(Credit: Flickr/Jeff.Dlouhy)

Usable Glass Strength Coalition: Patience, perseverance and progress

Lou Mattos

This case study on building an industry–university–government coalition is based on a presentation by Mattos at the 2011 Ceramic Leadership Summit.

Theoretical vs. usable strength of glass

Condition of Glass	Strength (lb/in^2)
Theoretical/lab demonstrated	2,000,000
Pressed articles	3,000–8,000
Blown ware	
•Inner surface	4,000–9,000
15,000-40,000	
Drawn tubing or rod	6,000–15,000
Glass fibers	
•Freshly drawn	30,000–40,000
•Annealed	10,000–40,000
•Telecommunication	>100,000
Window glass	8,000–20,00
•LCD (0.65 mm)	45,000
•Chemically treated cover glass	100,000–200,000

Glass always gets a bad reputation for two perceived deficiencies: It's heavy and it's breakable. People often prefer not to have a glass bottle or cup because they are afraid they might drop and break it. Or, they say it's easier to work with a lighter-weight product. These criticisms apply to many glass products, whether it is bottles or architectural designs.

We in the materials community know that glass is actually very strong. We hear and say all the time, "glass is actually stronger than steel."

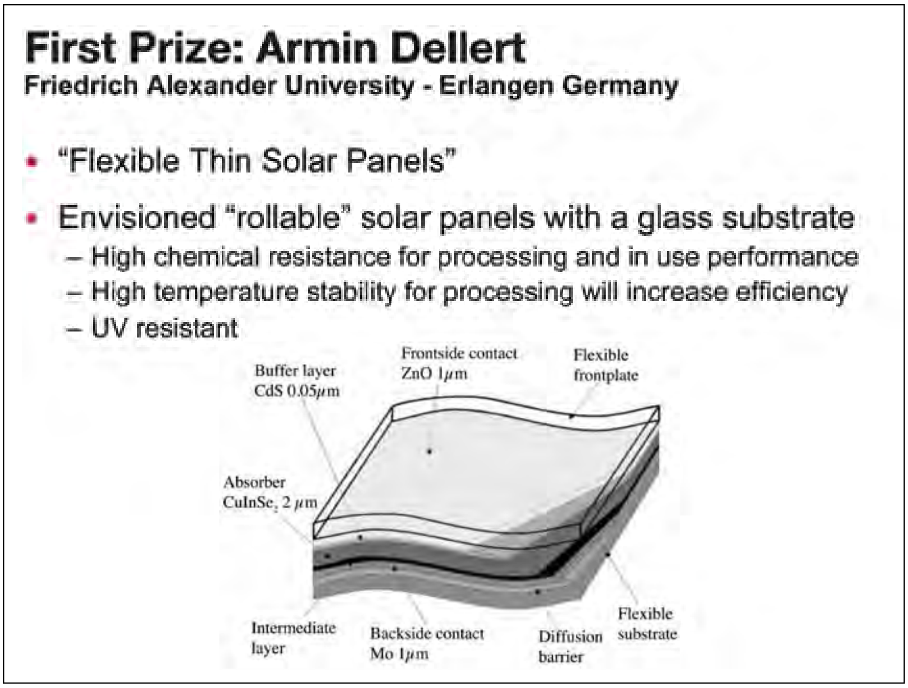
The reality is we've all seen a table of theoretical-versus-usable strength of glass, but we know that once glass articles are made, everything done to them decreases the strength. In that end, glass articles have about 0.5 percent of the material's intrinsic strength.

With glass fibers, for example, the fibers are strong when they are initially made, but as they are handled, they quickly decrease in strength. They also are attacked chemically on their surface.

One well-known strengthening technology is chemical treatment of glass, and chemically tempered smartphone cover glass is a hot product. But, chemical treatment is limited to certain applications, and because of the length of time it takes and other expenses, it isn't commercially viable for many uses.

Another way to strengthen glass is through lamination. For example, bulletproof glasses, made by sandwiching glass layers together with polymer layers, can stop a .357 magnum bullet. Another lamination example is above and on the cover of this magazine: "The Ledge" at the Willis Tower Sky Deck in Chicago—where visitors can stand in a five-sided box 1,353 feet above the sidewalk with a clear view of the city.

One more example of glass strengthening is thermal-tempered glass. We know tempered safety glass is used all through our daily life for everything, from coffee carafes to shower



(Credit: L. Mattos, Jr.; CLS 201)

What could be done if glass strength was increased by a factor of 50, from 0.5 percent of its intrinsic value? Armin Dellert's suggestion won a contest on this subject sponsored by ACerS, GMIC, CGR and NSF.

doors, but it comes with limitations in thickness and weight.

Glass strength versus strengthening glass

Perhaps it is a little unfair, but in a sense, chemical and heat tempering are ways "Band-Aid technologies." The goal is to fix problems after the glass has formed. Chemical and heat tempering, however, do not address the fundamental issue with glass, which is not to strengthen the glass but to make the glass stronger.

These are very different conceptual approaches. If I chemically strengthen something, what I'm trying to do is treat the surface flaws to stop a flaw from propagating into the glass. The other approach is to reduce the probability of a flaw being generated in the first place.

Wouldn't it be optimal to understand flaws better and understand the nucleation of flaws in glass through chemistry and through process control? Wouldn't it be better to have an improved base of glass *before* applying advanced tempering techniques to it?

Thus, the concept behind the Usable Glass Strength Coalition is to develop a qualitatively stronger base of glass and, then, using strengthening techniques, make an enormous leap up in total glass strength.

Some members of the glass community wondered, "If today we are using only 0.5 percent of the strength of glass, what would happen if we were able to increase that by 50 times, where we use 25 percent of the intrinsic strength of the material? What impact would that have on the world?"

There was a real desire to begin to grasp what that kind of change could mean. In 2007, four groups — the Glass Manufacturing Industry Council, The American Ceramic Society's Glass & Optical Materials Division, Alfred University's Center for Glass Research and the National Science Foundation — sponsored a worldwide contest and asked students what new products or engineering opportunities for cost savings could emerge if glass of any type were available at 50 times its current strength.

The response was great, with 47 submissions from 28 universities in five countries. The students came up with fascinating, creative ideas (all are available on the GMIC website), and it's worth reviewing a few of them.

The first prize went to Armin Dellert at the Friedrich Alexander University (Erlangen, Germany), who conceived of flexible, thin solar panels. The idea was to use glass that is so thin that it's rollable. His idea was to create multilayer solar cell films that take advantage of materials that have to be fired at higher temperatures, such as copper indium selenite. When these materials are used on polymer substrates and fired, they can reach only about 13-percent efficiency. Dellert calculated that if the active material and substrate could be fired at a slightly higher temperature, the efficiency could increase to 20 percent. In addition, the units would be UV resistant and generally have better chemical resistance to the environment.

Second prize went to Julieann Heffernan, from the New Mexico Institute of Technology, for her proposal to replace asphalt shingles with glass roof panels, which could be one-eighth of an inch thick and withstand the same stresses. According to her calculations, a 2,000 square-foot roof could be installed at similar costs with a weight reduction of 33 percent, plus a 50 percent increase in R-value.

The third-prize winner is really inventive. From the Missouri University of Science and Technology, Charles Rawlins' concept was for glass high-altitude balloons for weather and scientific work, and even for use as cell phone relay towers in the rural areas where it is too expensive to build a cell phone tower. A vacuum would create a lift for the glass balloons more stable than gas-permeable polymer balloons.

Emerging techniques bringing new opportunities

So, that's the "Why" of glass strength. But, when it comes to thinking about forming a Usable Glass Strength Coalition, it is fair to ask, "Why is it important to push research in glass strength now?"

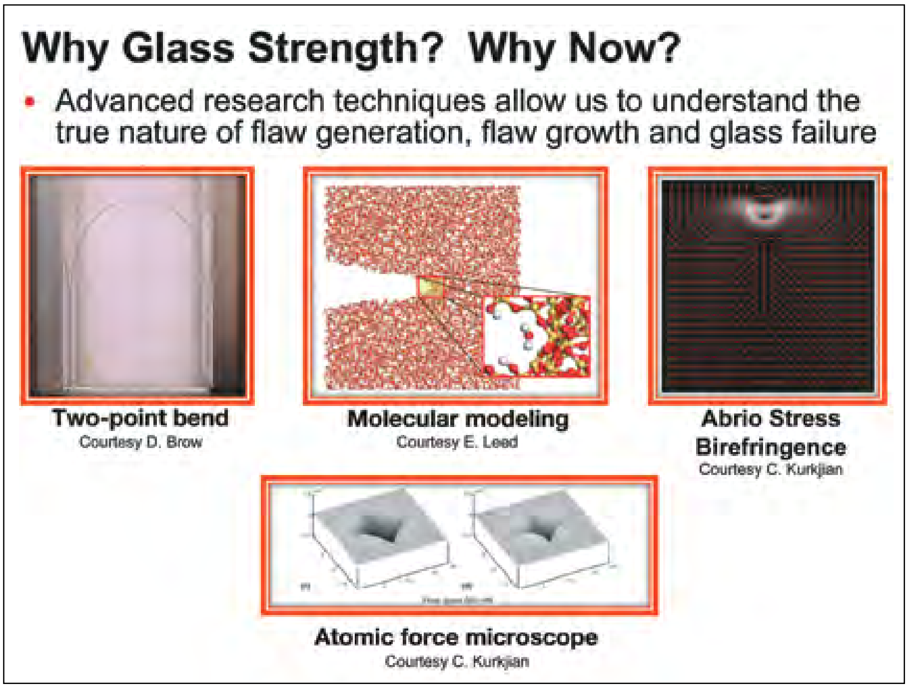
Now is a good time, because over the past two decades — despite a dramatic decline for research money for glass — there have been key advances in experimental techniques that bring us closer to being able to look at the true nature of flaw generation, flaw growth and glass failure.

One of the simpler new techniques is the two-point bend test. This and similar approaches allow investigators to remove processing effects and more accurately measure the early strengths of glass and understand compositional variations.

Another new and enabling technique is molecular modeling, a field that has grown by leaps and bounds, and, for glass, one big achievement is the ability to model flaws, see how a flaw is forming and what bonds are forming in it. We now are able to model and watch flaw growth and crack growth. Modeling brings advances in algorithms, which can now be exploited with new supercomputers accessible through national labs and universities.

A third testing method worth mentioning is the Abrio Stress Birefringence technique, which allows investigators to study the stress fields around an indentation flaw to see how the glass is absorbing the energy and to see how, for example, radial cracks are forming, how a crack can be blunted, and see where stresses are going. ASB is early-stage work and, as yet, hasn't been fully applied to glass strength.

Finally, there also have been incredible advances in atomic force microscopy, where you see indentations and relaxation of indentations, and investigators can employ optics to study the crack and its growth.



New analytical techniques are opening new opportunities for understanding why glass strength decreases early in many manufacturing processes.

The conditions are ripe for a coalition

So, we now have a stable of new, robust techniques. Unfortunately, when it comes to glass strength, the funding to put the techniques and the capabilities to rigorous use hasn't been available — thus far.

One problem is that these new capabilities are not centralized. Unlike a few decades ago, glass research is spread out among many universities, labs and private businesses.

Thus, the concept of developing a coalition to unite glass users, glass manufacturers, academics and government representatives was born as an effort to begin crafting a research roadmap, identifying public and private funding, and negotiating a method for sharing information in a "universal space."

We knew building the Usable Glass Strength Coalition wouldn't be easy and, so far, the journey has been three years in the making. It started as a loose formation of people showing up and discussing these concepts, and the early progress was due to the valuable efforts of Chuck Kurkjian, whose enthusiasm about glass strength helped the initial group push forward.

A key event for the USGC occurred in 2009, at the PACRIM conference in Vancouver. There, a glass-strength session brought together more than 100 representatives from research and industry. The first part of the session was, not surprisingly, a discussion on the reasons to focus on glass strength. Eventually, the discussion turned to one where the researchers, as a group, implored the glass industry representatives to support them. They said, "We don't have the money, but we have the tools. You need this!"

The Vancouver session led to further meetings at Alfred University, at Penn State and at ASTM in Washington, D.C. We persisted in coming together as a team so that members of industry, government agencies and universities could continue a conversation about this topic and how, collectively, we could push the research forward.

The initial phase of USGC culminated at the 2010 Glass & Optical Materials meeting in Corning, N.Y., where the interim coalition leaders obtained a commitment for a small but important amount of seed funding. After that, there was a productive meeting at Coca-Cola, followed by a meeting at the GOMD conference in Savannah, were the group was able to forge a research roadmap.

Moving from concept to progress — A longer process than expected

One drawback was that few of the key participants had coalition-building experience to apply. Furthermore, the participants were not, of course, a homogeneous group. Even the industrial representatives could be divided into two groups, depending on whether they made the glass (such as Saint-Gobain) or used the glass (such as Coca-Cola).

While the theoretical payoff of a successful coalition might be huge, there were also many risks. With no track record, justifying to one's superiors participation in this type of venture, let alone asking for financial support, wasn't easy.

However, there is a good argument for private-sector participation in something like the USGC: Most companies no longer perform fundamental research. The private sector's research is almost entirely focused on solving internal problems and manufacturing issues. Understanding this situation gave USGC supporters confidence to continue to move forward.

After the meetings in Vancouver, Alfred and Penn State, we realized that a missing piece was a clear mission statement and set of objectives for the USGC. Therefore, we crafted a mission statement that briefly shows that the coalition knows what the work is that needs to be done.

That mission statement led to a statement of our overarching objective, "To develop a precompetitive research program to identify critical parameters for improving the usable strength of glass." The key term here is "precompetitive." Competition among the companies is a very real concern, and by limiting the USGC's work to "precompetitive" fundamental research, we think we can enable companies to work together as a consortium for everybody's good.

We broke down the USGC objective into three parts. The first is to gain a fundamental understanding of methods for improving usable glass strength. In other words, "Get back to the fundamentals."

The second part — develop and standardize new tools and testing methods — is critical. We all talk about strength differently and we don't use the same tools. Some companies use a two-point bend test, some use a three-point bend and others use a ball drop. Are the tests relative? Is abrasion testing the same as impact testing, or the same as indention testing of strength? We have to come to a common language and a set of common tools.

The third part of the USGC objective is to develop the next generation of glass technical experts and researchers.

Moving forward with dual teamwork

The USGC began with two teams. One was the Core Research Team composed mainly of academic researchers. The CRT was told, "You have a lot of great ideas. Now you have to think about the way the industry would think about it. You have to put together a plan of attack on the research. Demonstrate a progression of where one step is going to lead to another, and, finally, where we might see some usable glass strength in our industries."

The other team was the Strength Steering Team, which included representatives from many US and European companies, plus some from Turkey and Japan. Prior to the 2010 GOMD meeting in Corning, the SST put together a seed-funding proposal to finalizing the "nuts and bolts" of the coalition, itself. The idea was to accomplish the administrative and diplomatic tasks of addressing the structure of the coalition, drafting a membership agreement, getting team members and their organizations to take the step of moving from "interested party" to formal membership and, finally, creating a more robust research roadmap that we could use. This work played an important part in getting the seed-money commitments at the Corning meeting.

"Glass companies cannot independently support a fundamental research agenda to understand and significantly improve the usable strength of glass. However, by working together with pooled funding and shared risk, the opportunity to significantly improve the usable strength of glass is achievable."

\- USGC Mission Statement

The SST's role continues and the desire is to have representatives from all segments of the glass industry. The SST already has "specialty," fiber and container-making interests but, currently, no flat glass representative. It has talked with several flat class companies and believes there they will be more interested when the final membership documents and roadmap are ready.

In the meantime, the SST has had good representation from manufacturers, users and even other consortiums

Initial USGC team composition

Core Research Team (CRT)	Affiliation
Brow, Richard	MST
Brown, John	GMIC
Click, Carol	O-I
Cormack, Alastair	Alfred University
Green, David	Penn State
Gulati, Suresh	Corning Incorporated
Gupta, Prabhat	Ohio State
Hamilton, Jim	Johns Manville
Huff, Norman (Tom)	Owens Corning
Kurkjian, Chuck	Rutgers U & U of S.ME
LaCourse, William	Alfred University
Pantano, Carlo	Penn State
Sakoske, George	Ferro
Tomozawa, Minoru	RPI
Varner, James	Alfred University
Varshneya, Arun	Alfred University
Wiederhorn, Sheldon	NIST
Yoldas, Bulent	Consultant

Strength Steering Team (SST)	Company
Bratton, Kenneth	Emhart
Brossia, Charlie	Retired A-B (SST Vice Chair)
Brown, John	GMIC
Cornelissen, Madonna	Corning
Greenman, Michael	GMIC
Gulati, Suresh	Corning (retired)
Hamilton, Jim	Johns Manville
Hand, Russell	U of Sheffield
Hartman, David	Owens Corning
Huff, Norman (Tom)	Owens Corning
Iturbe Acha, Enrique	Vidrala
Kurkjian, Chuck	CRT (Chair)
Lubitz, Günter	Vetroconsult
Mattos Jr., Louis	Coca-Cola (SST Chair)
McCarthy, Patrick	Owens Corning
Pantano, Carlo	Penn State
Quan, Frederic	Corning (retired)
Roos, Christian	IPGR
Sakoske, George	Ferro
Strahs, Glenn	DOE
Trenkamp, Douglas	OI
Uriarte, Alex	Vidrala
Zach, Chris	Energetics

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Key USGC meetings

- PACRIM 2009; Vancouver – June 2009
- Alfred University – August 2009
- Penn State – September 2009
- ASTM; Washington D.C. – January 2010
- GOMD; Corning, N.Y. – May 2010
- The Coca-Cola Co., Atlanta, Ga. – September 2010
- Savannah, Ga. – April 2011

(such as IPGR, which is a European container consortium). The list of current participants includes Coca-Cola and Diageo (a manufacturer of spirits and liquor), Rio Tinto Minerals and US Borax.

Progress in putting the USGC online has been slower than some had hoped, but not unreasonably so given the revolutionary nature of this effort. Practically speaking, the group has taken the necessary time to focus on three important and unavoidable questions:

- What is the membership structure?
- How do we handle intellectual property?
- What will be the USGC's long-term funding plan?

USGC membership structure

Is launching a coalition like the USGC complex? Yes, especially when one considers some basic membership questions.

For example, what is the role of non-US companies? Many companies headquartered outside the US have participated in coalition planning meetings and would like to be a part of the effort, and many of the companies are global companies with multinational facilities. But foreign participation could be a sticking point for some funding sources. At this point, the general consensus is that the USGC should be an open consortium because of the multifaceted value in having global players.

Another membership issue regards antitrust matters. When a group of companies that are all in the same sector come together, questions arise about who can join and when can they join. Can a competitor be excluded?

Finally, there has been a discussion around the idea of multiple membership levels within USGC. Would suppliers and manufacturers benefit more from the coalition's work than users? Some argue that manufacturers benefit more broadly than users, and should therefore make the greatest investments and drive the group forward. Some on the other hand, see a potential conflict with user members of the USGC who can buy glass from nonmembers of the coalition.

These are difficult considerations, and the USGC is still working on drafting good resolutions and finding consensus.

Being smart about IP

Even though the work of the USGC is defined to be precompetitive research, that doesn't mean intellectual property will not be generated, and participants assume that the precompetitive work will engender new concepts and IP that will find use downstream.

Universities and companies are accustomed to retaining control over the intellectual fruits of their work. But, the USGC already involves many universities and many companies. Does the IP belong to those that do the research or to those that pay for it? A related question has to do with the timing of membership and how that affects taking advantage of the IP. Will future members get the same licensing rights and access to royalties as current members?

Another matter is the publication of research results. USGC participants believe that publishing is very important, and they understand that anybody who is going to do the research will want to publish. But publishing again raises the openness-versus-exclusivity dichotomy.

These IP issues underline the importance of making sure that all USGC members have a full understanding of everyone's IP rights and how each can later exploit that technology.

A practical funding model: Self-funding.

Because the core concept behind the USGC is so novel, and because they have become removed from fundamental research, it is understandable that industry members would be hesitant about investing in the coalition's efforts. But, without significant early funding, there is a danger that a critical mass of research will not form.

To help shape new thinking about such an investment, the coalition's interim leaders asked industry representatives at one USGC meeting to take a piece of paper and write down the answer to this question: "If you were going to launch glass-strengthening research at your company what would it cost you, and how would you structure the budget?"

Surprisingly, the answers they wrote down all fell in the same narrow range of costs, people and time: All the companies predicted it would cost in the range of \$3–\$7 million and take about five years, with the first meaningful results coming at around the three-year mark. Although the similarity of the results initially shocked them, the company representatives admitted that it is not an unreasonable amount for the USGC to spend.

Thus, the USGC's proposal for a \$6 million, five-year effort, is in line with the industry's own thinking. The coalition asserts that a meaningful effort ultimately would involve approximately 10 graduate student researchers (at \$100,000 per year), plus equipment expenses of about another million dollars. These researchers would focus on three to five broad areas of research.

The USGC participants believe industry support for a \$6 million effort will eventually appear, but are looking for ways to "prime the pump." A university-driven concept was considered, but ultimately rejected, because glass research has become so dispersed. The USGC also considered a matching-funds approach, where companies would each put in a set amount, which would be multiplied by a government matching-fund grant.

But, what USGC participants ultimately realized is that, at least in the beginning, the coalition needs to be a self-funded organization. The reason for this is that the coalition's interim leadership believes the glass industry has to demonstrate that this effort is what it wants. They have to demonstrate to government agencies and universities that the funding is going to be there over multiple years, that there is a structure in place and that it's important to them. USGC leaders are convinced that the government will invest when it finds that glass strength is an important part of our growing economy and that we need this breakthrough work to move forward.

How does USGC put a self-funding mechanism into place? Even a \$1 million fund-raising goal requires getting 10 companies to contribute \$100,000 each. That's not an easy thing to do.

Consensus Coalition Research Program

- Minimum 5-year fundamental research
- Start applying research findings internally after about 3 years
- 10 student researchers
- \$1 million/year for students
- Equipment expenses (about \$1 million total)
- Three–five broad topics of research

\$6 million total estimated funding

Forging a roadmap

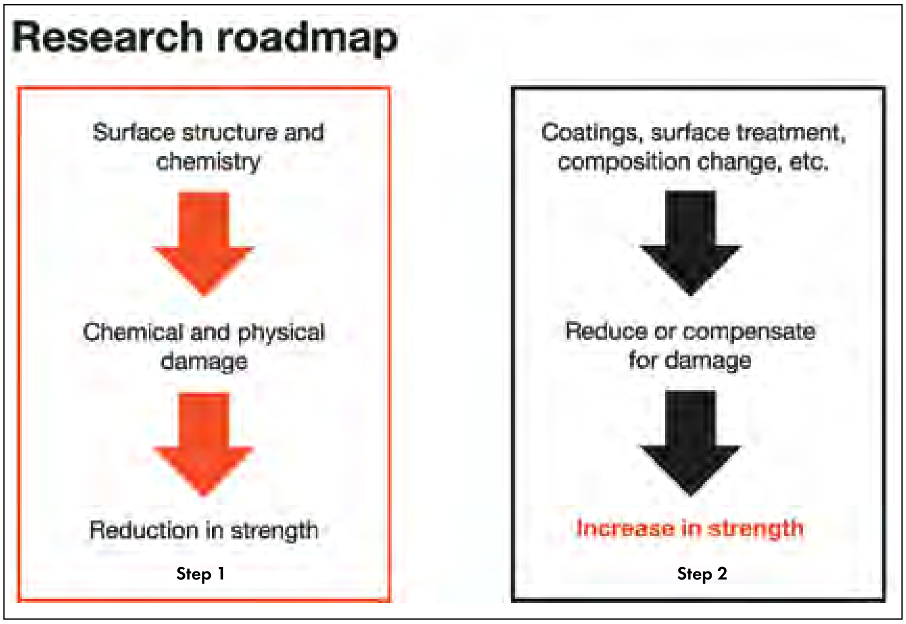
Before companies formally can be approached to invest in the USGC, the coalition needs to be able to say what the outcome will be three or five years down the road, and show them the path we intend to take to get there.

Along these lines, the coalition's Core Research Team organized a research roadmap meeting in Savannah, Ga., in 2011, led by Alistair Cormack (Alfred University). The group affirmed the need to go all the way back to flaw generation.

A basic question is, "How do cracks nucleate?" We all talk about it and say that we understand it and we know what is going on, but the tools are now there to observe what really happens to bonds. We want to put those tools together to see what's happening with weakening mechanisms, surface roughness and melt history.

Another thing we want to understand is the relationship between crack initiation and contact damage, and we have ways of studying these phenomena. A lot of people say it's a matter of abrasion versus indentation, and say they are taking this measurement using that tool. But, is it a good measure? Were the right tools used? Are the same tools being used by various groups?

Related to this, university researchers have asked glass industry members to supply them with a library of known manufacturing defects. The academics say they know fractures, have seen and studied defects and generally know where they come from. The missing piece is to understand how cracks and flaws link reproducibly to manufacturing steps. They want to know if, for example by using the Abrio method, they can reproduce the same stress fields in the lab as they see in a manufacturing flaw.



(Credit: L. Mattos, Jr.; CLS 201)

Another piece of this is knowing the differences between mechanical and chemical damage. Depending on what industry you're in, this question plays a different role. For example, in locales where Coca-Cola uses refillable glass bottles, the bottles are washed in caustic soda that is always chemically attacking the glass. Likewise, glass fibers get attacked all the time. If there is a hole in the coating, the fiber is attacked by chemicals in the atmosphere and the fiber weakens.

Regarding glass chemistry, it's not really about saying it's soda–lime versus borosilicate glass. This research is not just for one composition but for knowledge that can be applied to a specific composition. Ideally, one would like to know that a specific shift in structure could yield a significant increase in strength.

The USGC also wants to look at the role of surface structure, defects and reactive sites. There is a lot of work now on using coatings to protect glass or add functionality, but we need to understand what really is the role of the coating. Does a coating block water from getting to a flaw? Does it change the modulus inside of a crack and functionally change the inside of the glass? We have all these hypotheses, and, because the tools are in place, now it's time to take a deeper look.

Stitching the roadmap together

One key thread that runs through all of the roadmap discussion is the topic of modeling. The ability to do atomistic and finite-element analysis modeling are now a part of the research toolbox, and we need to use macroscopic and microscopic modeling of flaws.

Researchers now have the capability to visualize a flaw, introduce water to the flaw and then watch what happens to the bonds and to that flaw. They can look at the surface and model how a crack or indentation starts on the surface, which bonds break first and how the environment interacts with it. Such abilities will allow the USGC to benefit from insights and algorithms at speeds unheard of a few years ago.

To simplify the roadmap, the USGC has developed a simple, two-step graphic. The first step starts with understanding surface structure and chemistry. That is where the flaws of interest start. A component of this is understanding the effect of chemistry on surface structure, and how surface structure is impacted by chemical and physical damage. And, that, of course, leads to reduction in strength. Therefore, the first goal of our research roadmap is to have the researchers tell us why glass shows a reduction in strength.

The roadmap's second step moves in a direction that is a little more application-specific. And, admittedly, this may involve work that is no longer precompetitive research, but something that evolves into competitive research along with universities, and may be part of the coalition's function as the years go on.

Progress report

Having the roadmap gives USGC supporters something specific to show potential industry investors. However, based on feedback from potential members, USGC supporters realized that another problem was that the coalition seemed too abstract, lacking administration, management, IP oversight mechanisms, etc. It dawned on USGC leaders that the coalition needed a firmer entity to be tied to, and the most logical choice was the Glass Manufacture Industry Council. GMIC already is a recognized glass industry representative and many of the companies participating in the USGC discussions belong to the Council.

The GMIC agreed to allow USGC to operate as a separate function within the council's existing structure. Under this arrangement, GMIC members do not automatically become USGC members. Likewise USGC members will not also have to be members of GMIC. GMIC still will focus on the industry and its initiatives, but the USGC will be focused on funding universal research.

As mentioned above, to get it off the ground, the financial model is for USGC to be a self-funded coalition for the first three years. The target would be to start off with six to ten industry members, with a balance between manufactures and users. The fee is still to be determined, and it will be important to get input back from the companies. The interim leaders of our group believe the original goal of $1 million per year might not be realistic at first, and the USGC will probably need to be able to show specific value before it can get to that funding level.

Then, after the initial three-year period, the goal is to have the USGC's research advance to the point where the university representatives are in a better position to seek matching funds from government agencies because they will have built-up a research base and results to justify moving forward.

With most of the institutional and financial-model issues resolved, the biggest obstacle the USGC interim leaders have been trying to hurdle is reaching consensus on a formal membership agreement. The past year has been spent working with the interim leadership, various legal experts and company representatives to create an operating agreement that could be reviewed by potential members and signed.

This has necessitated many teleconferences among the interested parties, and progressive iterations of the agreement have been reviewed by legal counsel and those who represent typical members, including manufacturers, suppliers and universities.

After reflecting on the long process, USGC leaders concluded that it would be too difficult to gain consensus on an operating agreement that incorporated the ownership of IP by the members.

Rather than try to resolve conflicting IP interests, the interim leadership in December 2011 elected to take a new tack. They redrafted a membership agreement based on a model in which the generated IP would became public domain, an approach that would have several advantages, such as providing early access to the IP. USGC has shared this new draft with representatives of the potential member companies. At the time of this writing, the drafts are still being reviewed by management, but the coalition leaders are optimistic that consensus on an operating agreement is near.

Besides finalizing the membership agreement, the USGC interim leaders have drafted a request for research proposals. The idea is to create a highly structured RFP that also will provide potential members with more specificity about the direction research will take. Currently, the leadership is collecting feedback from company representatives on the RFP.

Lessons learned

The work of building the USGC is stressful and frustrating at times. All the participants and leaders wish it could move faster. The reality is that forming a coalition is hard work and none of us are used to doing it.

One of the biggest lessons learned is that companies join coalitions, but they don't start coalitions. The problem with getting a group of companies to work together is that they reflexively fear it will become a joint venture. Companies don't like joint ventures in these situations because they can quickly become complicated, especially with multiple companies.

USGC supporters did not want a joint venture either, and the Center for Glass Research turned out to be a positive model for the glass-strength group. It is easier for companies to join the CGR because it already exists. They find out what the CGR is planning, and then, if it fits their priorities, they join. We are trying to do something similar with the USGC.

By putting USGC under the GMIC to form this entity — the whole goal is to provide the companies with a document they can get behind and an organization they can join.

The coalition's interim leaders believe the research money is there in companies. Glass companies are coming back to funding research, including external research, and they have more money available to grow. Thus, if a coalition is there with the specific topics they are interested in, they will join.

Fundamentally, the USGC is on the right track and now is the time for its success. The interest in glass strength is exploding like never before, and there are a number of recent news stories that underline this. These stories include one company's launch of a miniature glass-bottle-blowing plant to test new processes for hardening bottles; another company's research into moving from a two-stage to a one-stage bottle-blowing process to eliminate defects; and the testing of bulk metallic glasses for high-strength new applications.

From the perspective of confirming the USGC's vision, the biggest development has come from the Erlangen Glass Group, which announced that the German Science Foundation (DFG) agreed to a $16 million priority program on ultrastrong glasses.

The point of these examples is that the interest in improving the strength of glass is a hot topic for industry, and some governments are starting to catch on to what sweeping changes could be made if there are breakthroughs in the next few years. The supporters of the USGC know now is the time for glass strength breakthroughs, and we're determined to patiently work to find the path forward.

About the author

Lou Mattos Jr. is the lead glass scientist for the Coca-Cola Co. in Atlanta, Ga. In his current role, he focuses on glass strength and coating systems to deliver increased functionality for glass packaging. Prior to joining Coca-Cola, Mattos served as a research scientist and technical manager with Saint-Gobain Abrasives and the Ferro Corp. He is a graduate of Alfred University, where he earned a BS in ceramic engineering and a MS and PhD in ceramic science. He currently serves as the cochair for the USGC.

(Editor's note: Douglas Trenkamp, of Owens-Illinois, is the current chair of the UGSC). ■