



# Usable Glass Strength – Forming a Research Coalition

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## Workshop Report

Sponsored by GMIC/DOE

In Conjunction with ACERS/GOMD 2010 Meeting

**20 May 2010 – Corning, NY**

### Morning Session

**8:00 a.m. – 11:00 a.m. Overview and General Concept**

8:00 *Welcome – Michael Greenman (GMIC) and [Glenn Strahs](#) (DOE)*

8:10 *Introduction – Charlie Brossia*

08:30 *Overview of proposed coalition structure – Lou Mattos*

(Note: [Greenman, Brossia and Mattos presentations in one document](#))

9:00-11:30 *Discussion of structure – Facilitated by Gabe Tincher and Chris Zach*

#### **Concerns: What hurdles exist to forming a coalition?**

- Do companies have the patience to wait 5 years for results?
  - Response: Shorter cycles are possible
- Is the target funding match rate achievable?
  - Coalition members will determine
- Will the pre-competitive research be useful without significant company spending to transfer research to commercialization?
  - Unlikely. Pre-competitive research yields foundations on which further company, sector, or industry research can be built.
- How well do we understand government goals and meeting those goals with our proposals?
  - Government goals are clear. Proposals must be built to fulfill those goals.
- Do we have an understanding of international funding sources?
  - Involvement of international partners in coalition will lead to understanding of international funding sources.
- How do we leverage national laboratories?

- To be determined! They have had a very low profile in recent years with reduction of DOE funding. We'll need to reach out to them – we have two to start with!
- How do non-U.S. companies participate when funding source is U.S. government?
  - To be determined on case-by-case, but similar situations may be relevant with non-U.S. funding sources.
- Is research too fundamental?
  - Government and companies may be interested more in improving processes
  - There will be opportunities for both fundamental and process/application research.
- Will the coalition duplicate work being done by ICG? How can they work together?
  - ICG members are part of CRT and SST. We will coordinate
- Companies have an innate resistance to pre-competitive research
  - All the work done with the DOE in 1998 to 2005 was pre-competitive. Participation from industry was positive.
- There are many aspects of strength; what will be the priority and how large is the scope?
  - Up to coalition to determine.
- How do we ensure timely feedback and communication between researchers and stakeholders?
  - Need to know that research is on track and focus is valuable.
  - Coalition will identify reporting practices.
- What is the access to researchers after the research concludes?
  - Response: Hiring the researchers is one likely option
  - Case by case basis.
- What is the probability of success, of finding a useful solution? What is the risk?
  - Unable to determine at this early stage, but participants in process to-date believe probability is there
- ITAR: restrictions on communicating information about high-strength products (glass fiber) internationally will affect how research is conducted
  - International Trafficking in Arms Regulations - Needs to be understood

### ***Motivation for Building a Coalition***

- Improving usable glass strength is critical for a vibrant glass industry in the future
- Competitive material industries are heavyweights (Steel, Aluminum, Chemicals (plastics),) and they conduct significant collaborative research; they are not sitting still
- A successful glass research coalition would be a signal to others of industry initiative and willingness to collaborate

### ***Structure, Membership, and Benefits***

- What are the benefits of joining at the seed stage rather than waiting?
  - Opportunity to provide input into research direction and roadmap
  - Opportunity to define the fundamental questions that will be asked
  - Get access to the early outputs of research
  - Higher membership numbers will lower the cost for each participant

- Will have a say in determining future membership
- Chance to be early to market with game-changing glass products; first mover advantage
- Founding members could have unique advantages and privileges in the structure
- Early members can anticipate outcomes and launch work on process engineering to take advantage of this progress
- To have access to students for hiring
- To be covered by IP protection for members
- Comments on the structure of the coalition
  - May need two schemes – one that is pre-competitive and one that involves IP contracts between a subset of companies to develop proprietary technologies
  - Companies can pay for proprietary research as needed
    - Submerged Combustion Melter (SCM) project is an example
  - Companies can pursue individual paths when needed
  - Program creates a dialogue between researchers and companies
  - See ICG as a model for successes
- Three models for structuring the coalition
  - NSF/University Centers
  - Pooled-funding with government leverage
    - SCM model
  - Company-funding only (no government funding)

***The written objective of the coalition –( Note: this is the initial step – the means to launch the establishment of the coalition)***

- As written: “To develop a pre-competitive research program to identify critical parameters for improving the usable strength of glass.”
  - “identify critical parameters “
    - Output will not provide a new, strong glass to companies
    - Output will outline a path for companies to pursue in their own research to develop new and improved products
  - “pre-competitive research”
    - Output is knowledge and understanding that companies will use individually to design products
    - Research on fundamental science will avoid potential ITAR problems
- Additional objective: “The development of the next generation of glass technical experts and researchers.”
- Objective could be to develop methods for obtaining parameters
- At what point must work be subdivided for respective sectors? How much is cross-cutting?
  - This is determined by coalition in its early work, and during development of roadmap.
- Will be focusing on commercial soda-lime glass rather than multiple compositions, initially
- First stage focuses on contact damage

- Question was raised in regards to pursuit of radical innovation vs. fundamental science and which is the right goal to create a meaningful impact
  - – Coalition must be open to opportunities for radical innovation and pursue as appropriate.

### ***Funding Sources***

- Energy Advanced Research Projects Agency (ARPA-e): Funds transformational energy research (modeled after DARPA)
- National Science Foundation (NSF)
- Department of Commerce (DOC): Interest in saving and creating jobs, manufacturing, exporting products
  - National Institute of Science and Technology (NIST) within DOC
- Department of Energy (DOE)
  - Industrial Technology Program (ITP); Solar Program; Wind Program; Building Program; Automotive Program; State Energy Program (SEP)
- DARPA – Defense Advanced Research Projects Agency
- DOD – Various service research offices
- DOT – Department of Transportation – Interest relating to automobiles, lightweighting, mileage, efficiency
- European Programs – various EU programs are available. Work on various elements of strength could be carried out in Europe (or elsewhere)
- State Programs – many states have their own research agendas relating to jobs, energy efficiency, emissions.
- Private Foundations – Various foundations request proposals for energy efficiency, buildings, etc.
- Self Funded – Coalitions of glass companies can pool resources to finance appropriate research.
- International science research fund
- International military programs
- Glass Trend model – all company money (except specific projects)
- Users (thanks, Coca Cola)
- Broadening the coalition to other materials in the fundamental research stage
- Varying degrees of scope to meet the needs of funding sources
- Suppliers (lithium, hydrogen, etc)
- U.S./country partnerships

### ***Technology Roadmap and Path Forward***

- Roadmap sets milestones and arranges them sequentially based on priority and prerequisites
- Researchers then develop proposals to achieve milestones
- Possibility of support from DOE to develop roadmap

### ***Intellectual Property***

- Agency policies vary; there are ways for companies to retain IP and not assign it to government
- Need governance policy so companies can determine when/what is published
- University policies vary in regards to granting royalty-free licenses; some will not do it

### **11:30 a.m. – 1:00 p.m. Lunch**

#### ***Presentation: “Open Innovation – The Radical Future of R&D” – Joe Arcadi (Owens Corning)***

Joe Arcadi delivered a presentation on the emerging concept of open innovation and how it is being applied at Owens Corning. Open innovation is the practice of “opening the doors” of the R&D organization and actively soliciting and searching for innovative ideas from outside the company. One leader in the movement has been Proctor & Gamble. Owens Corning has been pushing a shift to open innovation over the last several years and will soon commercialize the first outputs of the process. In the spirit of open innovation, [Joe is sharing his presentation here:](#)

## **Afternoon Session**

### **1:00 p.m. – 4:00 p.m. Technical Factors and Organizing Plans**

*1:00-1:10 Introduction of research plan – [Chuck Kurkjian](#)*

*1:10-2:10 Research presentations – Speakers: various, Moderator: Carlo Pantano*

1. Dr. Charles Kurkjian, Adjunct Professor, Rutgers University and University of Southern Maine – [Contact Damage](#) - overall importance of and techniques for studying indentation.
  - a. Status/Background: This is the most important issue to be addressed in a pre-proprietary way.
  - b. Challenges: The lack of collaboration in glass research in the past has very seriously hampered glass progress, even though in many cases glass scientists did the earliest and most original and innovative work.
  - c. Plans for research to move forward:
    - i. Description of the techniques to be applied in this study, especially the use of stress birefringence.
    - ii. List the number of new techniques of great promise, some of them requiring additional work to make them fully useful to the study of glasses.
2. Dr. Richard Brow, Professor, Missouri University of Science and Technology – [Inert intrinsic strength](#). Composition/processing effects and possible relaxation effects. Importance to damage processes.
  - a. Status/Background: We have used 2 point bending to study the intrinsic strength of glasses.
  - b. Challenges - Composition and processing effects are shown to be extremely important.

- c. Plans for research to move forward: Since the intrinsic strength is directly related to the sensitivity to contact damage, such strength studies are necessary. We will need to show that there are possible relaxation effects seen in such studies that may be critically important in the damage processes.
  
- 3. Dr. Carlo Pantano, Professor, Penn State University – [Coatings](#). Coating parameters. Use of Hertzian contact in understanding coating behavior.
  - a. Status/Background: Hertzian contact is being used to measure the threshold for surface cracking and the effective surface modulus on commercial float glasses, both with and without coatings.
  - b. Challenges: While there are distinct effects of the coatings, we have no first-principles explanation for those effects.
  - c. Plans for research to move forward: We need more understanding of how coatings work, what material parameters are of importance and a model to incorporate them.
    - i. The use of the stress birefringence technique should be helpful in such studies. In addition to understanding the behavior of (coated) surfaces under blunt contact stress, this approach can potentially offer a screening method for selecting and optimizing new coating materials and processes before the more laborious process of in-service testing.
  
- 4. Dr. Arun Varshneya, Professor, Alfred University – [Modeling of ion exchange strengthening by use of indentation](#). (Chuck will present, as Arun has conflicting event)
  - a. Status/Background – Substantial progress has been made in developing higher surface stresses at higher rates in the last few years.
  - b. Challenges – Even faster and cheaper techniques are necessary for this process to be used more widely and for this, more fundamental understanding is necessary.
  - c. Plans for Research to move forward - The optimization of compressive stresses in the surface of glasses by ion exchange may be simply modeled by employing indentation techniques to study the importance of both shear and volume yield points.
  
- 5. Dr. Prabhat Gupta, Professor, the Ohio State University/ Dr. Alastair Cormack, Professor, Alfred University – [Modeling Techniques](#) - Description of the range of modeling techniques to be applied to contact damage problem.
  - a. Status/Background - Description of the range of modeling techniques now available
  - b. Challenges: Development of constitutive equations for the description of indentation and scratching.
  - c. Plans for research to move forward: Coupling of modeling with experimental indentation results will allow the inverse problem of the calculation of stresses from the observed retardation to be accomplished.
  
- 6. Dr. Suresh Gulati, Corning, Inc – [Review of real world problems](#) and relevance of this basic work.

- a. Status/Background: Since glasses fail at the ‘weakest link’: that is the largest flaw, the task is to minimize the size and number of flaws. The tail in Weibull distribution is of major importance.
- b. Challenges: Surface strength can be improved. It will take resources and post processing of glass articles. The importance of introducing surface compression reliably will be stressed. Damage resistance can be maximized. Importance of coatings (where possible) and role of surface compression along with depth of compression in improving damage resistance.
- c. Plans for research to move forward: Indentation studies will help characterize real-life flaws along with stress concentration associated with them. Comparison of surface strength before and after indentation is needed to quantify changes in damage resistance.

2:30-3:00      *Discussion of priorities and funding agencies – Facilitation: Gabe Tincher/Chris Zach*

## **Technical Factors and Organizing Plans**

### *Discussion of Research*

- Does this research apply to the weakest bottle in a set of 10,000 bottles? The mean is more than adequate, but the weakest link is the problem.
- Fatigue: where is this incorporated in the roadmap?
- Seed funding: Pantano expressed need for some initial funding to perform research (“prime the pump”) to produce a competitive proposal (for the Abrivo tool)
- Cannot jump directly into requesting big funding from government without laying a foundation of partnership between companies and universities
- Thermal damage: are we studying thermally-induced cracks?
  - This is not in the initial stage, but can be included later
  - Requires working alongside companies to obtain real manufactured items
- Abrasion was discussed as a research topic
- Why is glass so vulnerable to process damage?

### *Priorities and Gaps*

- The goal of filling in the gap in fundamental knowledge isn’t concrete enough to sell to management
  - We need to eventually deliver a modeling tool or something tangible that can be used directly for product development
  - This vision is required before it will be possible to commit to multi-year endeavor
  - Commitment to multi-year endeavor will only evolve if coalition is able to develop a viable and challenging roadmap during their discussions. We must sell management on the concept of approving a coalition to explore the possibility of identifying deliverables.
- Development of technology roadmap can proceed in parallel but independently from initial research stage

- What does seed money cover and how much is required? It was agreed that we will request \$10,000 up-front from each glass company wishing to participate in initial stages. Funds to cover expenses of non-company experts for two meetings to initiate coalition and develop roadmap, to ensure achievements are likely and that we don't need to return to ask for more, and to support development of initial pre-competitive proposals.
  - Funds will be managed by the GMIC in a separate account and reported to coalition members on a monthly basis. The coalition that forms will determine allocation of funds not expended during initial stages.

3:00-4:00      *Present and discuss timeline – Presentation: Lou Mattos, Facilitation: Gabe Tincher/Chris Zach*

*Next steps*

- What is the right size for the coalition?
  - Need at least 2 companies from each glass sector to balance inputs and priorities (4 sectors  $\times$  2 companies/sector  $\geq$  8 members)
- Seed money is to fund ~2 meetings of companies and researchers to
  - 1) develop research roadmap and
  - 2) refine structure of the coalition
  - Roadmap and structure development can be carried out in parallel.
- During these 2 meetings, companies will decide whether to move forward and form 2<sup>nd</sup> feed fund to fund initial research
- 2 parallel paths
  - Companies building a coalition and defining a roadmap
  - NSF proposal and initial academic research proceeds.