nanoparticles in Glasses**

- **Microstructure and composition**: PbS:AgNPs glass shows a homogeneous distribution of PbS QDs and AgNPs.
- **Formation process**: PbS:AgNPs glasses form by a simple solution process.
- **Advantages**: PbS:AgNPs glasses exhibit high optical and magnetic properties.

- **Summary**:
  1. PbS QDs formed in glasses by co-exchanged process.
  2. PbS QDs precipitated in glasses by co-exchanged AgNPs.
  3. AgNPs can control the size of PbS QDs in glasses.
4.6 R&D Activity Field “Information, Education and History”

4.6.1 INFORMATION AND COMMUNICATIONS (TC01)

Chairman: Dr J M Parker, the University of Sheffield, UK
Secretary: Mrs E Flygt, Glafo, Sweden
Members: Dr K Bange, Schott, Germany
Mrs I Debaisieux, St Gobain, France
Dr J Vitkala, Tamglas, Finland

SUMMARY

This year has been unusually busy with the publication of two important new volumes, numerous press releases, and changes in the web site, particularly organising a move to a new host. All these have taken place alongside the day-to-day tasks of production of CTC minutes and maintaining lists of committee members. TC01 has also linked with TC23 to run a second student workshop in Montpellier.

PLANS AND DELIVERABLES FOR 2010

The main deliverables of TC01 in 2010 have been:

- Continuing revision and updating of the ICG and EFONGA Web sites
- Revision of the leaflet listing ICG officers
- Assisted in the 2nd Student workshop in Montpellier with TC23
- Minutes of CTC meetings
- The editing of News Briefs
- Assisting in the publication of two new ICG volumes

ACTIVITIES in 2010

Publicity remains a core activity of TC01 and has been assisted by the preparation of informative Press releases by members of the CTC and Steering Committees. The contributions of Klaus Bange are particularly acknowledged. Another aspect of publicity is the ICG web site. The quantity of data downloaded on a monthly basis from the web site is shown in Figure 1; it continues to expand rapidly increasing by 40% per annum over each of the last 5 years. However the number of individual visits during the last year has remained fairly static this year at 17000, with just over 11000 unique visitors but with fewer pages viewed than in 2009. These figures exclude visits by search engines.

A major project started this year has been to transfer the host for the web site from the University of Sheffield to a commercial organisation which will help with the web design. These new web pages will become live in early 2011 and will give greater
freedom in allowing editing by several different users of the system. Being a content managed system it will also require less proficiency in web design by the users. The statistical information available should also improve. The host site will be a secure web server in London with a reputation for uninterrupted service.

The currency of the leaflet listing ICG officers has been maintained and copies are now available for download from the website. Updating of the database of members though is still a task in hand.

Discussions have continued within the Steering Committee on the corporate image and particularly the ICG logo. Thanks to the work of Lucien Belmont and his team a new logo is now agreed together with instructions on its use. This will be available shortly for download from the ICG web pages.

A major activity this year was the 3rd edition of the ICG history book ‘Winds of Change’. The previous versions required digitisation as well as extensive updating. The task was undertaken jointly with the new Editorial Board sub committee within the Steering Committee and Prof A Duran made a major contribution by collating the photographic information and liaising with printers based in Madrid. The published text was distributed at the ICG 2010 Congress in Salvador, Brazil.

At the same time Dr K Bange with Prof M Weissenberger-Eibl produced a book entitled “Making Glass Better: an ICG roadmap with a 25 year Glass R&D horizon”. This was based in part on the output from the four year long EFONGA project that finished in 2009. The ICG editorial board assisted in the production of this text.

PUBLICATIONS AND OTHER CONTRIBUTIONS

- ICG Web site
- ICG Officers leaflet
- Preparation of minutes for the CTC
- Various news items relating to annual conferences and other significant activities, with the Editorial Committee
- ICG Winds of Change History Book prepared for the ICG Congress in Brazil
- Assisted in the preparation of the ICG Roadmapping book “Making Glass Better” written by Dr K Bange with Prof M Weissenberger-Eibl

KEY PLANS FOR 2011 AND DELIVERABLES

Specific goals for TC01 during the next year include:
1) Transfer the ICG Web site to its new host and improve content
2) Encourage and support more TCs to produce their own web pages, e.g. by introducing standardised formats and data management systems
3) Set up a system to allow regular updating of ICG History text
4) Generate and assist with editing Press Releases on key ICG success stories
5) Minutes of CTC meetings
6) Produce an ICG entry for the Wikipedia web pages
4.6.2 EDUCATION & TRAINING (TC23)

Chairman: 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
            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

Applicants: N. Papadopoulos, Greece; Candida, Brazil

SUMMARY
As in 2009, the main focus of activities during the year 2010 was the organization and support of workshops, among which were the Montpellier Student Workshop 2010, and the Workshop on Glass Surfaces as part of the “Clear as Glass” series, held during the ESG meeting in Magdeburg, Germany on 1 June. Prof. Duran continued the development of an International Training Team but had found the recruitment of younger academics and people from industry difficult. Additionally, plans include the generation of a new format for the ICG Book List, and a compilation of available courses on glass. TC23 met in Salvador jointly with TC01 on 20th September.

PLANS AND DELIVERABLES FOR 2010
Activities for 2010 almost entirely focused on the successful organization and realization of different workshops and tutorials. The deliverables, beyond the immediate impact of the events themselves, consist in the lecture slides - and in some cases in full texts - of the individual courses and workshops that are available for download.

ACTIVITIES IN 2010
Membership review
Committee membership was reviewed and a core team defined. Dr R Hand (Sheffield) expressed an interest in joining the committee while Profs Richardson and Beerkens wished to attend meetings as regular guests. Representatives from other key countries are being sought.

Montpellier Student Workshop 2010
A second Montpellier Student Workshop was organized by TC23, specifically Prof Conradt, Prof J Parker and Prof B Hehlen, who made the local arrangements. The workshop, like the previous event, was motivated by the idea to establish an international network among future glass scientists and technologists by exposing them to a series of attractive and excellent lectures and giving them ample opportunity to interact both academically and socially. This year no EFONGA funding was available so
the event had to be self supporting. A contribution to the costs from the Languedoc-Roussillon Regional Council and from the University Montpellier 2 helped to maintain fees at a low level and we thank these sponsors for their support, and Profs Vacher and Hehlen for making the applications.

Lectures were given by 9 academics, including 4 from the University of Montpellier. In spite of the charge for accommodation and a small conference fee the event was still able to attract 26 young people from 10 different European Countries, Canada, USA, India, Japan and Thailand. The programme was run over an extended period of 5 days from 26-30th July and under the general title: ‘Glass: the fourth state of matter?’ Lectures were more focused than for the first summer school, in response to comments made by the students and lecturers, with specific themes on: ‘the glass transition’, ‘crystallisation’ and ‘glass surfaces’. On the first day all the students attending gave a short presentation of their own research interests by way of introduction. On subsequent afternoons they were divided into groups of 5 and given tasks to solve, with a presentation of their results on the final day of the workshop. The lecture slides for the 2nd Montpellier Workshop are available for free download. To access these please contact Prof J M Parker: j.m.parker@sheffield.ac.uk.

The organizing committee decided to hold future workshops at the same location, thus establishing the “Montpellier Student Workshop” as a regular international event with a hopefully wide recognition.

ICG Tutorial “Clear as Glass” on the Glass Surface, Magdeburg 2010
This event was the fourth one in an ongoing series. The series is motivated by the idea to attract more young people to national and international conferences on glass and to integrate them within the glass community. The 2010 tutorial concentrated on the Optical, Mechanical, Chemical, Biological Aspects of Glass Surfaces and was attended by approximately 50 conference delegates, not all being students as was the case - and the intention - the previous year in Vancouver. It was run as an afternoon session on 1st June during the ESG conference held in Magdeburg, Germany. Lecture slides are available for free download. For further information, please contact http://www.hvg-dgg.de/en/.
Other courses

A further student workshop was held in Cambridge, UK on ‘Characterisation Techniques’.

An internet course focusing on Glass Relaxation ran for the first time in 2010 and was supported by members of TC23. 50 to 70 students participated in both the USA and Europe with 15 students completing the set exercises, submitting homework, and passing a written final exam for formal assessment. TC23 will consider ways of making this more widely available. A total of 20 lectures (2 x 45 min each; slides with oral instruction online) are available for free download at:

As reported by Prof Richardson, previous courses held under the same format within the USA. are also available for free download (see, e.g., the course under the above website, GlassPropertiesCourse.htm). The internet courses are motivated by the fact that at most universities the number of academic teachers and students devoted to glass science and technology hardly ever reach a “critical mass” which justifies the local organization of an extended number of highly specialized courses on glass.

Glass course database

The development of a database on available courses in Glass Science and Technology is in progress. Prof Conradt tabled an initial document to be completed for every institution offering appropriate teaching. He proposed that the information required should include:

- Profile of organising institution
- Course language
- (A thesis list MSc, PhD)
- Course level (e.g. pregraduate, postgraduate, postdoc)
- Email address
- (Thesis list MSc, PhD)
- Institution’s web link

TC23 members have been asked to contact their NPOs and universities in neighbouring countries to initiate the process of collecting data.

PLANS FOR 2011 AND DELIVERABLES

The present TC23 members agreed to continue organizing workshops in the future with a high priority. Thus, for the year 2010, the following events are planned:

- a third Montpellier Student Workshop, 04-08th July 2011,
- another „Clear as Glass“ Workshop, at the next DGG Annual Conference in Saarbrücken, Germany, 21st June 2011.

Collection and collation of information on glass related courses at undergraduate and postgraduate level throughout the world.

TC23 also intends to update the Books website and produce a list of recommended reading for students taking undergraduate and postgraduate courses.

PUBLICATIONS AND OTHER CONTRIBUTIONS

The lecture slides for the 2nd Montpellier Workshop are available for download using the GoogleDocs shared drive facility. To access these please contact Prof J M Parker: j.m.parker@sheffield.ac.uk
The lecture slides for the „Clear as Glass“ tutorial held at the ESG conference in Magdeburg, Germany, are available for free download. For further information, please contact http://www.hvg-dgg.de/en/.

Joint Meeting of TC23 and TC01 at the ICG Annual Meeting 2010 in Salvador, Brazil; from left to right:
R Conradt, M Liska, R Hand, A Duran, A Helebrant, H Inoue, A Claire, J Parker

The Committee at Work
SHORT REPORT FROM THE 93rd MEETING IN VÄXJÖ ON APRIL 8-9, 2010

1 Opening, welcome and response
Dr Sundberg welcomed us to the Glass Research Institute (Glafo) in Växjö and Mr Jamieson our chairman opened the meeting.

Dr Pascal Marque of Corning S.A.S (Avon, France) a characterization specialist using XRD and XRF participated for the first time. He gave a short introduction to his work at Corning and all members present replied briefly about their current activities.

2 Membership
Present at the meeting were 10 members and one guest. Two guests were communicated via telecom for discussions on dolomite / paragraph 9.1
Members present were Mrs C Strubel, Dr J Simons, Mr Jean-Marc Carpentier, Mr S Jamieson, Dr Mrs Tepiwan Jitwatcharakomal, Dr P Sundberg, Mrs I Lesieur, Mrs M Scarpa, Dr D Michiels, Dr S Smolders. Dr Pascal Marque was an invited guest in replacement of Dominique Brochot.
Guests participating via telephone links were Sam Leese and Ståle Pedersen (both of Sibelco).

Mrs Dr Maria Malheiro has taken up a new position as a liaison officer between industry and academia, and consequently she will leave our committee. Her active contribution to the committee will be missed by us all, but we hope for a new member from Saint Gobain Recherche in Paris.

Apologies for absence were received from Mr D Brochot, Mrs Dr M Malheiro, Mrs E Chorus, Dr R Eiden, Dr H Kipphardt, and Dr Leos Bauer.

Mr Stuart Jamieson our new chairman will familiarise himself with the formal requirements for membership in our committee. To fulfil their membership applications CV:s are requested from new members.

3 List of documents issued since the 91st meeting
A list of documents issued since last meeting was distributed at the meeting. A search function for these documents was requested for easy search of the documents, and Dr Sundberg accepted to investigate the capacity of SharePoint in this respect.
4 Report of the 92nd Meeting (doc No ICG/TC-2/09-1540)

The report from our 92nd meeting was distributed to members shortly after the meeting in November, as was an action sheet. The items included in the action sheet were followed up at the meeting, with the following comments:

- Main elemental composition of CRM BAM S005 - Report will be circulated by Dr Sundberg before the next meeting.

5. Matters arising from the Committee, not covered by this agenda

5.1 Mercury in glass

Mercury together with lead, cadmium and hexa-valent chromium is regulated in Directive 94/62/EC on packaging and packaging waste. A maximum level of 200 mg/kg for the sum of these elements is allowed at present. Of these four elements, mercury is normally not present in glass and special efforts are needed in order to retain any mercury in the glass melt. However in order to demonstrate the ability of an analytical technique to quantify the element in glass a reference material is needed.

Mrs Martina Scarpa described the preparation of a working standard with a high content of mercury. (document ICG/TC-2/10-1557) It was possible to prepare samples with up to 1 mg/kg of mercury. During the melting stage to produce the soda-lime-silicate matrix containing mercury, more than 99 % of added mercury was lost.

Dr Sundberg presented the revised document with the outcome of our collaborative work on mercury. The study involved the two samples melted in a previous campaign and distributed at our previous meeting in St Helens. A total number of seven laboratories participated in the collaboration with the two samples marked “Fusion 1” and “Fusion 2” respectively. Initially one laboratory mixed their results, but after re-analyzing the two samples they could agree in their results with all other laboratories. The revised results - mean values and standard deviations are shown below

<table>
<thead>
<tr>
<th></th>
<th>Mean Value</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusion 1</td>
<td>0.90 mg/kg Hg</td>
<td>0.16 mg/kg Hg</td>
</tr>
<tr>
<td>Fusion 2</td>
<td>0.74 mg/kg Hg</td>
<td>0.11 mg/kg Hg</td>
</tr>
</tbody>
</table>

Dr Sjaak Smolders presented trials to quantify mercury in glass by XRF (document ICG/TC-2/10-1558) With long counting times and a chromium tube it was possible to quantify mercury in levels above 1 mg/kg in glass.

As a working standard is needed with a slightly higher mercury content, it was decided that we should try to produce a melt with a target in the range 1-2 mg/kg of mercury. This could be achieved by lowering the melting temperature. Mrs Scarpa kindly accepted to do this. Dr Smolders kindly accepted to mix and homogenise the material, in quantities up to 1 kg.


6.1 The ICG Coordinating Technical Committee

Our committee is now acting in a “Basic Science” cluster together with TC03 Basic Glass Science, TC10 Optical Properties and others. This cluster lead by Prof René Vacher comprises ten different committees with a focus on glass structure and glass properties.
The Co-ordination Technical Committee asked us to prepare a poster for the Brazil ICG conference in September.

The mission of our technical committee is now under revision by CTC. Therefore Prof Vacher was invited to discuss the future direction of our committee and the mission of our new cluster. Mr S Jamieson accepted to contact Prof Vacher before our next meeting.

Mr Jamieson showed the press release for the 2010 Summer School organised by ICG CTC.

6.2 ASTM proposals for new standards affecting the glass and solar industry

Mr S Jamieson informed about a newly formed committee in US on solar glass applications. Following a workshop in April 2008 held by US Department of Energy, on how the glass and solar industries could best meet each other’s needs, one outcome was to develop solar glass standards as a beneficial for the market role. The standards should set the norms for transmission, strength, coatings and other characteristics, so that glass could be taken from any supplier. ASTM was consulted and initiated the formation of a new committee. This new ASTM committee E44.20 on Glass for Solar Applications was formed September 29, 2009. Participating in this meeting were representatives from ASTM committees E44 on Solar, Geothermal and Other alternative Energy Sources and from C14 on Glass and Glass Products. The potential topics that could be covered by this committee include:

- Glass - strength, characteristics and composition (as iron content)
- Coatings - silver coatings, reflective antireflective
- Film quality - coatings specifications thickness, optical properties
- Durability and reliability - mechanical properties, longevity of structure

BAS - Bureau of Analysed Samples - is initiating collaboration on low iron float glass for solar applications. Mr S Jamieson is on their steering committee. In addition to chemical analysis, Mr Jamieson suggested to contact ICG / TC10 Optical Properties to see if they could be involved.

6.3 C-S-N in AZS by a range of analytical techniques

Following collaboration with Dr Kopsel on traces of carbon, nitrogen and sulphur in refractory material at ppm (mg/kg) levels such techniques are investigated. Techniques like LECO’s system, Glow discharge mass spectrometry (GDMS), SIMS / TOF / SIMS and possibly other techniques can be used.

The Glow discharge mass spectrometry seems to be a technique with good detection limits for these three elements. The results for nitrogen are worth pursuing as these are much higher than the other elements.

Results from three laboratories were compiled during our meeting in Mainz. More results are expected from Maria Malheiro and Stuart Jamieson.

7 Publications in progress

In the February issue of 2010 of Glass Technology European Journal of Glass Science and Technology Part A - our report on the Surface Ablation Cell - SAC - was published. This is the first part describing the technique. In a second part by GLAFO in collaboration with
Mr Stefan Karlsson, Vaxjo University (SE) the technique is used to study ion diffusion in float glass. See section 8.1 below.

8 Oral presentations

8.1 Ion exchange processes on float glass surfaces by SAC (Mr S Karlsson, Linneaus Univ).

Mr Stefan Karlsson presented his results obtained during his post graduate studies at Linneaus University using the surface ablation cell - SAC - to determine ion diffusion coefficients in float glass. One part of this project could be used to strengthen float glass around holes for example. This work is accepted for publication in Glass Technology European Journal of Glass Science and Technology Part A.

8.2 Chemical characterisation of recycled glass - from sampling to XRF (Dr S Smolders)

Dr Sjaak Smolders outlined the process of characterising foreign glass cullet by XRF. Cullet is now a valuable raw material used in many products. The recycled CRT-glass goes back to factories in the Far East. Recycled container glass and flat glass are used in products like glass wool and various other applications like pearls, tiles and glass decorations.

The sampling procedure started from a lot of about 100kg and by homogenising and division by quartering reduced down to 400gram samples. Four samples, each consisting of 400g coarse cullet were taken to the laboratory for composition analysis. After reducing cullet size and splitting down to 15 gram portions, these were analysed by fused bead XRF. The work was published in Glass Technology European Journal of Glass Science and Technology Part A in February 2010 under the title “Chemical characterisation of recycling glass. From sampling to analysis by X-Ray Fluorescence analysis”. Authors J Smolders and P Krystek.

9 Results from collaborative investigations

9.1 Iron determination in dolomite - Sibelco Samples A, B and C.

For discussions under this item we had telephone contact with Sam Leese and Stale Pedersen of Sibelco. Their Company kindly distributed three dolomite samples, Dolomite A, B and C respectively during March 2010. Stale Pedersen is their Glass Application Manager. Unfortunately this was too late for most members to determine the iron content in the samples. The final date for submitting the results were set to end of June 2010.

It was agreed to investigate how the analytical procedure affected the outcome of iron determinations in dolomite. During our previous meeting Mr Jamieson showed that the outcome of the iron determination depended upon the technique used. In order to investigate this discrepancy it was further suggested to use MAS decomposition also for the quantification by AAS / ICP. It was decided that laboratories could use their routine methods for this assessment.


No more results are expected and a summary will be prepared.
9.3 **Proficiency test of vitreous ceramic Novatek DB2009-1**

Unacceptable high deviations were observed for some elements, notably sodium and potassium. More results expected before a report can be prepared.

9.4 **Total sulphur and sulphide sulphur determination in yellow glass - 2010 update.**

A “yellow glass” with a high proportion of sulphide / sulphur was distributed in early 2008 for the determination of sulphide sulphur and total sulphur. The following members are participating in the study: Mr Brochot / Mr Pradeau, Dr Sundberg, Mrs Chorus, Dr Mrs Malheiro, Mrs Scarpa, Mrs Strubel, Dr Simons / Mr Carpentier, Dr Smolders, Mr Jamieson and Mrs Kerestecioglu.

In the first round presented in October 2008, 11 sets of results for total sulphur, and 7 sets of results for sulphide / sulphur were received from participating laboratories. A table with the results were compiled (doc no ICG/TC2/08-1475). The high standard deviation of the results called for actions, and it was decided to repeat the exercise using two selected methods.

1. For quantification of total-sulphur and sulphide sulphur ICP-OES was suggested. The dissolution was completed with either HCl/HF or HCl/HF/Br\textsubscript{2} depending upon the sulphur species to quantify. Dr Simons kindly translated the method from a sulphide determination in the refractory materials according to EN-1744-1. (Doc ICG/TC-2/09-1516). The addition of bromine water should be done in excess.

2. For quantification of sulphide sulphur a titration method using a sulphide Ion Specific Electrode (ISE) to find the titration end-point was used. The method was obtained from Dr Bauer. (Doc ICG/TC-2/09-1525).

Only three more sets were obtained and an updated table with results were compiled (doc no ICG/TC-2/09-1475-update). However no evaluation was completed due to the low number of new results. It was decided to wait for more results.

10 **New Topics**

10.1 **Glasses with high fluoride content.**
Mrs Strubel proposed to study fluoride determination in high fluoride optical glasses. Today this is done by pyro-hydrolysis or XRF. The proposal for a new topic was accepted by the committee and Mrs Strubel informed that samples were available from Schott.

10.2 **Additional new topics**

In addition to suggestions listed below, Mrs I Lesieur suggested a work on viscosity measurements and agreed to prepare a proposal for our next meeting.

New topics suggested recently:
Glasses with increased durability (Mrs Dr Tepiwan Jitwatcharakomal)
Collaboration with DGG on sand calibration for XRF with impurities of Fe-Al-Ti-K-Mg. (Mrs Elke Chorus)
Arsenic determination in pharmaceutical containers (Dr Peter Sundberg).
Next meeting will be held in Eindhoven on October 21 and 22 2010 by the kind invitation from MiPlaza Materials Analysis.

Dr Mrs Tepiwan Jitwatcharakomal invited us to Thailand for our 2012 spring meeting.


INTERNATIONAL COMMISSION ON GLASS
A SOCIETY OF SCIENTIFIC AND TECHNICAL ORGANISATIONS
TC 2 - Technical Committee 2

REPORT FROM THE 94th MEETING IN EINDHOVEN ON OCTOBER 21-22, 2010

4.6.3 1 Opening, welcome and response
Our chairman, Mr Stuart Jamieson, opened the meeting, and thanked the organisers for the invitation to Eindhoven.

The head of the MiPlaza Material Analysis Division - Dr Hans Damsteegt - welcomed us to the “High Tech Campus” in Eindhoven and briefly informed us of the history of Royal Philips Electronics and the developments in recent years to a more open company. Founded in 1891, the company started their business in Eindhoven with the production of light bulbs. Today it is a global company with 100 000 employees, organised in three major divisions, with a focus on Health Care and Lighting.

Their glass expertise is now also available for external customers as part of their “Open Innovation” approach. 1600 people work in the Philips Research division with laboratories worldwide. The MiPlaza Material Analysis department in Eindhoven is the largest within the company. The central facilities are well equipped with many specialized instruments and a broad competence, including specialists in the identification of glass defects and problems associated with the glass melting process.

The meeting started with brief presentations of all participants around the table.

2 Membership
Present at the meeting were 12 members and one guest. Members present were Mrs Christine Strubel, Mrs Ayse Kerestecioglu, Dr José Simons, Mr Stuart Jamieson, Dr Peter Sundberg, Mrs Martina Scarpa, Dr Dominique Michiels, Dr Sjaak Smolders, Dr Philippe Pradeau, Mr Daniel Capon, Mr Sam Leese, and Dr Mrs Sylvie Abensour.

Dr Abensour is a new member representing Saint-Gobain Recherche in Paris. Dr Abensour is new to the position of laboratory manager, but has long experience in the glass field. Present as a guest was Dr Mrs Petra Krystek - head of the analytical section of MiPlaza. Dr Krystek specialises in ICP-OES and ICP-MS techniques.
Apologies for absence were received from Mrs Elke Chorus, Mrs Isabelle Lesieur, Dr Ralf Eiden, Dr Heinrich Kipphardt, Dr Mrs Tepiwan Jitwatcharakomai and Dr Leos Bauer.

3  List of documents issued since the 93rd meeting
A list of documents issued since last meeting was distributed at the meeting. The list covered the documents from ICG/TC-2/10-1540 to ICG/TC-2/10-1566.

4  Report of the 93rd Meeting (doc No ICG/TC-2/10-1566)
The report from our 93rd meeting in Växjö was distributed to members at the meeting.

5. Report of the Members-Liaisons with other Committees.
5.1  Report from ICG-CTC (Coordinating Technical Committees)
Mr Stuart Jamieson presented a press-release from the ICG-CTC distributed earlier this year. The press-release presents a new report with the title “Making glass better”, that is outlining the future of the European Glass Sector. The report is a road-map and forecasts the use of glass in combination with other materials. A copy of the press-release will be distributed within our committee. The road-map is also available from the ICG website.

In order to improve co-operation between the technical committees of ICG, new cluster groupings were announced. Our committee is now forming a tri-cluster with TC10 “Optical Properties” and TC19 “Glass Surfaces”, under the generic theme “Glass characterization”. Mr Jamieson was not sure how it will affect our work, but we will try to receive information from our cluster chairman, Prof. René Vacher, before our next meeting.

All Technical Committees of ICG were asked to prepare posters for the annual conference, that this year was held in Brazil. As no TC02 member was available to attend the meeting, Mr Jamieson approached CTC several times for more information or instructions about the poster format, poster size, printing and where to send it, etc. We received no further information and consequently were unable to send our poster to the meeting. Some comments in general terms were received from Prof. Vacher, due to the absence of posters at the recent ICG conference in Brazil.

5.2  Collaborations with other technical committees of ICG
A study on flat glass - more specifically low iron rolled PV glass - was initiated by TC13 “Environmental issues” to provide information regarding the CEN TC351 and the Construction Products Directive.

The study focuses on leaching of antimony from these glasses. Five different glasses from different glass manufactures were collected centrally and distributed to the participating laboratories. Several members in our committee are participating in the study. The leaching parameters were taken from the Dutch national standard method “EA NEN 7375:2004 - Leaching characteristics of moulded or monolithic building and waste materials - Determination of leaching of inorganic components with the diffusion test”.

Mr S Jamieson reported from setting up the test at NSG Technology Centre (doc. ICG/TC02/10-1568). Most of the glass plate is covered in wax, and only one face is
exposed to the leaching media. The leaching takes place in deionised water at room temperature, and the solution is replaced regularly. The full test takes 64 days in the deionised water. The leachate is analyzed with respect to pH, conductivity and quantitatively also for traces of antimony. The leaching tests are currently running in participating laboratories. A full report from TC13 is expected before our next meeting in April/May 2011.

6. Collaborative work initiated at earlier meetings

6.1 Evaluation of Glass Ceramics “Novatek”

Preliminary results were discussed at our previous meeting and a preliminary report was distributed in August to participants. Since then, two more participants joined the study and these results are now included in an updated result sheet. (ICG/TC02/10-1550 - version 4)

In the study 16 laboratories participated representing 12 different organisations, of which only two produce glass ceramics. It was observed that many results from the two organisations producing glass ceramics (i) often were very close to each other; and (ii) their results often appeared in the centre of the distribution of results. In many cases these results were close to the consensus values.

Unacceptable high deviations were observed for some elements, notably sodium and potassium. For sodium - for example - the results ranged from 0.47 to 1.14 % Na2O on the same sample!

The laboratory reporting the highest values used atomic absorption, whilst the lowest value was obtained by XRF. For XRF it was proposed that the zinc level could interfere, and another analytical technique was suggested. The laboratory reporting the highest value, did not remove the decorations on the sample prior to grinding. As this could influence the outcome, the laboratory kindly agreed to repeat the sodium quantification after removing the decorations mechanically. The importance of matching acids and matrix for the atomic absorption technique was stressed.

One laboratory (Lab 6a) reported often high/low values and many were considered to be outliers. It was reported that the laboratory used the XRF in a semi-quantitative mode without a proper calibration. Dr Smolders suggested that the lab should set up a proper calibration for the instrument using lithium tetraborate beads after an initial semi-quantitative test. This approach takes a lot of time, but is required as no glass ceramic reference materials are available. Calibration should preferably be based on selected CRM's matching the concentration ranges of the sample. This needs to be done using lithium tetraborate beads and apply matrix corrections, as so many different CRM's are used in the calibrations.

A report will be circulated for comments. Dr Sundberg said that a draft report will be prepared before the end of this year, including the outcome of the test initiated above on sodium.

6.2 Mercury content in glass

Mercury - together with lead, cadmium and hexa-valent chromium - is regulated in Directive 94/62/EC on packaging and packaging waste. A maximum level of 200 mg/kg for the sum of all four elements is currently allowed. Of these four elements, mercury is
normally not present in glass and special efforts are needed in order to retain any mercury in the glass melt. It was noted that more than 99.9% of added mercury was lost during the melting stage. However, in order to demonstrate the ability of an analytical technique to quantify the element in glass, two samples were prepared and distributed by Mrs Scarpa in April 2009.

Seven laboratories took part in the study. A draft report was distributed prior to our meeting asking for comments. The received comments are included in document ICG/TC02/10-1563 - dated October 14, 2010. The report also contains the revised results. The final results are:
Fusion 1: 0.90 (Std dev 0,14) mg/kg Hg and Fusion 2: 0.74 (Std dev 0,11) mg/kg Hg.

This study showed a homogenous sample could be prepared and the techniques for mercury determination in our laboratories are of a high standard.

The samples used in the inter-comparison were only prepared in a small amount and are not available for distribution any longer. However, as there is a need for reference materials with mercury - or at least a working standard - another candidate material was prepared. A new glass sample was prepared by Mrs M Scarpa and kindly ground, homogenized and sieved by Dr S Smolders. 650 gram of this ground sieved sample is now available for use as a candidate material to a CRM or a working standard. Contacts will be taken with BAM and other institutions to see if it can be certified. The sample is now stored at Stazione Sperimentale del Vetro (SSdV) under the supervision of Mrs Scarpa. Its level of mercury is around 1 mg/kg.

Due to heavy workload in the melting department of SSdV, they were not able to attempt for a glass melt with higher mercury content. It is not clear if more attempts will be made for a glass with higher mercury content.

6.3 Determination of Iron in Dolomites A, B and C

This study was initiated following observed discrepancies of low iron determination in dolomite due to sample origin. It was previously shown by Mr Jamieson, that the differences vary with the origin of the samples i.e. sometimes negative bias, sometime positive bias. This may be due to different mineralogical forms of iron oxides present in these minerals.

In order to investigate this discrepancy, three different dolomite samples were distributed for a round robin excersise. The samples were kindly distributed by Mr Sam Leese to participating members. The following members accepted to participate in this study: Mrs Strubel, Mr Simons/Carpentier, Mrs Chorus, Mr Jamieson, Mrs Tepiwan Jitwatcharakomal, Mr Sundberg, Mrs Lesieur, Mrs Scarpa, Dr Michiels, Mr Smolders, Dr Mrs Malheiro, Mrs Kerestecioglu, and Mr Pradeau. Members not present were also invited to participate.

It was agreed laboratories could use their routine methods for this initial assessment. It was further decided to also investigate the influence of analytical techniques. In doing so, it was suggested to use the same decomposition solution for all wet chemistry quantification techniques.

Dr Sundberg showed a compilation of all results received so far. A preliminary draft was distributed as document number ICG/TC02/10-1562. In general terms the outcome of the study was acceptable, as shown in table 1. With a level of about 100 mg/kg an
acceptable spread in this kind of round robin is around 10 ppm. It was noticed that the outcome depended more on the decomposition technique - and not so much on the quantification technique.

While samples A and C had similar spread in their results; both in shape and in reported standard deviation, sample B seemed to indicate at least two different levels of iron (Fig. 1). For the purpose of identifying inhomogeneous samples, it was decided two laboratories should exchange samples. Laboratory 4 (highest result) kindly accepted to analyse the iron content in the sub-sample analysed in laboratory 14 (lowest results).

<table>
<thead>
<tr>
<th>Dolomite ID</th>
<th>mg/kg Fe2O3</th>
<th>Conclusions:</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Germany</td>
<td>72</td>
<td>Homogenous sample</td>
<td>Sample exchange between high &amp; low laboratories.</td>
</tr>
<tr>
<td>B: Asia</td>
<td>66</td>
<td>Sample not homogenous (?)</td>
<td></td>
</tr>
<tr>
<td>C: Spain</td>
<td>95</td>
<td>Homogenous sample</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Outcome of collaboration on iron quantification in dolomite.

Decompositions without fusing the residue - i.e. with only acidic decomposition - gave in many cases low results. This was especially true for sample B.

Within this collaboration some laboratories applied different quantification techniques to the same decomposition solution. This compilation had not been completed before the meeting, but the general picture was the different quantification techniques gave more or less identical results. This strengthened the conclusion that the outcome depended on the decomposition technique.

Mr Jamieson said although the dolomite samples investigated here gave the same results with different means of quantification, this was not always the case in their laboratory. For that purpose contacts had been taken with a local university to study the iron valence states in similar materials by Mössbauer spectroscopy. Mr Jamieson kindly agreed to report the outcome of the study at our next meeting. This material is available if we should need to do additional testing on the material.
Mr Leese kindly accepted to make a similar investigation on the undissolved residues from dolomites A, B and C, also using Mössbauer spectroscopy and but also other petrographic methods if available. Furthermore, Mr Leese kindly suggested investigating the sampling protocol followed for the three samples. It was agreed these investigations should be completed before the end of January 2011.

It was decided to also include the sample weight in the evaluation process. Therefore, participants were kindly asked to submit this information to Dr Sundberg before end of November, 2010.

6.4 Update on low iron glass sand, LIS-2009

A report summarising the outcome of our proficiency test for a low iron sand LIS-2009 (document ICG/TC2/10-1562) was circulated prior to the meeting, as no more results are expected. Results from 21 laboratories, representing 12 organisations, were compiled into this report. The consensus value of iron in the sand lot was 61.9 mg/kg Fe₂O₃ - with a standard deviation of 3.1 mg/kg Fe₂O₃. This is an extremely good result, both the number of participants and also the low standard deviation.

Certificate of participation had been distributed to members after individual requests. Dr Sundberg promised to send this document to all participants.

Mr Leese informed the committee a single bag containing 1000 kg of this sand is still available and under the supervision of Dr D Michiels. With the impressive outcome of the proficiency test the sand lot ought to be put in use. Preferably, the sand could be certified and/or sold by an appropriate organisation. Mr Jamieson kindly agreed to ask SGT or The Bureau of Analysed Samples (BAS) for advice in this matter. *(Later: BAS is to investigate whether they are able to accept the material. BAS would have to undertake some analytical examination of the material to confirm homogeneity and iron content. There are no problems in accepting TC02's data; the issue is compliance against their own (and ISO17025) sampling and analysis protocols. The issue will also be discussed at the next SGT A+P Committee Meeting scheduled for 14/12/10.)*

6.5 CRM Sand standard BCS528 from BAS

Bureau of Analyzed Samples (BAS) - in cooperation with the Society of Glass Technology (SGT) Analysis and Properties Committee - are now working to replace an exhausted standard glass sand as part of their collection of glass related CRMs. Mr Jamieson informed the committee the certification campaign for BCS528 is in its final stage. All results are now reported to the organisers and the preliminary evaluation indicates the results are consistent and of high quality, i.e. low standard deviations. In total over 20 laboratories participated in this exercise, the majority being drawn from our own committee.

In the candidate reference material the following elements will be given certified levels of content: SiO₂, TiO₂, Al₂O₃, Fe₂O₃, Cr₂O₃, CaO, MgO, BaO, PbO, Na₂O, K₂O, and LOI.

The level of iron is about 1000 mg/kg as Fe₂O₃.

The approximate levels of MnO, Sn, P₂O₅ and ZrO₂ in the candidate material will be listed for information only.

Mr Jamieson showed briefly the certification report and a drafted certificate of the material. These documents will normally be distributed to the participating laboratories.
Once the campaign is completed. It was anticipated the certification work could be completed in November 2010, and the material will be available for sale from early 2011. (Later: BCS528 was signed off by The Honorary Advisory Committee for BAS on 4/11/10. The material will be released following acceptance by the Society of Glass Technology Council in December).

Mr Jamieson said the organising committee at BAS was pleased with the outcome. The Organisation was particularly pleased with the low spread in reported data when compared against previous round robins of this type. BAS would also like to pass on their thanks to all who participated in this valuable work programme and they look forward to working with us on future projects.

7. New collaborations

7.1 Glasses with high fluoride content

Mrs Strubel proposed a collaborative study on fluoride determination in high fluoride optical glasses. The proposal for a new topic was accepted by the committee at our previous meeting and Mrs Strubel brought glass samples to this meeting.

The following members accepted to participate: Mrs Kerestecioglu, Dr Simons, Mr Jamieson, Dr Sundberg, Mrs Scarpa, Dr Michiels, Dr Smolders, Dr Pradeau, Mr Capon, Mr Leese, Mrs Strubel and Mrs Dr Abensour.

Any other members wanting to participate are requested to contact Mrs Strubel directly for a sample.

The determination is currently done via pyro-hydrolysis or by XRF (!). In the wet chemical route, the final quantification step is done by titration, by ion-specific electrode (ISE) or by ion chromatography (IC). The most precise method is generally titration, but in the current method the end-point could be difficult to determine. In the past some disagreement between the methods has been observed. The sample is not based on a typical silica glass type composition but has the following approximate composition in terms of % by weight of the element indicated:

<table>
<thead>
<tr>
<th>Element</th>
<th>% by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>5-10</td>
</tr>
<tr>
<td>Ba</td>
<td>20</td>
</tr>
<tr>
<td>Ca</td>
<td>8</td>
</tr>
<tr>
<td>Mg</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Na</td>
<td>&lt;1</td>
</tr>
<tr>
<td>O</td>
<td>15-20</td>
</tr>
<tr>
<td>Sr</td>
<td>20</td>
</tr>
<tr>
<td>F</td>
<td>25</td>
</tr>
</tbody>
</table>

A circular letter will be prepared. It was decided that results should be submitted to Mrs Strubel with a copy to Dr Sundberg, before the end of February 2011.

7.2 New proficiency tests

The following four suggestions were made during our previous meeting in Växjö:

1. Mrs I Lesieur suggested then a work on viscosity measurements and agreed to prepare a proposal for such collaboration. Mr Jamieson kindly accepted to send a reminder as this topic was approved by all members present. (Later: IL emailed immediately after the Eindhoven meeting)

2. Mrs Dr Tepiwan Jitwatchararakomal suggested more work on glasses with increased durability, and agreed to prepare a proposal for such collaboration. Mr Jamieson
kindly accepted to send a reminder as this topic was approved by all members present. *(Later: TJ emailed immediately after the Eindhoven meeting).*

3. Mrs Elke Chorus suggested then collaboration with DGG on sand calibration for XRF with impurities of Fe-Al-Ti-K-Mg. Mrs Strubel kindly accepted to investigate the status of this investigation with the DGG committee involved. *(Later: CS has forwarded information to SNJ and PS)*

4. Dr Peter Sundberg suggested organising a collaborative work on Arsenic determination in pharmaceutical containers. For the purpose of the investigation the vials must contain some small amount of arsenic. Dr Sundberg kindly accepted to pursue this topic, and try to find suitable vials for testing.

8. Oral presentations

8.1 Bubble analysis (Mr. Joost den Brinker)

Mr. Joost den Brinker described the possibilities of MiPlaza to characterize gaseous inclusions and quantify its contents in glass samples. The dedicated mass spectrometer could be loaded with up to 64 samples before the analytical cycle is started - and this is often operated overnight. The section also supports external customers in this area.

8.2 Glass faults (Martien Hendriks)

Mr. Martien Hendriks described the possibilities of MiPlaza to help external customers in characterizing glass faults. The best way to identify glass ceramics was by SEM. Hexavalent chromium could be characterized by XPS.

9. Future Meetings

Next meeting - spring meeting of 2011 - will be held in Dessel / Belgium by the kind invitation from Sibelco. The date and other details will be provided by Mr Sam Leese after confirming with his company.

Our following meeting - fall meeting of 2011 - will be held in Venice by the kind invitation from Stazione Sperimentale del Vetro in Murano. More details will be provided by Mrs Martina Scarpa.

At our previous meeting, Dr Mrs Tepiwan Jitwatcharakomai invited us to Thailand for our 2012 spring meeting.

10. A.O.B.

Mr. Jamieson passed on his thanks to Dr Sjaak Smolders and Dr Mrs. Petra Krystek for their hospitality at this meeting.

The Committee also thanked Dr Jose Simons for his longstanding support, expert commentary and outstanding contribution to the work of the TC02 committee and wished him well in his retirement.
International Commission on Glass Technical Committee  
TC 05-Nuclear and Hazardous Waste  
Vitrification

About TC05
- approved by the ICG Coordinating Technical Committee (CTC) and the Steering Committee (SC) in 2000  
- The vision is to establish a forum to present, discuss, and disseminate technical information on waste glass chemistry, vitrification processes, melt technologies, and waste glass environmental performance

Recent Accomplishments
- Organized the symposium Glass and Cermics for Nuclear and Hazardous Waste Treatment at the PacificSCIIDAO in Vancouver, Canada, 2009
- 17 papers were presented
- The papers were included in the Ceramic Transactions conference proceedings volume (Ceramics for Environmental and Energy Applications, Ceramic Transactions, Vol. 933, American Ceramic Society, Westerville, OH, 2010)
- The book "Advanced Materials for Advanced Nuclear Reactor" written by R. E. Bank, M. Ospina, and W. Li was recently published in Materials for Engineering, Vol. 3
- Organized the Special TC 05 Waste Forms and immobilization processes for nuclear and hazardous wastes at the ICG-International Congress on Glass 2010 (ICO2010)
- 16 papers were presented
- The papers were included in Proceedings of the ICO2010
- Round-Robin testing was coordinated by Brian Riley at Pacific Northwest National Laboratory for development of an ASTM procedure on liquidus temperature (T_L) for simulated and non-simulated waste ashes.
- Three different testing methods were employed: a Gradient Temperature Furnace Method (GTF), a Uniform Temperature Furnace Method (UTF), and a Crystal Fraction Extrapolation Method (CFE)
- Three glasses were studied: ARG-2, Zr-6, and AMC-19
- Testing was conducted by 14 institutions from 9 countries including:
  - PNINL, Pacific Northwest National Laboratory (USA), B. Riley, J. Long, J. Crow, J. Verno
  - SNLNL, Savannah River National Laboratory (USA), P. Johnson, J. Marks, D. Peeler
  - Universidad de Medellin y Reggio Emilia (Italy), C. L. P. Lellis
  - XRLNL, National Health Laboratory - Data Solutions (USA), R. Short, M. Hodgen
  - BNL, National Institute of Standards (USA, B. Hand
  - CEA, Centre de Marneux (France), J. L. Jauchau, C. Nguyen
  - ICN, Institute of Chemical Technology (Czech Republic), M. Jelinek
  - VSL, Vrije State Laboratory (Belgium), A. Bischak, I. Popp
  - ESL, Idaho National Laboratory (USA), R. Schalke
  - Materials Laboratories, Inc. (USA), R. W. Kellogg

Committee Members
Chairman:
J. C. Marks, Savannah River National Laboratory, US

Vice-Chair:
E. DeAngelis, Areva, Inc. France

Secretary:
D. K. Pontel, Savannah River National Laboratory, US

Members:
A. Bontempi, Imperial College London, UK
T. Bovim, Oak Ridge National Laboratory, USA
D. Danilenko, Areva, Inc. USA
M. Drzal, Argonne National Laboratory, USA
C. Fink, Commissariat a l'Energie Atomique, France
R. Hand, University of Sheffield, UK
M. Harrison, National Nuclear Laboratory, UK
M. Kuramar, Slovak Academy of Science, Slovakia
W. Lee, Industrial Research Institute of Northern Ireland, UK
C. Lemel, University of Houston, Texas, USA
B. Monecke, New University of Liege, Belgium
M. Ospina, University of Sheffield, UK
M. J. Paraz, Ceramic and Glass Institute, Universitat, Spain
J. Kordylewski, Inst. S. de la Ceramica y Tecnologia de la Construccion, Spain
C. Resk, National Nuclear Laboratory, UK
J. J. Rosiak, Univ. Of Saskatchewan, Canada
P. Stachnik, Institute of Nuclear Energy, Poland
C. Voyer, Consultant, France
J. Wiehenn, Pacific Northwest National Laboratory, USA
S. Winterberger, Institute for Nuclear Energy, Germany

Contact: Dr. James Marks, Savannah River National Laboratory, USA; e-mail: jmarks@srnl.gov

Revised Temperature Round-Robin

Liquids Temperature Round-Robin

T_L is an important property for verifying proper processing of the molten technology or glass system being studied for waste immobilization. In waste glass processing, the product is known to exist in one of three states: undercooling, a melt, or a solid. The former state is produced by the introduction of a small amount of crystals, which are in contact, in the melt. The latter state is produced by a fast cooling of the melt. The crystals are then entrapped in the melt. The third state is produced by a slow cooling of the melt. The crystals are then embedded in the melt.

Summary of Results
The above results were all calculated using the O.S. and defined as "O.S." The O.S. represents the average of the results from the three laboratories. The O.S. was determined by the following equation: O.S. = (T_{L1} + T_{L2} + T_{L3}) / 3, where T_{L1}, T_{L2}, and T_{L3} are the results from the three laboratories. The O.S. was determined by the following equation: O.S. = (T_{L1} + T_{L2} + T_{L3}) / 3, where T_{L1}, T_{L2}, and T_{L3} are the results from the three laboratories.

Summary of Results
The above results were all calculated using the O.S. and defined as "O.S." The O.S. represents the average of the results from the three laboratories. The O.S. was determined by the following equation: O.S. = (T_{L1} + T_{L2} + T_{L3}) / 3, where T_{L1}, T_{L2}, and T_{L3} are the results from the three laboratories. The O.S. was determined by the following equation: O.S. = (T_{L1} + T_{L2} + T_{L3}) / 3, where T_{L1}, T_{L2}, and T_{L3} are the results from the three laboratories.
1. Introduction

We organized the TC07 meeting during the ICG2010. All the participants gave either oral or poster presentations in the Congress and during the business meeting. They deeply discussed the main points of interest on glass nucleation and crystallization and the development of novel or improved glass-ceramics. The following section will show the continuation of the strategy of the TC07 related to the following topics:

- new properties and new applications of multi-component glass-ceramics;
- fundamental studies of the kinetics mechanisms of nucleation and overall crystallization (e.g. surface versus internal crystallization).

2. Oral reports of the TC07 members

R. Müller, Germany

R. Müller reported on his close collaboration with the research groups of ED Zanotto and T. Komatsu. The main focus with E. Zanotto has been studies of cordierite and diopside crystallization based on surface nucleation and crystallization. The main results were demonstrated in a joint publication. With Komatsu’s group, research was focused on lithium iron phosphate glasses and their crystallization behaviour. The key was the control of LiFePO$_4$ crystal size and fraction.

G. Querel, France

G. Querel studied with his group the mechanisms of internal nucleation and crystallization in MgO-Al$_2$O$_3$-SiO$_2$ glasses containing ZrO$_2$. The most surprising effect was the analysis of the crystallization mechanism that was nucleation controlled, but not diffusion controlled.

A. de Pablos-Martin, Spain (guest), co-worker of TC07 member M.J. Pascual

This guest presented research on applied nanotechnology related to glass-ceramic formation. The main focus of their research program is the development of oxyfluoride glasses and the control of the crystal phase precipitation in nano-scale dimension. Here, collaborations with other groups, including TC07 member J. Deubener (and Prof. Rüssel, Germany) were very helpful.

R. Hill, UK

R. Hill studied and presented the crystallization of bioactive glasses with focus on fluorapatite precipitation. Based on the latest findings and previous studies he carried out, the bioactivity of Sr$^{2+}$ containing glasses is obvious. A new surprising effect is the discovery of bioactivity (to bond to living bone) of an Na$^+$-free glass. This result is a very good example of the necessity of fundamental research in combination of applied research in multi-component glasses.

J. Deubener, Germany

J. Deubener focused his research on a study of early crystallization phenomena in a commercial, low expansion, lithium aluminosilicate glass-ceramics. Three stages could be analysed in detail:

a) nucleation and interface controlled growth of crystals,
b) stagnation, that is no growth or nucleation happened,
c) coarsening process.
These studies helped Schott AG, Germany to control the mechanisms of this low expansion glass-ceramic formation.

A. Sakamoto, Japan
The main research of A. Sakamoto was focused on glass-ceramics with a possible application of a glass-ceramic on new Li-ion battery. The glass-ceramic should show a large surface area and the crystallization of LiFePO$_4$ is the main focus. Reactions including amorphous phase formation were studies. The project is a collaboration with T. Komatsu (also TC07). Here please see also the activities of R. Müller. All these research programs focus on a close collaboration between the TC07 members.

W. Höland, Liechtenstein
The collaboration of W. Höland with different TC07 members (J. Deubener, R. Müller) continues the studies on the relationship between microstructure formation and mechanical properties. At present the studies are focused on the base glasses of lithium disilicate, apatite and leucite glass-ceramics.
A second topic of his studies are the research on the origin and characterization of different surface crystallization mechanisms. Here the fundamental basis is given by some TC07 members (E. Zanotto, V. Fokin, R. Müller, J. Deubener).

**Summary:** Most of these research programs focus on a close collaboration between the TC07 members!

3. **Future activities and dates**
The members agreed to have the 2012 or 2013 crystallization conference in Germany. J. Deubener would like to organize this conference in Goslar.

**Minutes of the TC07 meeting in Corning, USA, May 19, 2010**

**Attendees:** M. Davis, T. Komatsu, and W. Höland. J. Deubener was ill and could not take part. The results of his work were presented and discussed by W. Höland.

1. **M. Davis, USA**
Mark’s current research activities are related to the development of electrically conductive glass-ceramics. His materials are derived from alkali-silicate and alkaline-earth silicate systems. Present activities are focused on the determination of several properties.
Comparison of lithium disilicate (Example 1 = “L2S”) +/- added silver +/- added sugar experiments: (a) denotes increase in conductivity in going from glassy L2S to fully crystalline L2S; (b) indicates that simply adding silver to the L2S composition has no effect on composition, nor does the furnace atmosphere; (c) shows that the addition of sugar as a reducing agent, particularly with a reducing furnace atmosphere, has a pronounced effect on the resulting conductivity.

2. T. KOMATSU, Japan

Komatsu focused some of his present research activities on the study of elastic and mechanical properties of glass-ceramics with nanocrystals. His results demonstrate a good comparison to the existing knowledge on multi-component glass-ceramics and the determination of mechanical parameters in correlation to the chemical nature and microstructure of the materials:

MICRO- AND NANO-SCALE DEFORMATION IN OPTICALLY TRANSPARENT GLASS-CERAMICS WITH FRESNOITE BA₂TISI₂O₈ NANOCRYSTALS

OPTICALLY TRANSPARENT GLASS-CERAMICS (COMPOSITION: 40BAO-20TI0₂-40SIO₂) CONSISTING OF NONLINEAR OPTICAL BA₂TISI₂O₈ (BTS) NANOCRYSTALS (DIAMETER: ~100 NM) WERE FABRICATED, AND THEIR ELASTIC AND MECHANICAL PROPERTIES WERE EXAMINED AS A FUNCTION OF THE VOLUME FRACTION OF BTS NANOCRYSTALS USING CUBE RESONANCE, VICKERS INDENTATION, AND BERKOVICH NANOINDENTATION (STANDARD-TYPE AND CONTINUOUS STIFFNESS MEASUREMENT (CSM-TYPE) IN ORDER TO CLARIFY MICRO- AND NANO-SCALE DEFORMATION BEHAVIOR IN GLASS/NANOCRYSTAL COMPOSITE MATERIALS. THE CUBE RESONANCE METHOD SHOWS THAT THE YOUNG’S MODULUS INCREASES FROM 84 TO 107 (GPA) WITH INCREASING VOLUME FRACTION OF NANOCRYSTALS AND THE POISSON’S RATIO WAS ALMOST CONSTANT OF 0.28-0.29. THE VICKERS HARDNESS (HV) AND FRACTURE TOUGHNESS (KC) INCREASE FROM 5.0 TO 6.0 (GPA) FOR HV AND 0.48 TO 1.05 (MPA.M¹/₂) FOR KC WITH INCREASING THE VOLUME FRACTION. IT IS FOUND FROM NANOINDENTATION MEASUREMENTS THAT THE DEFORMATION ENERGY INCREASES WITH INCREASING VOLUME FRACTION. IN PARTICULAR, THE PLASTIC DEFORMATION ENERGY IS FOUND TO BE 114-136 KJ MOL-1, WHICH IS CLOSE TO THE BA-O SINGLE BOND ENERGY (~138 KJ MOL-1), SUGGESTING THAT THE BREAKING OF BA-O BONDS MIGHT BE IMPORTANT FOR THE PLASTIC DEFORMATION IN THIS GLASS. THE YOUNG’S MODULUS EVALUATED FROM CSM-TYPE NANOINDENTATION MEASUREMENTS FOR A DEFORMATION SCALE OF
ABOUT 100 NM SHOWS THE VALUES OF 98 GPA FOR THE GLASS AND 110 GPA FOR THE GLASS-CERAMICS WITH NANOCRYSTALS. THE ELASTIC/Mechanical PROPERTIES OF THE GLASS ARE LARGELY IMPROVED DUE TO THE NANOCRYSTALLIZATION.

![Graph showing Vickers Indentation and fracture toughness](image)

Figure 1. Values of Vickers hardness and fracture toughness evaluated using indentation as a function of the volume fraction of Ba$_2$TiSi$_2$O$_8$ nanocrystals.

![Graph showing Young's modulus](image)

Figure 2. Values of Young’s modulus evaluated using the Berkovich CSM-type nanoindentation technique as a function of displacement (penetration depth) of the indenter for the precursor BTS glass.
Figure 3. Values of Young’s modulus evaluated using the Berkovich CSM-type nanoindentation technique as a function of displacement (penetration depth) of the indenter for the crystallized (at 790°C for 1 h) sample.

3. and 4. W. Höland, Liechtenstein

Nucleation in multi-component systems and microstructure - $K_{tip}$ relation of base glasses for glass-ceramics and Relationship of microstructure and $K_{tip}$ of three types of glass-ceramics (by J. Deubener, Germany).

These results are based on a presentation based on a joint publication with J. Deubener and R. Müller. The determination of the crack opening displacement of leucite-type, lithium disilicate-type and apatite glass-ceramics allowed to compare the crack propagation and the determination of $K_{tip}$, the $K$ value at the crack tip, of the three materials. The results, demonstrated in a publication by Apel E., Deubener J., Bernard A., Höland M., Müller R., Kappert H., Rheinberger V., and Höland W., “Phenomena and Mechanisms of Crack Propagation in Glass-Ceramics,” *J. Mech. Behav. Biomed. Mat.*, 1, 313-325 (2008) were discussed during the TC07 meeting. The highest $K_{tip}$ value was determined for the commercial lithium disilicate glass-ceramic used for dental bridges and crowns.

In continuation of this study, J. Deubener, W. Höland and some members of the University Buchs in Switzerland (M. Höland, A. Bernard) are studying the COD behaviour of the base glasses of these three glass-ceramics. This research relates to the study of multi-component glass-ceramic systems and the relationship between microstructure and mechanical properties. At the moment, a scientific publication is in progress. One of the net result is that the microstructure of the glass-ceramics correlates with the determined $K_{tip}$ values of the glasses; i.e. a clear relationship between microstructure and properties.
Session 1 Application of Sensors in High Temperature Processes
S1 Overview of needs for sensors in the glass industry
Wilfried Linz, Schott AG, Mainz, Germany
S2 Milestones of process control in ferrous metallurgy - past, today and future -
Wolfgang Glitscher, Heraeus Electronite International N.V., Houthalen, Belgium
S3 Inventory of sensors applied in industrial high temperature processes
Erwin Engelaar, Ruud Beerbens, TNO, Eindhoven, The Netherlands (NL)
Annual_report_TC15-2010.doc
S4 Mobile Sensors for Process Parameters in Tunnel Kilns for Ceramic Product Firing, Dr. ing J.C. Marks, Stichting Technisch Centrum voor de Keramisch Industrie (Technical Centre Foundation Ceramics Industry), Velp, NL

Session 2 Sensors for melts
S5 Ultrasonic sensors for high temperature melts (glass, metal, silicon)
Anne Janis Faber, TNO, Eindhoven, The Netherlands
S6 Electrochemical sensors for glass melts
Hayo Müller-Simon, HVG, Offenbach, Germany
S7 On-line electrochemical sensors for the glass industry
Paul Laimböck, READ-OX, Valkenswaard, The Netherlands
S8 LIBS based sensors to observe the glass production process
Bernhard Fleischmann, HVG, Offenbach, Germany

Session 3 Sensors for Combustion & Flue Gases
S9 Fiber optic sensors for process control
Ulrike Willer, Wolfgang Schade, Fraunhofer Heinrich-Hertz-Institut + TU Clausthal, Faseroptische Sensorsysteme, Goslar-Clausthal, Germany
S10 Sorting of Recycled Glass in Real Time by HySpex Hyperspectral Imaging System, Ivar Baarstad, Peter Kaspersen, Norsk Elektro Optikk A/S, Norway
S11 Measurement of CO and O₂ in Gases at High Temperatures, Dung Do Dang, Ove Bjørøy, Peter Kaspersen, Norsk Elektro Optikk A/S, P.O.Box 384, N-1471 Lorenskog, Norway, peter@neo.no, http://www.neo.no
S12 Energy Savings by (Natural) Gas Chromatography, Dr. Stefan Malcharek, Siemens Process Analytics, Product Marketing Gas Chromatography, Siemens AG, Karlsruhe, Germany

Session 4 Other Sensors & Process Control
S13 Oxygen sensors - Ingressed air & PLC integrated model for thermal balances of regenerators
Dr. Peter Hemmann, STG GmbH Cottbus, Germany
S14 Application of soft sensors and process control based on dynamic glass furnace simulation models
Leo Huismann, Piet van Santen, TNO, Eindhoven, The Netherlands
S15 Moisture measurement for raw materials in glass, cement and ceramic industry
Mirande Wolvekamp, ACO Automation Components, The Netherlands
S16 KeyNote Model-Based Predictive Control for Industrial Processes
Prof. Dr. Ir. Ton Backx, Eindhoven University of Technology, Eindhoven, The Netherlands
International Commission on Glass

TC18 Properties of Glass Forming Melts/Glass Melting

Minutes (Protocol)

Annual Meeting Magdeburg, Germany

At the occasion of the ESG/DGG / Glass Trend conferences

Annual meeting ICG-American Ceramic Society

Monday, 31 May, 2010

TC18 Meeting Magdeburg, Germany, 31 May, 2010

Topic: Annual meeting of the ICG technical committee on Properties of Glass Forming Melts (TC18)

Date meeting: 31 May, 14.00-17.15 hrs.

Location: Maritim Hotel, Magdeburg, Germany

Participants: Reinhard Conradt (RWTH), Martin Horsley, (NSG/Pilkington), Leena Hupa (Åbo Akademi University), Mathi Rongen (TNO), Andreas Kasper (Saint Gobain-HRDC), Hande Sengel (Şişecam), Barbara Hein-Reche (O-I), Lubomir Némc (ICT Prague), Jaroslav Klouzek (ICT Prague), Miroslav Polak (ICT Prague), Sam Leese (Sibelco), Ruud Beerkens (TNO).
Distribution: TC18 members, participants, Klaus Bange (CTC), René Vacher (CTC), Detlef Köpsel (Schott AG, TC14), Masataka Kawaguchi (NEG), Shige Aoki (NEG), Erik Muijsenberg (Glass Service, TC21), Thomas Pfeiffer (Schott AG), Nobuyuki Kido (Asahi Glass Ceramics), Marie-Helene Chopinet (Saint Gobain Recherche), Chikao Tanaka, Rei Kitamura, Gulcin Albayraki (Şişecam), Alexis Clare (CGR, Alfred University), Phill Ross (GICI), Christopher Berndhäuser (Schott AG, TC25)

Objective: Overview of recent TC18 activities (2009/2010), New role TC18 within TC Cluster Glass Production, Future Seminars & Workshops, New Chair person, Round Robin on Thermodynamic Modelling of Multi-Component Silicate Melts, Presentations TC18 member

Agenda meeting, 31 May 2010, Magdeburg

1. TC18 2009 activities (reported in March 2010 to ICG)
2. Future of TC18 & Chair
3. New structure of cluster Glass Production/Glass Melting (TC11, TC13, TC14, TC15, TC18, TC21, TC25)
4. Roadmap for research on glass melting: new glass melting concepts, waste heat recovery, tailored batches for glass melting, sensors & process control.
5. Future activities TC18
6. Round Robin on thermodynamic modeling of multi-component silicate glass (melts)
7. Future seminars on glass melting
8. Presentations from TC18 members.

Oral Presentations after the end of this regular TC18 meeting:

1. Leena Hupa:
   Activities around glass melting properties/melt properties (crystallisation, liquidus, viscosity) of compositions of interest for medical applications (bioactive glasses/biodegradable glasses).
2. Jaroslav Klouzek & Lubomír Némec:
   Glass melting research activities
3. Ruud Beerkens:
   EGA during melting of glass forming raw material batches to identify sulfur-carbon reactions
Summary of TC18 meeting
The participants (12 persons) introduced themselves. Activities in 2009 are reviewed and progress on Round Robin Modeling of Chemical Activities of Components in Multi-Component silicate melts and new role of TC18 in Cluster “Glass Production (TC11, TC13, TC14, TC15, TC18, TC21, TC25)” has been discussed.

Actions:
1. A new chair should take over from Ruud Beerkens
3. Continuation Round Robin Thermodynamic Modelling
4. Future topics: Viscosity models for silicate melts

Ruud Beerkens (acting chair) presented a power point (see annex) to guide this TC18 meeting in Magdeburg.

Top 1.

TC18 activities in 2008 & 2009
- A meeting was held at HVG in Offenbach, Germany on 8. January 2009 to discuss follow-up activities derived from the BRIG expert meeting on “Innovation in Glass Melting for the Year 2020”. It was decided during this meeting to start the organization of a 2-days seminar/workshop on sensors for glass production (This workshop will take place on 4.-6 October 2010 in Maastricht, The Netherlands).
- Organization of a workshop-seminar on EFONGA activities between 2005 and 2009 on 7 and 8 May 2009 in Montpellier France (see annex 1). During this workshop 14 papers have been presented. 7 of these papers were contributed by TC18 members.
- In co-operation with Glass Trend, a seminar on: Glass Melt Quality & Glass Defects was organized in Istanbul, 12-14 May 2009 with about 50 participants.
- A roadmap vision on developments for glass melting processes from 2009 - 2020 was discussed on 8 May 2009.
- An annual meeting of TC18 was organized in Vancouver Canada on 1. June in connection to the ICG annual meeting.
- A Round Robin Test on Thermodynamic Modelling of Multi-Component Glass Melts is progressing

TC18 meetings in 2009:
• Meeting on 1. June 2009 in Vancouver
• 12-14 May 2009, Istanbul seminar on Glass quality and glass defects
  In co-operation with TC14 and GlassTrend and hosted by Şişecam.
• Co-operation in Montpellier EFONGA meeting 7 & 8 May 2009 with a workshop on activities of TC18 with several presentations on glass melting and fining.

**Deliverables in 2008 & 2009:**
- Collections of power point presentations of Montpellier EFONGA workshop: 7 - 8 May 2009 - several presentations.
- Seminar on Glass Melt Quality & Glass Defects on 12.-14. May 2009 in Istanbul

TC18 contributed by lectures to the Summer School in Montpellier in May 2009 for PhD students in field of Glass Science & Technology.
Furthermore TC18 contributed to the tutorial “Clear as Glass: Thermodynamics & Chemical Technology in Glass Melting”, organized by Prof. Reinhard Conradt (TC23) in Vancouver on Wednesday 3. June 2009:

**Reinhard Conradt: Thermochemistry of mineral raw materials, glass melts, and solid glass.**
Calculation of enthalpies and entropies of real raw materials, and industrial glasses and glass melts. Use of tabulated thermodynamic data. Calculation of the latent heat of the batch-to-melt conversion, and the tangible heat stored in a melt.

**Reinhard Conradt: The glass furnace - a thermochemical reactor.**
Ruud Beerkens, Thermochemistry of combustion
Different types of available fuels. Short summary on reaction mechanism of combustion in glass furnaces. Combustion calculations: gross and net calorific values of real fuels, oxygen/air demand, flue gas volume and composition, adiabatic flame temperature. A short discussion on cause of NOx & dust emissions, evaporation, carryover will be presented. Heat transfer from flames to melt.

Ruud Beerkens, Mechanisms, thermochemistry and kinetics of refining.
Physics and chemistry of refining and fining. Mechanism of primary and secondary fining. Examples of the traditional sulfate fining process for soda lime silicate glasses. Technological measures supporting the fining process. Sulfate chemistry in relation to gas evolution from glass melts.

Pavel Hrma, Transport phenomena during glass melting.

Top 2.-4. Role of TC18 & Future of TC18 and Cluster Glass Production - Roadmap

Glass Melting
TC18 is searching for a new chair person, there is one candidate. This candidate needs a few months time to make a decision on being available for chairing TC18 for the next 3 years (2010-2013). We expect this decision before the ICG congress in Brazil.

In 2009 the name of TC18 has been changed from “Properties of Glass Forming Melts” to “Glass Melting”.

TC18 promotes the co-operation with other Technical Committees of the ICG in the cluster Glass Production:

- TC11 Materials for Glass Manufacturing
- TC13 Environment
- TC14 Gases in Glass
- TC15 Sensors and Advanced Control Systems
- TC18 Properties of Glass Forming Melts → Glass Melting
- TC21 Modeling of Glass Melting Processes
- TC25 Modeling of Glass Forming Processes

TC18 is not only a Technical Committee on Glass Melting on its own, but works on topics that are important for these other TCs and TC23 (on delivering information and teachers for summer schools and glass technology courses to TC23).

Ruud Beerkens has been discussing the new structure of the cluster Glass Production with a central role of TC18. Some existing TCs in this cluster may stop their activities in
case there will be hardly progress of their activities. New technical committees may be initiated on topics such as “Energy Efficiency & Combustion in Glass Production”, “Thermochemistry & Chemical Engineering in Glass Technology”, “Furnace Designs” or task forces for specific tasks and topics may be formulated for a period of 3-5 years. Such task forces can be supervised and initiated by TC18 or other TCs and working groups per task force will be nominated. Some of the temporarily TC tasks and activities can then be transferred to such task forces.

Task forces may include the topics that are identified as being important for glass melting innovation in March 2008 at the Expert meeting on Innovation in Glass Melting (BRIG meeting):

- New glass melting concepts and glass furnace designs, based on segmented melters;
- Innovative batch preparation and batch selection methods and alternative raw materials for glass production: tailored batches;
- Recovery of the energy from the flue gases of fossil-fuel fired glass furnaces;
- New sensors and advanced process control for glass furnaces (focus on sensors).

In Summary:

TC 18 searches for a new chair person, supported by a core group (candidates for this core group: Hande Sengel, Mathi Rongen, Ruud Beerkens for 2010/2011).

TC18 will co-organize seminars with other TCs of the ICG and may start task forces on specific subjects.

TC18 supervises co-operation between other TCs in the cluster Glass Production and initiates actions that fit within Roadmap of Innovative Glass Melting 2010-2020.

Top 5. Future possible activities for TC18 (Italic refers to actions in cluster Glass Production):

- Task forces/working groups on specific glass melt topics (periods 3- max. 6 years)
- Thermodynamic modeling silicate melt: Round Robin (2008-2012)
- Setting up ICG training course modules Glass Melting - (TC23)
- Seminar (expert meeting) on New Glass Melting Concepts (BRIG1)
- Seminar (expert meeting) on Tailored glass forming raw materials (BRIG2)
- Seminar (expert meeting) on Heat Recovery from Flue Gases (BRIG3)
- Seminar (expert meeting) on Advanced Sensors & Process Control (BRIG4)
- Roadmaps for 2010-2020 on these issues
Reinhard Conradt shortly described several models for predicting the temperature dependency and composition dependency of high temperature viscosity (T >> Tg) of silicate melts. A new model has been proposed by John C. Mauro:


The evaluation of different viscosity models might be a future subject for TC18.

On request by TC23 (Education & Training in Glass Science & Engineering) of the ICG, TC18 may support future ICG training courses, tutorials and summer schools by offering training modules on glass melt topics (glass melting in general, combustion in glass furnaces, fining, chemistry of melting, glass furnaces) and teachers.

**In Summary:**
TC18 will co-ordinate in co-operation with the cluster manager and other TC chairs, activities in “Glass Production” and will initiate new task forces and consults/advises the Coordinating Technical Committee (ICG-CTC) for new subjects & starting new Technical Committees.

New future activities: Evaluation viscosity models, organization of glass melting seminars/expert meetings.

**Top 6. Round Robin on thermodynamic modeling of multi-component silicate glass (melts)**
TC18 started in 2008 a Round Robin on Thermodynamic Modeling of Multi-Component Silicate Melts. Three systems (binary, ternary and commercial float glass) have been defined by composition. It constitutes binary sodium silicates, sodium calcium silicate and a float glass melt. Laboratories able to develop and apply thermodynamic models for multi-component silicate systems are invited to calculate in the temperature range from 1200-1600 °C, the chemical activities of the single oxides (Na2O, CaO, SiO2, MgO etcetera) in these melts. So far only Dr. Pfeiffer (Schott Glas AG) and Prof. Conradt (RWTH) presented their results. TNO (van Limpt, Beerkens) presented some experimentally derived values for chemical activities of Na2O in similar glass compositions. These values are obtained from evaporation tests and electrochemical studies and sulfate equilibration of glass melts.
Ruud Beerkens summarized (see annex with the power point presentation) the results in graphical form from Conradt, Pfeiffer, van Limpt and Beerkens.

Leena Hupa (Abo Akademi) will also participate in this Round Robin and will present results in the future. NSG/Pilkington (Martin Horsley) handed results for the binary and ternary system to Ruud Beerkens during the meeting.

The differences found between the different models and used databases can be up to half on order of magnitude. Every laboratory used a certain model (commercial or own developed) or several models (Conradt) and approaches. Not only the models but also the databases for the stoichiometric compounds and the single oxides that have been used are sometimes different. Critical are data for CaO and MgO, since for these components the data from different thermodynamic tables can vary considerably. In all cases the reference states (solid, liquid, gas) should be given when reporting chemical activity of a single oxide in a multi-component system.

An example:

\[
\text{Erreur ! Des objets ne peuvent pas être créés à partir des codes de champs de mise en forme.}
\]

It is concluded that:

- More laboratories should participate;
- Participating laboratories should report the used databases;
- Participating laboratories should report on the reference states of the single oxides when reporting the chemical activities of these oxides;
- It is important when using commercial software with different options (slag A, slag B etc.) such as in FactSage, that the correct option has been selected. For instance by selecting certain option (e.g. model slag A) and applying this model for a glass composition (close to the composition under study) with known thermodynamic properties and thus validating these modeling results;
- More comparisons with experimental data are needed.

In Fall 2010, Prof. Conradt and Ruud Beerkens will review the progress of this Round Robin.

**Top 7. Future seminars on glass melting**

TC18 is involved in the organization of a workshop on Advanced Sensors and Process Control for High Temperature Processes. This workshop will be organized on 4-6 October in Maastricht, The Netherlands. TC15, The German Glass Society (DGG), Glass Trend will co-organize this event. The first day of the workshop will include 14-18 presentations on
developments of new sensors, needs for sensors and application of sensors and process control systems in glass furnaces, steel production, cement and ceramics industries. The second day is dedicated to discussions on future needs and developments required for better process monitoring and control as a basis for a roadmap Advanced Sensors and Control in High Temperature Industrial Processes 2010-2020.

It is recommended in this TC18 meeting to organize also a 2-days workshop on: “Innovative batch preparation and batch selection methods and alternative raw materials for glass production: tailored batches. An option is October 2011.
Volunteers for organizing and preparing such a seminar are: Sam Leese (Sibelco), Mathi Rongen (TNO), Andreas Kasper (Saint Gobain), Reinhard Conradt (RWTH).

Top 8. Presentations TC members
Three TC18 members presented a paper:
Leena Hupa: Recent Activities on Glass Melting Properties, Åbo Akademi University, Process Chemistry Centre Combustion and Materials Chemistry, Turku/Åbo, Finland
Goals of this research: to establish the requirements and limitations of tailoring bioactive glasses for various clinical applications
- high temperature properties as functions of glass composition
- in vitro bioactivity / reactivity as function of glass composition
- in vitro vs. in vivo reactivity

Lubomir Nemec: The Prague Laboratory topics and research prospects on glass melting Institute of Inorganic Chemistry of the AS CR,v.v.i., 250 68 Husinec-Řež and Institute of Chemical Technology in Prague, Technická 5, 166 28 Prague Czech Republic
This presentation analyzes the efficiency of glass melting processes in large tanks and shows an approach to evaluate the melting performance (efficiency of using available space for melting and fining) and to improve melting performance of tanks. Also the optimization of sulfate and carbon chemistry for improved melting and fining is discussed.
Ruud Beerkens: Sulfate-Carbon Chemistry of Soda-Lime-Silica based Batches and Evolved Gas Analysis during Melting and Fining of These batches. TNO Science and Industry, Eindhoven, the Netherlands.
The application of Evolved Gas Analysis to study reaction mechanisms of sulfate and cokes in glass forming batches and to understand the evolution of batch and fining gases is presented. Such studies reveal that sulfate reacts with reducing species to form sulfides (part of sulfates is converted into sulfides) during batch melting. Just after melting-in of the batch (1150-1350 °C), sulfides and residual sulfates react and form mainly \( \text{SO}_2 \) (with some \( \text{O}_2 \)) gases. This can lead to bubble formation and bubble growth in this temperature range. For oxidized batches the sulfate decomposes only at higher temperatures (> 1430 °C), forming \( \text{SO}_2 \) and \( \text{O}_2 \) fining gas.

**Other business:**

New books on Glass Melting or Thermodynamics:
“Glass Furnaces and Refractory Materials”

1. June and 2. June 2010

Magdeburg, Germany

Seminar: “Glass Furnaces and Refractory Materials”

In co-operation with TC11 and TC18 of the International Commission on Glass (ICG)

TUESDAY 1. JUNE, afternoon

13.35-14.00 Introduction of ICG-TC11, Technical Committee on Materials for Glass Manufacturing
Dr. Michael Dunkl, Dr. M. Dunkl Consulting, Meerbusch, Germany

14.00-14.50 Keynote lecture: AZS refractory materials - structure, testing and structural changes during application
Dipl. Ing. Bernhard Fleischmann, HVG, Offenbach, Germany

14.50-15.15 Monolithics in glass melting furnaces: state of the art
Dipl.-Ing. Bernhard Schmalenbach, Dr. Rongxing Bei, Dr. Stefan Postrach, Dipl. Ing. Götz Heilemann, RHI Glas GmbH, Wiesbaden, Germany

15.45-16.10 Refractories based on chrome-alumina: advantages and limitations
Dipl.-Ing. Bernhard Schmalenbach, Dr. Rongxing Bei, Dr. Stefan Postrach, Dipl. Ing. Götz Heilemann, RHI Glas GmbH, Wiesbaden, Germany

16.10-16.35 New high electrical resisitivity high zirconia fused cast material for alkali free glass melting
Michel Gaubil, Isabelle Cabodi, Cristel Morand SG CREE, Bruno Escaravage, Jeremy Poiret SG SEFPRO, le Pontet/Paris, France

16.35-17.00 The Behavior of Cord Making Material in F/H Channels as Depicted by Physical and Mathematical Modeling:
Dr. Esref Aydin and Mustafa Oron, ŞİŞECAM / Glass Research Centre, İstanbul-TURKEY

17.00-17.25 Quality characterization and specifications of refractory materials for glass melting furnaces
Dr. Michael Dunkl, Dr. M. Dunkl Consulting, Meerbusch, Germany

17.25-17.50 Corrosion of electrodes
Dr. Thomas Pfeiffer, Schott AG, Mainz, Germany

17.50-18.15 Refractory Futures - Long life Regenerators and Hot Melter Crowns
Trevor Wilson BSc. & Chris Windle BSc., DSF Refractories & Minerals Ltd. Buxton, Derbyshire, UK
WEDNESDAY 2. JUNE 2010, morning

08.30-8.55 Corrosion & Performance of Glass Melting Tanks
Prof. Dr. Ruud Beerkens, TNO Glass Group, Eindhoven, The Netherlands

8.55-9.20 First oxygen fired float glass furnace equipped and operated with a new heat recovery technology
Simon Jean-François¹, Doucchamps Olivier², Behein Johan², Joumani Youssef ³
¹AIR Liquide France, ²AGC R&D Center, Belgium, ³AIR Liquide Claude-Delorme Research Center, France

09.20-09.45 Modeling study on the riser design of glass melting furnaces
Dr. Matthias Lindig, SORG GmbH Co KG, Lohr am Main, Germany

09.45-10.10 Simulation study of impact furnace design on specific energy consumption, NOx emission levels, volatilization rates and refractory corrosion
Dr. Adriaan Lankhorst, Dr. Hans van Limpt, Ing. Andries Habraken, Prof. Ruud Beerkens, TNO Glass Group, Eindhoven, The Netherlands

10.40-11.05 Primary measures for NOx emission reduction of regenerative furnaces
Dr. Hans van Limpt, Prof. Dr. Ruud Beerkens, MSc. Jeanne Collignon, Ing. Marco van Kersbergen, Dr. Adriaan Lankhorst, TNO Glass Group, Eindhoven, The Netherlands

11.05-11.30 Practical experiences with an all oxygen-gas fired container glass furnace during its 16 years campaign
Jan Schep¹; Goos Kers²
¹Ol Europe, Schiedam, the Netherlands, ²O-I Manufacturing Netherlands BV Leerdam, The Netherlands

11.30-11.55 Repair of regenerators on furnaces in operation
Martin Schnorr, Christoph Jatzwauk, Horn Glass Industries AG, Ploessberg, Germany

11.55-12.20 Optimization of regenerator design and performance by modeling
¹Dr. Menno Eisenga*, ¹Ir. Erik Muijsenberg, ²Dr. Miroslav Trochta,
¹Glass Service B.V., G. Martinolanaan 95, 6229 GS Maastricht, The Netherlands, ²Glass Service Inc., Rokytnice 60, 75501 Vsetin, Czech Republic

13.35-14.00 Melting and Conditioning impacts on “Light Weight Glass” container production
Dipl. Ing. Farhad Ghafourian, Christoph Jatzwauk, Horn Glass Industries AG, Ploessberg, Germany

14.00-14.25 Glass furnaces with oxy-fuel combustion
Dr. Gerd Wachter, Schott AG Mainz, Germany

14.25-14.50 Redox state control in container glass furnaces - a practical approach
Sven-Roger Kahl ¹, W. Cieleback ², ¹Ardagh Glass Dongen B.V. The Netherlands, ²Ardagh Glass Nienburg GmbH, Germany

14.50-15.15 The centrifugal fining of glasses
Prof. Dr. Jaroslav Kloužek, Vladislava Tonarová, Lubomír Němec,
Laboratory of Inorganic Materials, joint Workplace of the Institute of Inorganic Chemistry of the ASCR and the Institute of Chemical Technology, Technická 5, 166 28 Prague, Czech Republic

15.15-15.45 Coffee Break

15.45-16.10 The concept of space utilization in the continuous glass melting
Prof. Dr. Lubomír Němec, Ing. Petra Cincibusová,
Laboratory of Inorganic Materials, joint Workplace of the Institute of Inorganic Chemistry of the ASCR and the Institute of Chemical Technology, Prague, Czech Republic

16.10-16.35 Studying bubble glass defects that are caused by refractory materials
Dr. Jiri Ullrich, Glass Service Inc. Vsetin, Czech Republic

16.35-17.00 The negative and positive effects of direct current on molybdenum glass furnace boosting electrodes
René Meulemans, Eurotherm B.V., Alphen aan den Rijn, The Netherlands

17.00-17.25 The march in glass process control
François Famchon¹ & Joël Cardon²,
¹AGMS (Arc Glass Melting Solutions), Arc, France, ²Arc International, Arc, France

Annex 3
Papers of 5-6 October 2010 sessions - Maastricht

Seminar: Advanced Sensors & Control in High Temperature Processes

Session 1 Application of Sensors in High Temperature Processes

S1 Overview of needs for sensors in the glass industry
Wilfried Linz, Schott AG, Mainz, Germany

S2 Milestones of process control in ferrous metallurgy - past, today and future -
Wolfgang Glitscher, Heraeus Electronite International N.V., Houthalen, Belgium

S3 Inventory of sensors applied in industrial high temperature processes
Erwin Engelaar, Ruud Beerkens, TNO, Eindhoven, The Netherlands (NL)

S4 Mobile Sensors for Process Parameters in Tunnel Kilns for Ceramic Product Firing,
Drs. ing J.C. Marks, Stichting Technisch Centrum voor de Keramisch Industrie (Technical Centre Foundation Ceramics Industry), Velp, NL

Session 2 Sensors for melts

S5 Ultrasonic sensors for high temperature melts (glass, metal, silicon)
AnneJans Faber, TNO, Eindhoven, The Netherlands

S6 Electrochemical sensors for glass melts
Hayo Müller-Simon, HVG, Offenbach, Germany

S7 On-line electrochemical sensors for the glass industry
Paul Laimböck, READ-OX, Valkenswaard, The Netherlands

S8 LIBS based sensors to observe the glass production process
Bernhard Fleischmann, HVG, Offenbach, Germany
Session 3  Sensors for Combustion & Flue Gases

S9  *Fiber optic sensors for process control*
Ulrike Willer, Wolfgang Schade, Fraunhofer Heinrich-Hertz-Institut + TU Clausthal, Faseroptische Sensorsysteme, Goslar-Clausthal, Germany

S10  *Sorting of Recycled Glass in Real Time by HySpex Hyperspectral Imaging System*, Ivar Baarstad, Peter Kaspersen, Norsk Elektro Optikk A/S, Norway

5  S11  *Measurement of CO and O₂ in Gases at High Temperatures*, Dung Do Dang,
Ove Bjorøy, Peter Kaspersen, Norsk Elektro Optikk A/S, P.O.Box 384, N1471 Lorenskog, Norway, peter@neo.no, http://www.neo.no

S12  *Energy Savings by (Natural) Gas Chromatography*,
Dr. Stefan Malcharek, Siemens Process Analytics, Product Marketing Gas Chromatography, Siemens AG, Karlsruhe, Germany

Session 4  Other Sensors & Process Control

S13  *Oxygen sensors - Ingressed air & PLC integrated model for thermal balances of Regenerators*, Dr. Peter Hemmann, STG GmbH Cottbus, Germany

S14  *Application of soft sensors and process control based on dynamic glass furnace simulation models*
Leo Huisman, Piet van Santen, TNO, Eindhoven, The Netherlands

S15  *Moisture measurement for raw materials in glass, cement and ceramic industry*
Mirande Wolvekamp, ACO Automation Components, The Netherlands

S16  KeyNote *Model-Based Predictive Control for Industrial Processes*
•  Prof. Dr. Ir. Ton Backx, Eindhoven University of Technology, Eindhoven, The Netherlands

ANNEXE TC24

TC24 Poster_2010