CERAMIC TECH CHAT

Episode 59

Title – “Untapped markets for chemically strengthened glass: William LaCourse”

INTRO

McDonald: “I’m Lisa McDonald, and this is Ceramic Tech Chat.

There are many technological problems in today’s world, and companies are often concerned about having enough trained personnel to tackle these challenges. That is why it’s so important to have faculty members at colleges and universities who recognize and nourish student passion for these topics, so they can successfully graduate and help develop innovative solutions.”

LaCourse: “Glass is a solution to so many problems, but there are more problems than there are glass scientists. I think it’s just important that the younger people, while they have the initiative and the desire to do these things, I think providing them with a way that might build into something bigger, I think is important for them.”

McDonald: “That’s William LaCourse, Emeritus Professor of glass science in the New York State College of Ceramics at Alfred University. Bill has conducted research in various areas of glass science, but ion-exchange or chemical strengthening of glass remains a major focus throughout all his years of teaching and working in the lab.

In today’s episode, Bill will share how several serendipitous encounters with giants in the glass field led to his employment at Alfred, highlight some of the untapped markets for ion-exchanged glass products, and give some fun anecdotes from his time as the Alfred sports announcer for football and basketball.”

(music)

SECTION 1

McDonald: “So, how is it you came to be interested in materials science and specifically these materials?”

LaCourse: “Yeah, when I was a high school student, there were really no engineering schools in the [New York] state system, and I was pretty much a family of eight. And I was the first one to go to school, and I wasn’t going to go to a private school, no question. So, I was only going to go to a state engineering school. And despite the fact that my father had come to Alfred to study when the tech Alfred state college and Alfred University were one—he was a student at the Alfred state institution and he was actually a short order cook at the local restaurant—and I knew that, but I didn't recognize Alfred as being a place that I would go. So, I ended up going to Stonybrook.

I ended up pretty much flunking out, but I said, 'Please, take me back,' and they did. For some reason, I then went from one Dean's list to another Dean's list in one semester, and finally I had a good enough acumen at the end of the four years—it wasn't brilliant, but it was okay—and they wanted somebody to work on a particular project. So, I got to work on two projects.

One was an artificial kidney, which delighted the heck out of me. I mean, I thought, 'Wow, working on an artificial kidney.' It was wearable, okay? A wearable artificial kidney. And it just really got me, but I couldn't see myself in a career because back then, biomedical materials weren't a huge place to go get a degree. This was 1966, 1967. And so, in order to make money, I did work on glass fiber for a professor who didn't even know what the definition of a glass [was], but he certainly knew other stuff. But I did find this glass really interesting.

And I had to write a big report for Owens-Illinois [O-I Glass, Inc.]. So, I had to research glass, and I came to this book called *Glass-Ceramics*. And I went home one night, and I stayed up all night reading this technical book about glass, and I just couldn't believe all these things could be done. I mean, right now, I'm so overcome just by the thought of that again, and it's still true today.

So, I got so excited about glass that every course that I took on the graduate level, I somehow got away to write an article or a paper for the teacher on glass. And I wrote one on the boric oxide anomaly, which is one of the biggies in the glass field, okay? And then, all of a sudden, this guy named Mackenzie, [John] Doug Mackenzie, came to Stonybrook. And he at that point was, I mean, I knew who he was because he wrote a couple of books, and he was just the leader of everybody.

And he came, and I talked with him, and I said, 'You know, I'm not that great a student, but I really would love to work for you.' And he didn't say anything, but when he got back up, and I, so, he tells this story, that here I am, this pretty much flunky [student], and I'm writing to him, telling him what I thought the boric oxide anomaly really was and how it worked and all this stuff. And he said, 'I've never had a student trying to tell me something that they knew nothing about.' And he said, "I just couldn't turn him down!' So, I got to work for the best, the most famous glass scientist in the world at that time. And he started the journal called the *Journal of Non-Crystalline Solids*, okay? Doug Mackenzie.

And finally, I just, he left and went to California, UCLA. I stayed behind for about six months and finished my thesis. It made me finish it really quick, and I then, I screwed up an interview, so I didn't get a chance to have a real job. So, I went as a post-doc to the Naval Research Lab, and there I got to meet some really great people, I was working on properties. But it was 1970, and in 1970, if you had a Ph.D., you didn't have a job, okay? There were no jobs for Ph.D.s.

And I get this call from Alfred, New York, and it was David Pye, and David Pye called and said, ‘I was talking with Doug Mackenzie, and he said that you might be an okay guy to come teach.’ And I said, ‘Teach? I’ve never thought about teaching. I could hardly learn myself. I mean, how am I going to teach?’ I didn’t say that to him, actually. But I thought that. So, at any rate, he said, ‘Well, why don’t you come up for an interview?’ And as things happened, I mean, things just happened out of the blue to me, and I feel so owing. I mean, I just owe the world something.

I came to Alfred, and Dave Pye, wonderful person. Have you met Dave?”

McDonald: “I have. I love him.”

LaCourse: “Yeah, great guy. He’s just wonderful. And we hit it off from day one. I came up here on I think it was a Wednesday, and I went home on Thursday, and I got a call Thursday night saying, ‘Come on up.’ And, again, it was just serendipity in the sense of the personalities met, and the need met.

And I came and I had literally knew nothing about glass. I mean, I had worked on that one little project, but that was all I really knew; I never got a chance to take a course in it. So, I was going to teach a course in glass here, and so I had to really learn it and everything. And I’m sure I screwed up for a long period of time, but I also probably came in with a different point of view.

And so, then teaching or doing research here at Alfred University for 50…this is the 54th year. Taught for essentially 51 of those years, and now I’m a research faculty, so I’m teaching in the laboratories. And I did many different things; I did not stick with one thing.”

McDonald: “That’s a lot of fun.”

LaCourse: “Yeah, lot’s of fun.”

(music)

SECTION 2

LaCourse: “So, the first thing I got involved with was, Dave said, ‘I want you to write a chapter on strength of glass in this new book,’ that was coming out. I’ve never done anything in strength of glass, so I had to learn all of it. And I wrote like a 50-page article on it, strength of glass, and I learned so much from doing it. And that led me into research areas. I got into the effect of flaws on the strength and then doing ion-exchange strengthening of glass.”

McDonald: “So, how does ion exchange work to make the glass stronger?”

LaCourse: “So, ion exchange, the best word I can come up with is it’s stuffing. So, you take this material, and you take a little tiny chunk of that material out, like a sodium ion. And you say, ‘Okay, now I’m going to shove this big atom, potassium, back into the same place that that sodium came from.’ So, you gotta kinda push it in, and as you do, it pushes out on the rest of the structure, right? And so, as it does that, if I do that all over the place, if there are cracks in the material, then the cracks get closed by the compression that’s generated from these larger atoms entering a smaller location than they really want.

So, ion exchange is done at a temperature where the structure itself cannot change. When it was melted, it was melted at a temperature where the sodium ion is sitting in the glass, and now you come along and you take those sodiums out just by putting it into a liquid where there are no sodium [ions]. And the sodium is moving around, and then once in a while, they’ll jump into the liquid, and they have to be replaced by another positive charge. And if you only got one sodium in there and 18 trillion billion of potassiums, potassium will jump in under the electric field. So, it goes in and it stuffs itself into the sodium site.

And that occurs deeper and deeper and deeper into the glass. So, at the surface, you’ll have a lot of potassium ions in the glass, and there’ll be a lot of compression, and so the cracks at the surface are closed. But as I go deeper into the glass, then there’s less and less potassium, and the compression is going smaller and smaller. And then eventually, there’s no potassium, and all of the compression that was put in at the surface has to be balanced by a small tension in the center of the material.

And that’s also true of safety glass, where you’re thermally tempering instead. And in those cases, you get large stresses, very thick areas, and then the center of the glass is under a fairly high tension. So, when a crack does get to the surface, like in safety glass, it explodes into pieces, like tiny pieces. Ion-exchange glass doesn’t explode into tiny pieces; it breaks into fairly large pieces, which is a problem of safety relative to, for instance, safety glass. So, that’s the basic thing. So, you’re creating a compressive stress.

There is another way to do it in which you take the sodium out and put a potassium in, but you do it at a higher temperature. Now the glass structure is able to rearrange and become different. Now it wants to become a sodium–potassium glass, and it has the structure of a sodium potassium glass. And there are some cases where that structure will have a lower thermal expansion coefficient, so that when I cool the material, the surface only wants to contract a little bit, but the inside wants to contract more. And when the inside contracts more, it pulls the surface into a compression, and you get strengthening. So, that would be nice, but there’s not that many cases where that works. But there are a few, there are a few.

And then, of course, the other ways of ion exchange are not for strengthening but simply to change a color. I can make a surface change color by removing sodium and putting in copper, or I can remove sodium and put in silver. And so, there are many different kinds of opportunities that way as well. But the big deal is the chemical strengthening.

And that's where the problem comes with soda lime glass, is that the glass that everybody makes is not made to do ion-exchange strengthening. It just takes too long for the alkali to move in from the surface, whereas Gorilla Glass from Corning is made from a composition in which the atoms move very quickly. Unfortunately, they're very, very expensive to make, and so they're not used as much in windows, for instance."

McDonald: "So, most of our soda lime glass, then, is strengthened through thermal tempering. So, how does thermal tempering different from ion exchange in the way in which it makes the glass stronger?"

LaCourse: "Okay, so, in the chemically strengthened glass, you take the whole glass, and you'll see it's rolled on rollers, and they make it really hot. And then all of a sudden, it goes to a temperature where the glass is actually a liquid, although it's extremely viscous. It's like, you know, a syrup in a 10-degree-below zero temperature; it's not really going to move around. And that's why they move it back and forth on the rollers, so that it never gets the chance to sink, okay, or to change shape.

And then they blow air on it from both sides. And it cools the surface to a solid, but the inside is still a liquid. It's very, very viscous, but it's still a liquid, and it continues to cool. The outside is now a solid. It can't get much, much smaller; it's already a solid. But the inside gets smaller, and it pulls the surface together such that if there's any cracks present, they close, and that's what gives it the strength.

The problem there is that if I have a really thin glass, I can't get the temperature difference between the surface and the inside to be big enough. So, when you blow it, then, well, the whole thing just gets solid too quick.

So, at any rate, thermal tempering is used down to about a thickness of 2 mm. And that's where there are some issues being generated in solar glass, solar panels."

McDonald: "So, let's talk about that a little bit. I know that there was a report that came out recently that was talking about a rise in spontaneous breakage of solar panels that has been going on. Why is that occurring?"

LaCourse: "Well, they're failing, and part of it is they're getting, to save weight, to save money, they were previously working with 3 mm sample thicknesses and now going to 2 mm thicknesses. And the ability to strengthen the 2 mm glasses are much, much less than for 3 [mm]. There's formulas that will tell you I can get maybe 100 units of strengthening with a 3 mm, and I'm down to like 40 with 2 mm thicknesses.

So, if there's not enough stress, and it's amazing, I can show you pictures that when you drop a hard particle, even like ice or hail, that hail has the velocity, and when it hits the glass, it causes a crack. And if there's not enough stress there to prevent that crack from forming, then you can get a flaw there. And, with time, that flaw, if there's more stress just from wind or whatever, cracks can grow very slowly in the glass. So, you can get time going on, and then eventually the glass just will fail at very, very low stresses. Just push on it and it will break.

So, what they're getting is not enough compression in the surface to give it high strengths. They're not going to get it from thermal tempering. You can do it with ion exchange strengthening, but it's going to cost you probably a doubling in the price, if not more, of the window. So, that's a real issue nowadays, and one that I've been pushing over the last year. I'm trying to say that, you know, there are markets out there which would benefit and safety issues that would benefit from having a less expensive glass that would rapidly ion exchange. So, that's one of the final areas that I'm working on in my whole career, and we just gave a paper announcing what we think is an advancement in that area.

And it's not just strengthening. If there's a large volume issue, and we're trying to use soda lime glass, if it takes a little bit different composition, it's just not going to be possible. It seems so silly, and yet it's the economics. I mean, I can understand a company not doing it because it's going to cost them money to do it. They'll have one market but might not be as huge as the others. And they'll make money off that, but it is cutting back on this commodity material."

McDonald: "So, like you talked about, there are some of these applications where chemical strengthening, we just might not have the time to use it, it might be too expensive. But what are some of the applications you've been involved with as end markets for this chemical strengthening, ion strengthening process?"

LaCourse: "I think probably people are familiar with the company, or many in the glass area are familiar with Saxon Glass. Saxon Glass was started by myself, doctor [Alexis] Claire, and doctor [Arun] Varshneya, a way long time ago. Doctor Varshneya remains with the company and has been the president for many years.

Saxon Glass, the way we got the business was I got a call one day from a company that made EpiPen containers, the little ampules. And they'd been doing a thermal temper on them, and they don't temper very well. Well, yeah, surprise. If I said 2 mm is a problem, then 1 mm is even more of a problem."

McDonald: "Yes, it's just like we talked about with the solar panels. Something very thin does better with the chemical [strengthening]."

LaCourse: "Exactly. So, I listened to them and I said, 'Well, could you send us some samples?' And they said, 'Yeah, we'll send you some samples.' And we took the samples, and we did a quick ion exchange.

Our company was not anything to do with ion exchange. We were dealing with chalcogenide glasses, okay, which were a big thing back then, and ion exchange wasn't. But we strengthened these glasses and went 'Wow. You know, it only takes us X hours, and we get the exchange done.'

And so, we send them back, and they give us a call back pretty much immediately, and they say, 'Well, wow, can you show us how to do this?' And we said, 'No, but we can do it for you maybe.' Because, lo and behold, I had just gotten a gift of an ion exchange bath from a company in the Midwest that took a liking to me, and I was a consultant for them, and they were doing ion exchange, and they wanted me to do a lot about ion exchange.

So, I had this thing, and I calculated the ampules are about this big and about this big around, and I said, 'I can do about two, three thousand in one treatment,' okay. So, we said, 'We would like to bid on how much it would [cost] to do this.' And we bid some exorbitantly low price because we were going to make money. I mean, we weren't really out to make a lot of money in the beginning. And so, we did that, and we got the bid, and I think the first year we made a million, we strengthened a million ampules.

And they were thrilled because there were no failures. People were getting a measurable percentage failure, 1, 2, 3%, of the glasses that were done by thermal tempering. And here these ion-exchange glasses were not failing at all. And I think doctor Varshneya can tell you that has continued and probably improved over the years, in that these ion-exchange ampules are just unbelievably reliable for the EpiPens for which they're used.

So, I think that there's people out there, and I'm just a little too old to do it, but if I had advice to talk to some young people, I would say, you know, there really are some applications of ion exchange, chemical strengthening, which need to be brought to market. Just as we talked about earlier, these flat pieces of glass that need to be stronger for solar energy. And so, you need to work on that."

McDonald: "While Bill enjoyed being part of the early success at Saxon Glass, he would like to emphasize that his good friend Arun Varshneya was the business leader, who managed the company and is primarily responsible for its current status. While Bill left the company after about five years, Arun continues to lead this quote 'wonderfully creative company,' which remains an active success."

(music)

BREAK

McDonald: "The Glass & Optical Materials Division of The American Ceramic Society focuses on the scientific research and development, application, and manufacture of all types of glass, including fiber optics, the encapsulation of nuclear and hazardous wastes in glasses, and the interaction of glass and ceramics in biosystems. Learn more about and join the Division at ceramics.org/gomd."

SECTION 3

McDonald: "You've gotten to mentor and work with so many students during your years here at Alfred. But there's also, outside of the research laboratories, you've been able to engage with, have fun with students as well on the Alfred campus community. And that has been through your work as the women's basketball coach. So, can you tell us a little bit about what it was like stepping outside of the laboratory and getting involved in the Alfred community in this way?"

LaCourse: "Yeah, well, I've always been a sports lover. So, it's happened a couple of times, I get asked by the coach in women's basketball if I'd like to help out just as an assistant coach. Because she'd be playing every day at noon with the students, and so I said, 'Well, that sounds interesting. I'd really like to do that.' And so, I got involved with that. I probably was an assistant coach for 12, 13 years.

The other thing that I got heavily involved in was announcing of the local football and basketball games. I think that was because, again, it was because my real love of sports, and I would always be at the gymnasium working with somebody, and I would go to all the football games and all that stuff.

So, anyway, I got asked about five years after I got to Alfred if I'd like to announce football games because the person who had been doing them had passed away. So, I gave it a shot, and I did it for 45 years, announcing the football games. And I was a very unusual announcer. To me, the Division III football, although very serious to the students and things, it needed to be, I don't think we should take it too seriously. So, I would joke around a little bit in the announcing, and I got to be known for doing that. Some people liked it, some people didn't. But I did last for 45 years."

McDonald: "Well, and I also heard you had a unique way of getting some of your science students to come to the game. So, what was that story?"

LaCourse: "Well, there would be many different ways, but the way that I enjoyed was, for instance, telling them that if you come, I have a test on Tuesday, and, you know, Saturday is the big game, I'd like to see a big crowd there, so come on down. I promise you when you get there, at halftime, I will announce the answer to one of the problems and maybe even more than one of the problems.

And so, they would get down there, and some of them I think came down at halftime, they didn't really go to the game, but looking for that free answer. And so, I'd say, 'Okay, the answer to one of the questions here in between #14 and #20, the answer is false.' And so, I said, 'That's worth two points of the 300-point exam.'

So, I wouldn't do that exactly the same every year because people would catch on to it, but they knew that I wanted them to come to the game, and they would always yell at me and say, 'Here I am, Doc!' I've always been known by Doc. There's no other name that I recognize."

McDonald: "But, you know, this sounds like a really great way to engage with the students, having them come to the event, encouraging them. It might be a little tricksy, but it's all in good fun. And it also shows the students that you're a person, you know, besides just the scary person grading their tests, which hopefully can make it easier for them to come to you with questions."

LaCourse: "I think so, yeah. They know I'm approachable, and I joke. I'm a very sarcastic person, okay? I'm sarcastic with myself, but I'm always knocking myself purely for letting the students know it's okay, you can joke with me."

McDonald: "So, I know we are getting near the end of our time. But with being so involved with the glasses, how is it that you came to know about and join The American Ceramic Society?"

LaCourse: "Probably did the first year that I was here."

McDonald: "As a faculty member?"

LaCourse: "Yeah, as a faculty member. People at Alfred are really part of the Society; it was our Society. So, I felt the need to do it. And as I say, I mean, I thought that it was, I mean, and it still is, a great service.

You know, I feel guilty. I've not done enough for the Society. But in terms of getting people to go to the meetings and taking advantage of all the great things that The [American] Ceramic Society does, that's my donation, I guess, to the Ceramic Society are people who love the field, and I think they catch it from me, in some sense. I really love working on the material and seeing what it can do for society."

(music)

CONCLUSION

McDonald: "Glass has played an integral role in human civilization for millennia, and it continues to provide new opportunities for technological advancements in today's world.

I'm Lisa McDonald, and this is Ceramic Tech Chat."

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"Visit our website at ceramics.org for this episode's show notes and to learn more about Bill LaCourse and ion-exchange strengthening. Ceramic Tech Chat is produced by Lisa McDonald and copyrighted by The American Ceramic Society.

Until next time, I'm Lisa McDonald, and thank you for joining us."