>> Lisa Friedersdorf: Good afternoon. My name is Lisa Friedersdorf. I'm the Director of the National Nanotechnology Coordination Office, and it’s my pleasure to welcome you to the webinar this afternoon. This is a kick off to some entrepreneurship activities that we have planned. The title of today's webinar is “Nanotech Entrepreneurs Share Commercialization Challenges and Successes.” First, we have Dr. Angelique Johnson, the founder and Chief Executive Officer of MEMStim LLC, a start-up that produces implantable electronics to treat neurological disorders. An expert in lean start-up methodology, she has educated students on building successful companies. Prior to earning her PhD in Electrical Engineering from the University of Michigan, she worked on brain and cognitive science projects at the Cleveland Clinic, MIT, and the California Institute of Technology. Our second panelist is Dr. Christopher Schuh. He is the Chief Scientist at Xtalic Corporation. Xtalic provides nanoscale engineered alloys for use in multiple sectors. Dr. Schuh is also the head of the Department of Materials Science and Engineering at MIT and Professor of Metallurgy. He received his PhD from Northwestern University in Materials Science and Engineering. Our third panelist for today is Dr. Gleb Yushin. He's the cofounder and Chief Technology Officer of Sila Nanotechnologies, which develops and manufacturers silicon-dominant anode materials for next-generation lithium ion batteries. He's a Professor at the School of Materials and Engineering at the Georgia Institute of Technology and Editor in Chief for *Materials Today*. He received his PhD in Materials Science from North Carolina State University.

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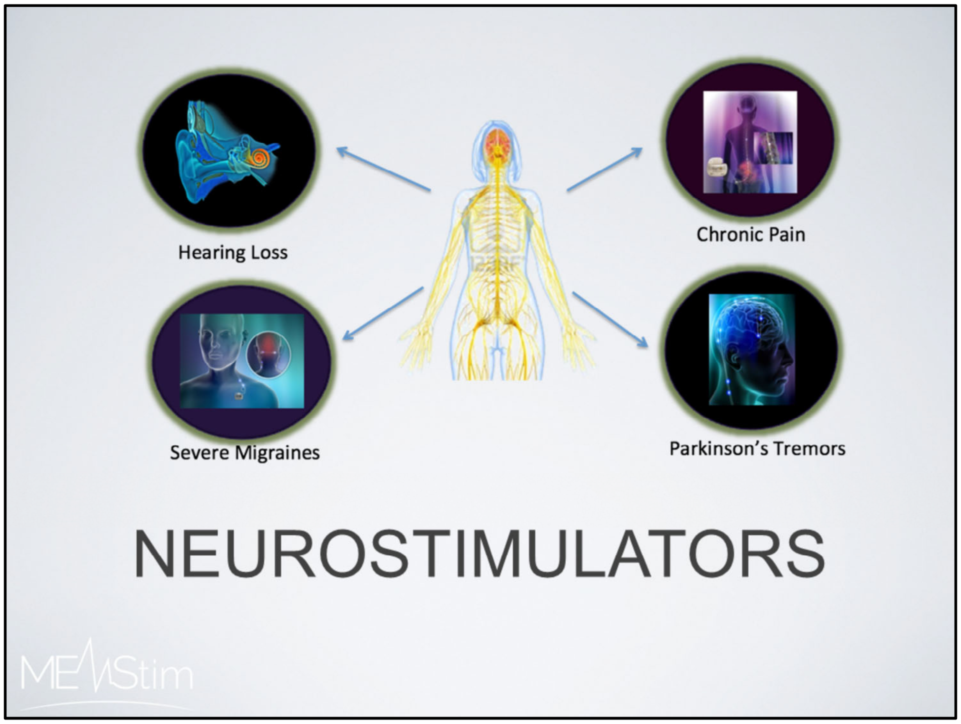
Nanotech Entrepreneurs Share Commercialization Challenges and Successes
3 Key Takeaways

1. Think like an innovator, act like a manufacturer. Science does not sell, innovations sell.
2. Explore platform materials that can be used again and again to generate a family of materials, and thus a family of products that will build long-range value.
3. As a start-up, a poor hiring decision can have a long-lasting, negative impact on your company. A slow hiring process can frustrate candidates, but a sound talent acquisition strategy will preserve your company culture.

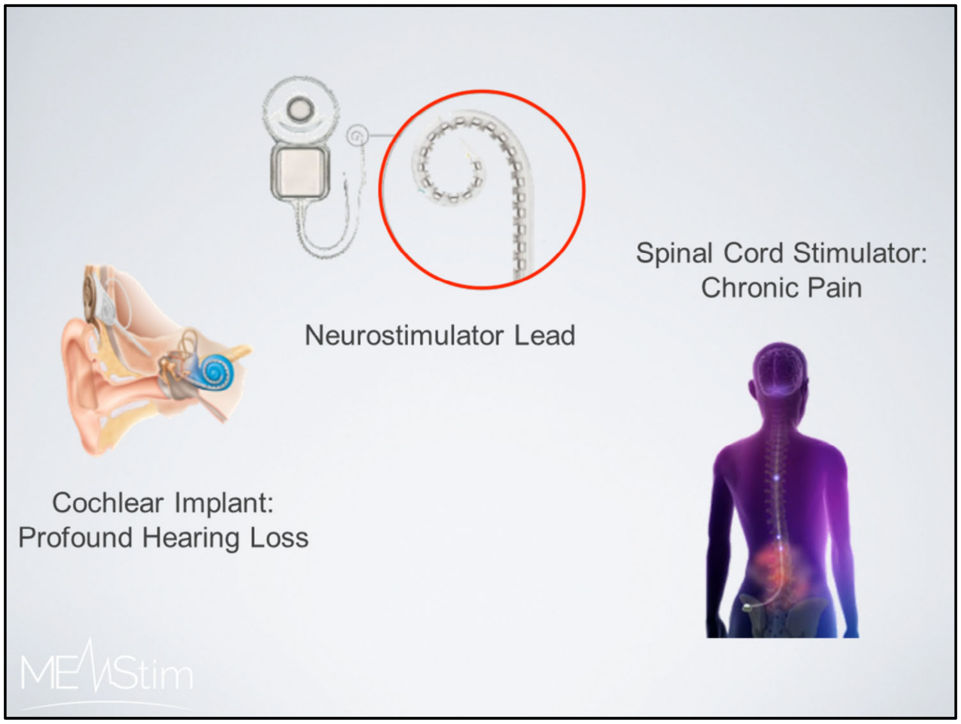
>> Lisa Friedersdorf: We will begin with Angelique

>> Angelique Johnson: Good afternoon, I'm the CEO and founder of MEMStim, LLC. We create neurostimulator leads using microfabrication and nanotechnology.

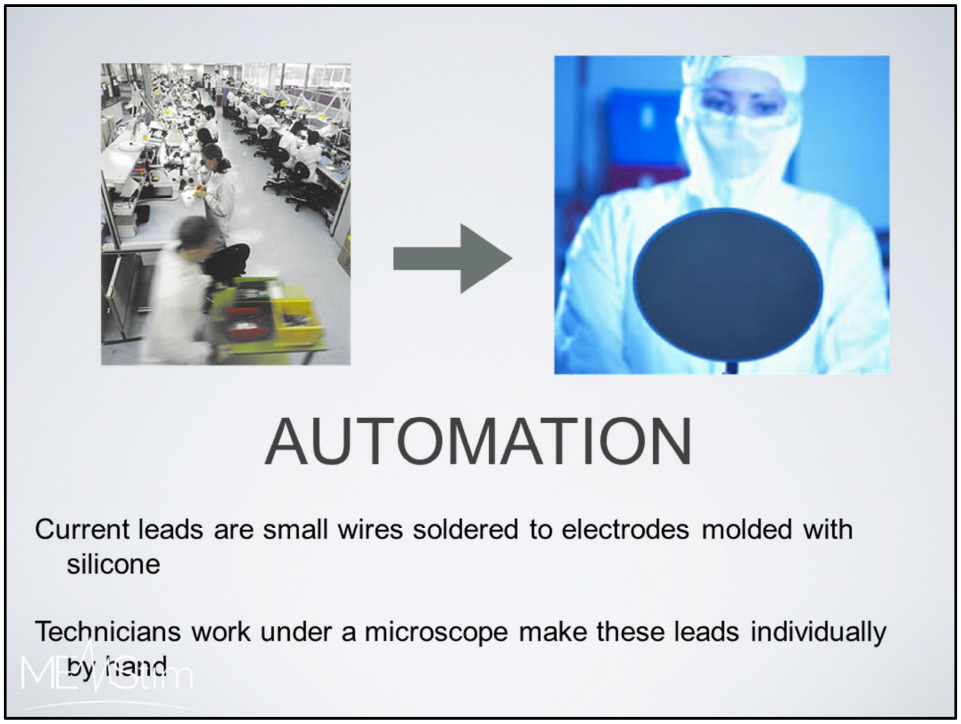
>> Angelique Johnson: I'll give a little background, but I'll focus my few minutes on entrepreneurship. So my take away for today is think like an innovator, act like a manufacturer. I'll get into what that means.



>>Angelique Johnson: For MEMStim, we work with neurostimulators. Any implanted stimulator: it could be different parts of the body, it could be hearing loss, copper implants for that, or deep brain stimulators—for Parkinson's tremors, stimulators for chronic pain, and a host of applications including implants, stimulators for severe migraines, obesity, and things like that.



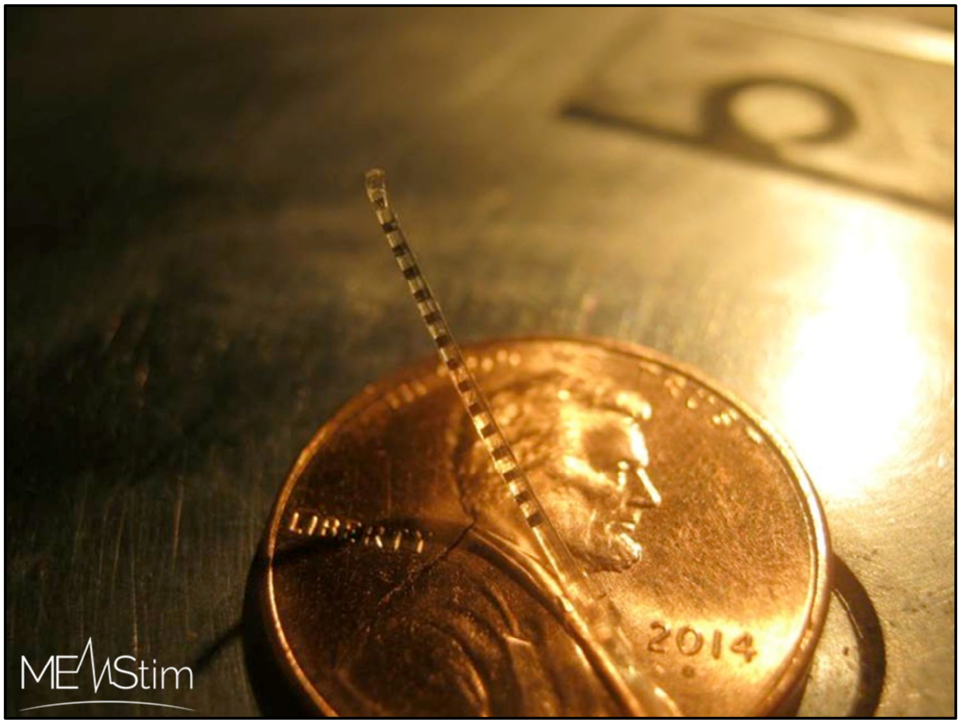
>>Angelique Johnson: All stimulators are made of two critical internal components. The first is the pulse generator, and the electrode lead that actually interfaces to the nerves and neurons, stimulating areas to restore or deliver some therapy. Cochlear implants and spinal cord stimulators are two types we're targeting, with cochlear implants being our initial market.



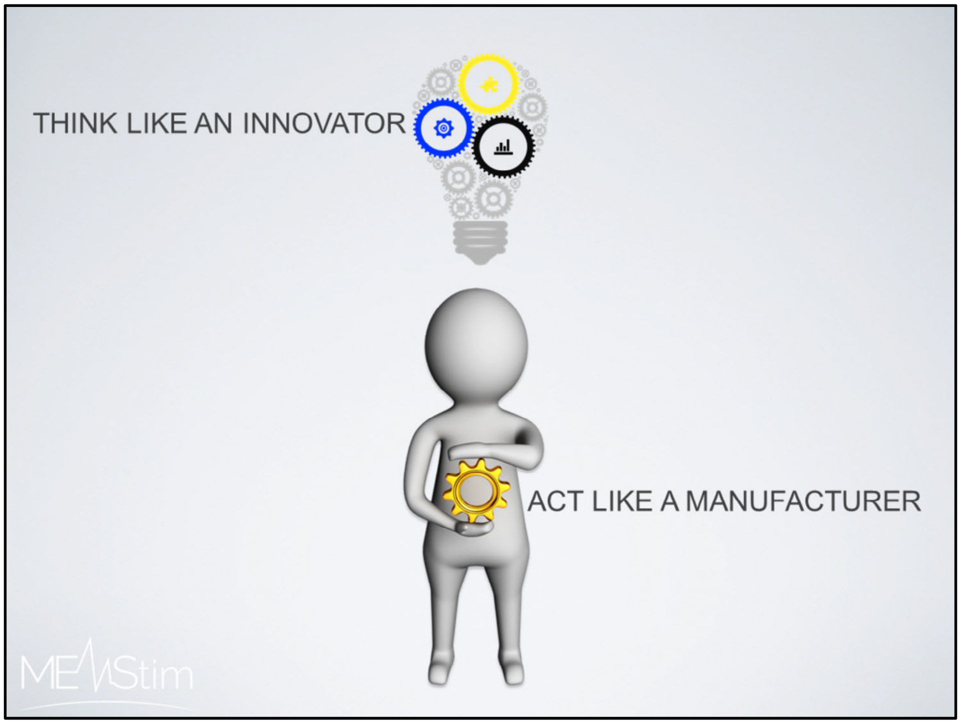
>>Angelique Johnson: And for that, what we're focusing on is how we get those electrode leads away from the hand assembly process, that is currently being used, into an automated technique. The leads are soldered together, small 25 micron diameter wires are being welded to platinum balls or foils a couple hundred microns on the side. Although this works and has good results in terms of long-term stability, it's a low-yield process, and there's not much to innovate when assembling things by hand. There is a lot that can be gained by moving to a more automated microfabrication technique where you're not only getting better cost benefits and better yields, but can add things into that technology as well.

>>Angelique Johnson: When we started our company, in the beginning, we had all these wonderful ideas of features and things we were going to put on it. We were going to have rings to control the stiffness, or microfluidic channels for drug delivery, the array going into the ear for surgical purposes, all these things. But we quickly learned, although we were envisioning these performance-enhancing applications, what the markets were demanding was not all of these benefits.

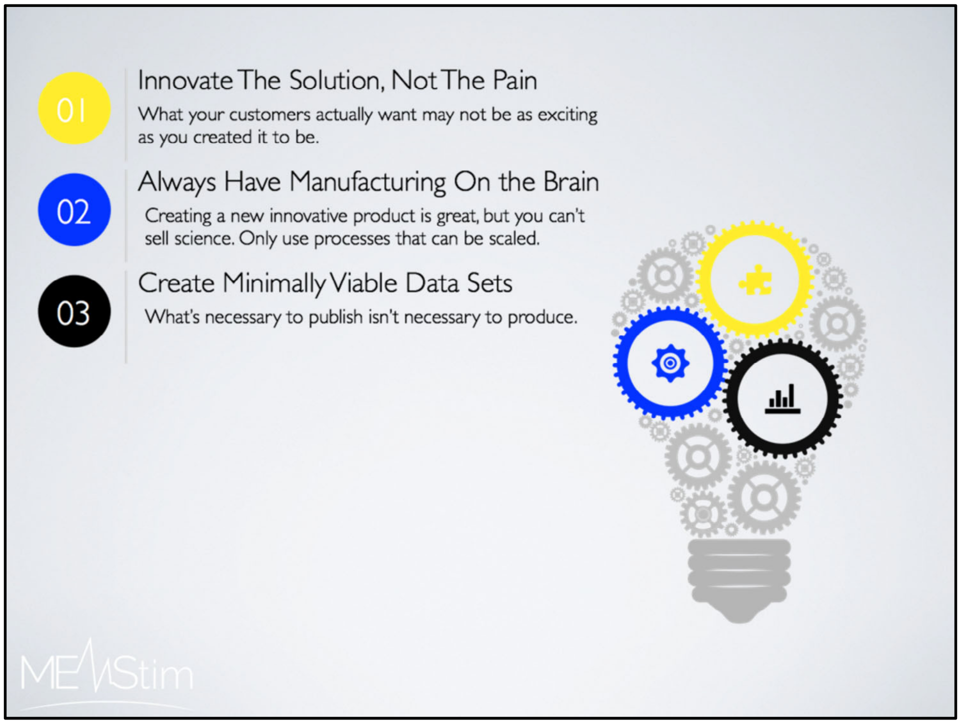
>>Angelique Johnson: They were looking for a stable, reliable manufacturing method that was, yes automated, but more importantly, would get to the FDA.



>>Angelique Johnson: We took a step back and went and made an electroarray which, in terms of performance, performed very similarly to current technology, but, in terms of the manufacturing process, it's wildly different than what they use today. When we have this manufacturing process fixed down and we get something that can be used in a human, then we can go back to all those performance-enhancing features. But really, that wasn't what the markets were requesting; they knew what they could do with microfabrication—every company had been working on it for several decades—but the bottleneck was being able to create something not only smart, not only automated, but really, more important than that, durable, and can stay in the body for a long period of time.



>>Angelique Johnson: That gets me into my last few minutes of my talk. Think like an innovator, act like a manufacturer. What that means: we come out of the academic setting; a lot of times we think like an innovator and act like an innovator. But when you're commercializing a product, you have to act like a manufacturer, but innovate your way through those solutions and challenges. One key area that I think a lot of companies miss out on, or we miss out on, initially—coming from an academic setting—was things like, how do you scale the process? So, it's one thing to build it in beakers, one thing to build it in a university clean room facility, but a totally different thing to have large production models. Thinking about your supply chain, how to get access in a “nano” area, how to get reliable access to nanomaterials, and things like that.



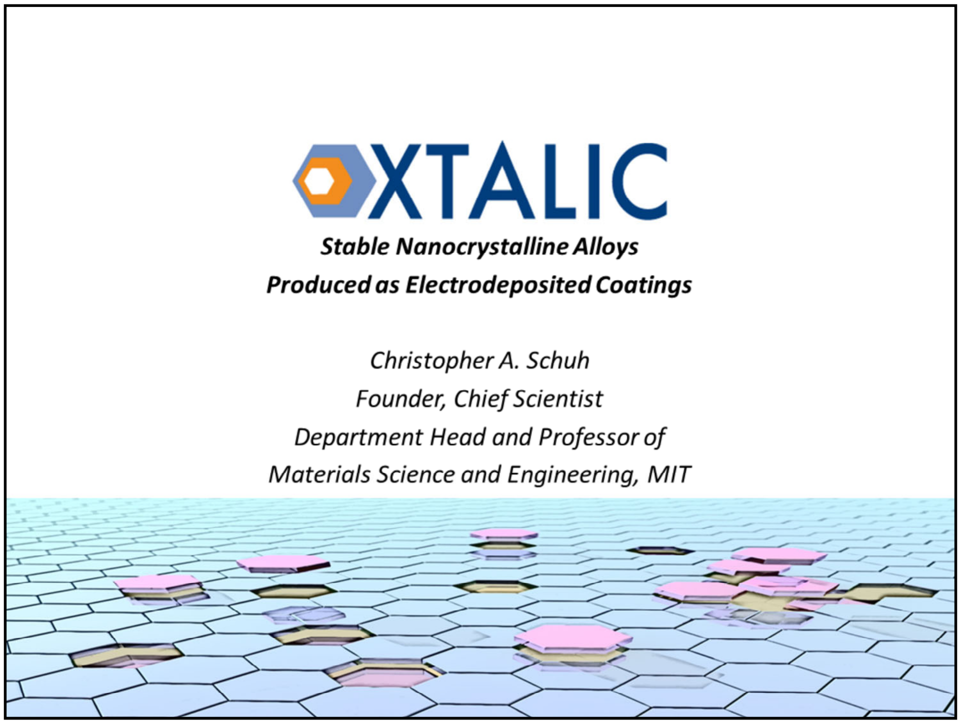
>>Angelique Johnson: A few suggestions for anybody that is in the nano area or the MEMS area:

1. Innovate the solution, not the pain. What customers want might not be as exciting as what you intend it to be. We tend to write publications and we write grants, and we think of the broader impact as an afterthought, so we innovate this wonderful, you know are we going to solve the world's pains with all these features we have? But when you go out and talk to customers, especially in a medical device, we find out that what they need may not be as sexy as you were hoping. But, how to get them what they need, although it's very simple, requires a lot of innovation, and that's really an area that I think some great strides could be made in.

2. Always have manufacturing on the brain. Creating a new innovative product is great, but you can't sell science. Publications are one thing, but in terms of a physical device or service that a company can use, you have to keep in mind that everything has to be scaled. Do you have enough access to the materials that you need to make thousands of these devices? Is the equipment you're using to manufacturer it based on one-off, hand-made tools in a lab setting or can that be expanded into a manufacturing floor in a larger setting?

3. Create minimally viable datasets. What's necessary to publish, isn't necessary to produce and it's a hard habit to break, but as scientists and engineers, you want to analyze every aspect of the research and development process, you want to get a lot of data, to see why something works, why it doesn't work, do a whole bunch of testing. But the testing you need to do to show that you can produce this and it does meet the specs that your customer wants, it's a different set of testing. Sometimes, you get distracted by going off on what may seem like an interesting avenue, in terms of testing, but it's actually not needed or useful in terms of creating a product that can be sold.

>>Angelique Johnson: So that's all I'll say with my time.



>> Lisa Friedersdorf: Thank you so much, what a great start to the webinar. I have a lot of questions but I will table them for now and we will move on to out next panelist, Dr. Christopher Schuh.

>> Christopher Schuh: Okay, thank you very much. That previous presentation was an excellent tee up for what I'd like to talk about today in regard to my own experience with commercializing the company, Xtalic Corporation, which began out of research in my lab at MIT.

Materials and Nanotech are ***Platform Technologies***

- *A single material can be used in multiple applications and markets, opening new commercial opportunities and enabling critical pivots*
- *A new concept in materials science can be used again and again to generate a family of materials, and thus a family of products that build long-range value*
- *As a faculty founder, one of my roles for Xtalic Corp. has been as the scientific lead in adapting this platform technology to the most commercially critical directions*

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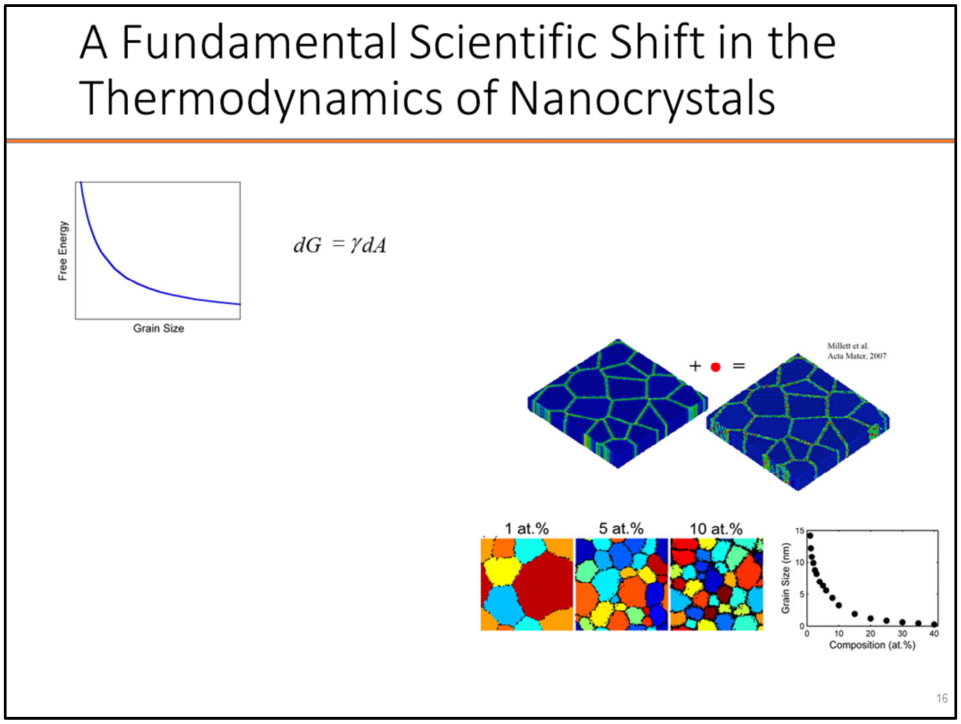
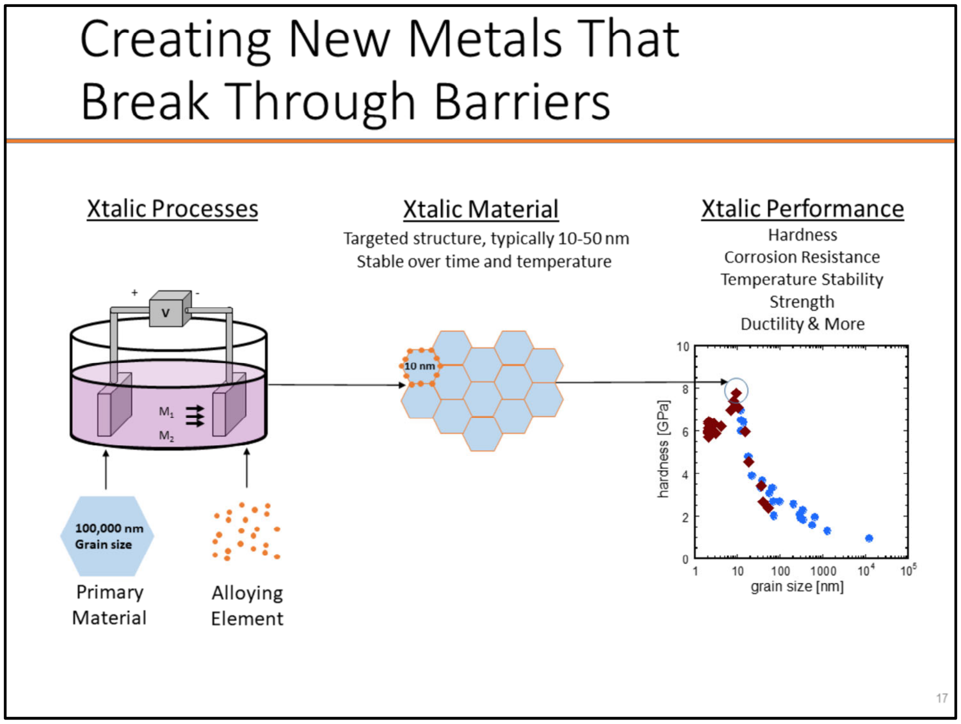
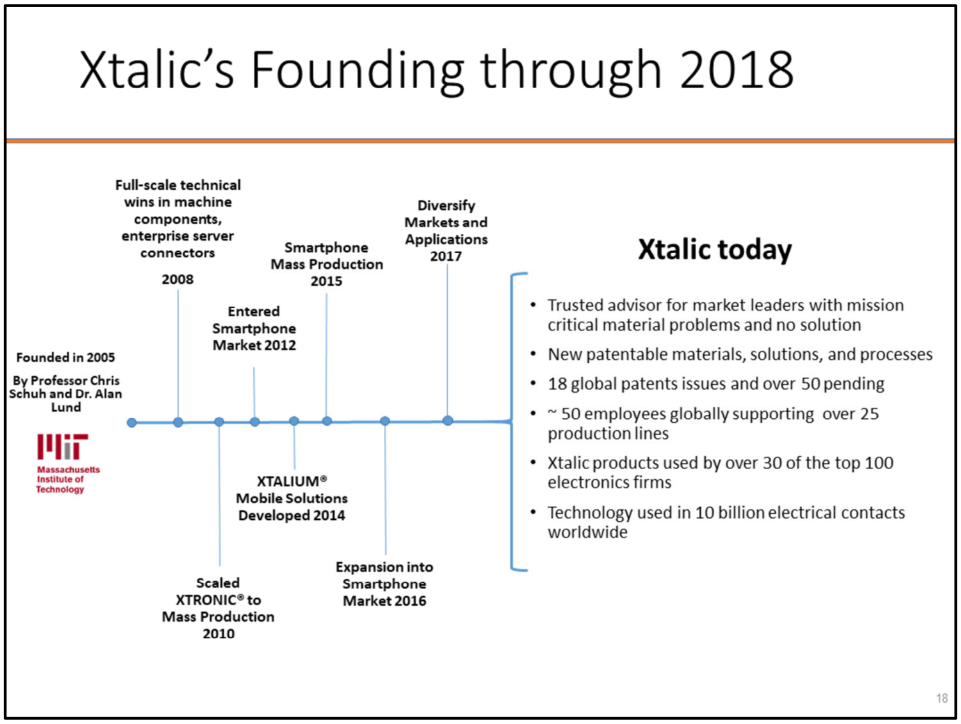
>> Christopher Schuh: The theme I've selected to focus on this afternoon is the concept that materials technologies and nanotechnologies have a really great benefit for commercialization in the sense that they are truly platform technologies. That means they can serve a lot of different uses, and this turns out to be tremendously important to keep in mind during the commercialization challenge because it allows you a lot of opportunities to reinvent yourself, to pivot and to grow the market opportunities available to you. My first point in regard to the platform technology is that in materials and nanotechnology, we don't use a material in a single location, we tend to use materials in lots of different places. That creates flexibility; it allows you to pivot when pivoting is necessary. My second point is that if you have a new concept in materials science and you've embodied it in a single material, the chances are good that a new concept can be embodied in other materials, which means that you, in principle, have a pipeline to have a number of products emerge from the same concept, and that's really important for building a long-range value for an enterprise. My final point is that as a faculty entrepreneur, my principle role is to be the person who understands the science and nature of the science as being a platform technology, and to help the company to address the market and pivot and maneuver through the landscape using all the creativity that the platform technology aspect permits.



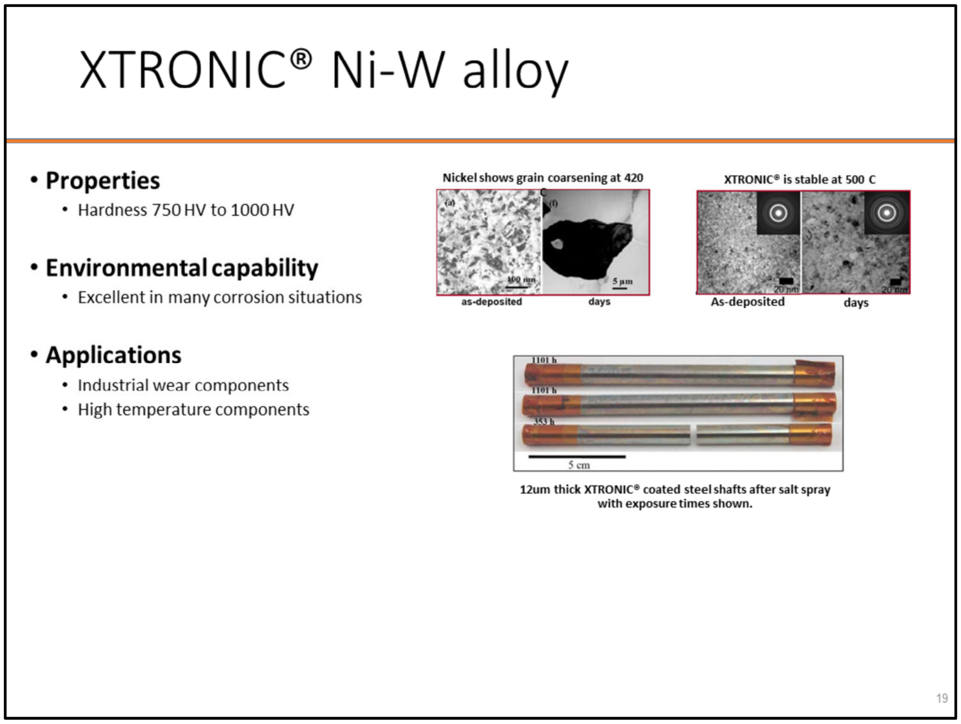
>> Christopher Schuh: I'll tell you a bit about the story of Xtalic. In a nutshell, what we're trying to do at Xtalic is produce metals that have extremely small internal length scales. We're trying to make extremely fine nanocrystalline metals. This graphic is an illustration showing that this is hard to do in nature. When you try to make nanocrystalline materials, you're introducing a lot of interfaces that have a lot of excess energy. The fundamental challenge to making nanomaterials: you need more energy than nature is usually willing to put up with. They are unstable. And my work at MIT has been on the fundamental science of how does one make nanomaterials thermodynamically stable? What this image illustrates is that my approach is essentially an alloying approach. I want to take a nanostructure—like the one shown here—and I add to that nanostructure alloying elements designed to decorate all the interfaces and change the chemistry of the interfaces. What I'm trying to do is then control the free energy landscape so that nanocrystalline materials are stable. And if one makes a stable nanocrystalline material, one can go further and control the nanostructure by controlling the stability point. And so, I'm trying to make metals where, with various additions of alloying elements, I can control the internal length scale of the metal. That turns out to be critical for controlling the properties of the metal.



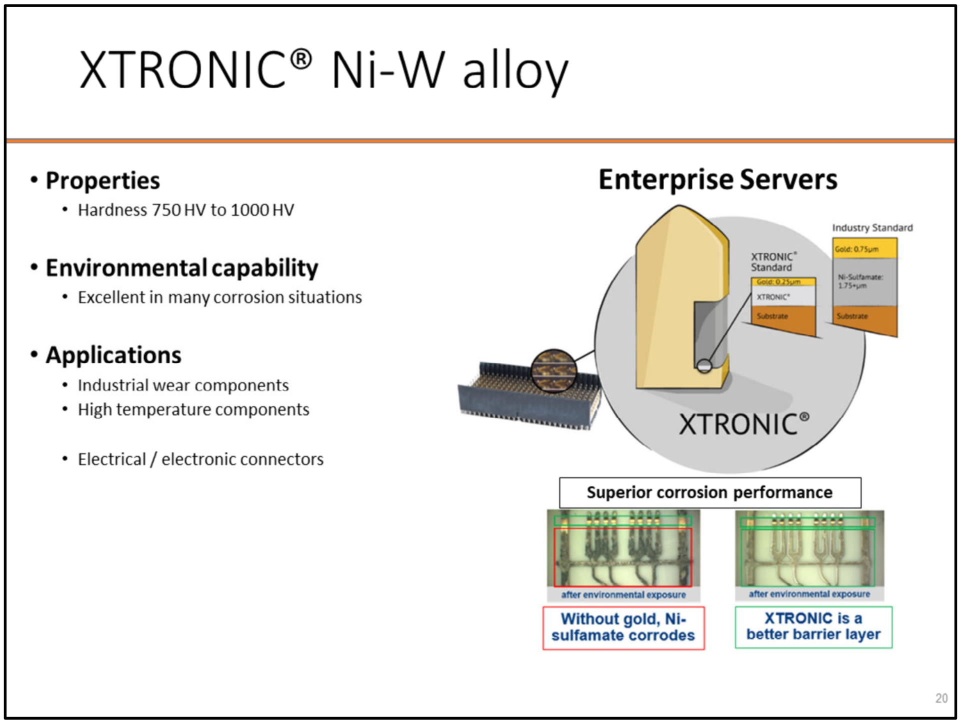
>> Christopher Schuh: The way this technology is embodied at Xtalic is in the form of electroplated metal coatings. What we tried to do is develop an electrodeposition process where metals are dissolved in an aqueous solution, and by applying voltage, we render metal on the surface of a component that is to be coated. The principle here is that I'm trying to deposit not just any metal, but a metal where an alloying element has been used to decorate interfaces inside that material and stabilize a very fine structure for the purpose of evoking optimum properties. This graph shows an example: I want my metal to be extremely hard and what I need to do to achieve that is target the hardest possible grain sizes. Hardness and many other properties exhibit the kind of curves I'm showing here, where there's a preferred optimum. Nanotechnology will help you get to that optimum, but you need to be able to dial it in and produce it reproducibly.



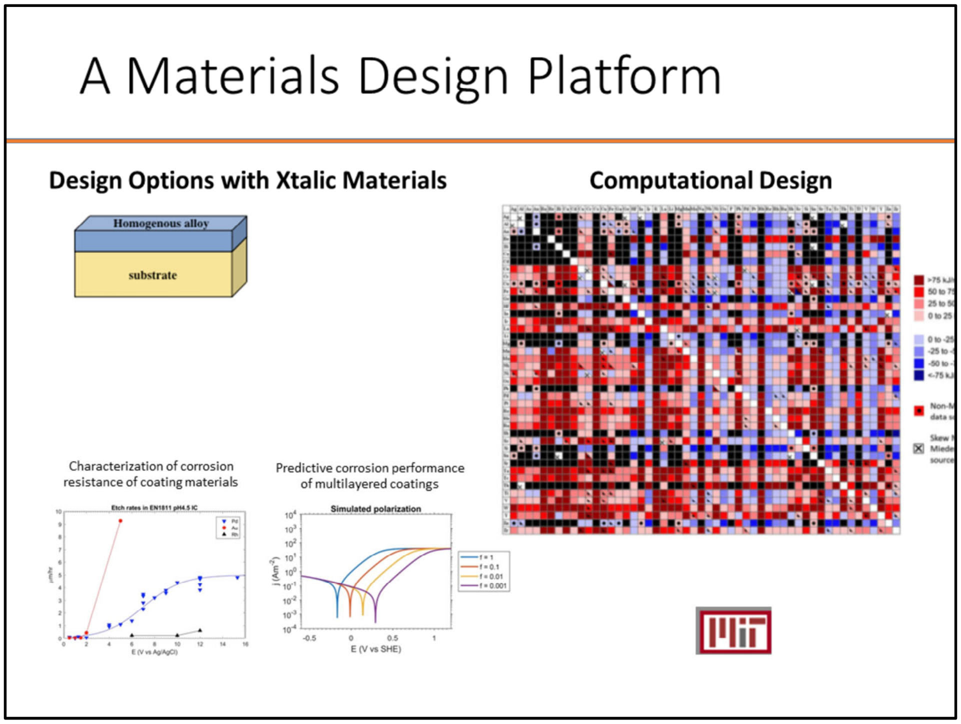
>> Christopher Schuh: At Xtalic, this concept was developed out of MIT in 2005. And I won't read this entire slide to you, but I'll come back at the end. The story between 2005 and now is one where there are many pivot points, where this technology needed to be adapted and improved and applied to multiple different materials to continually access new opportunities that were commercially viable at that time. That's what I'll talk about a bit more.



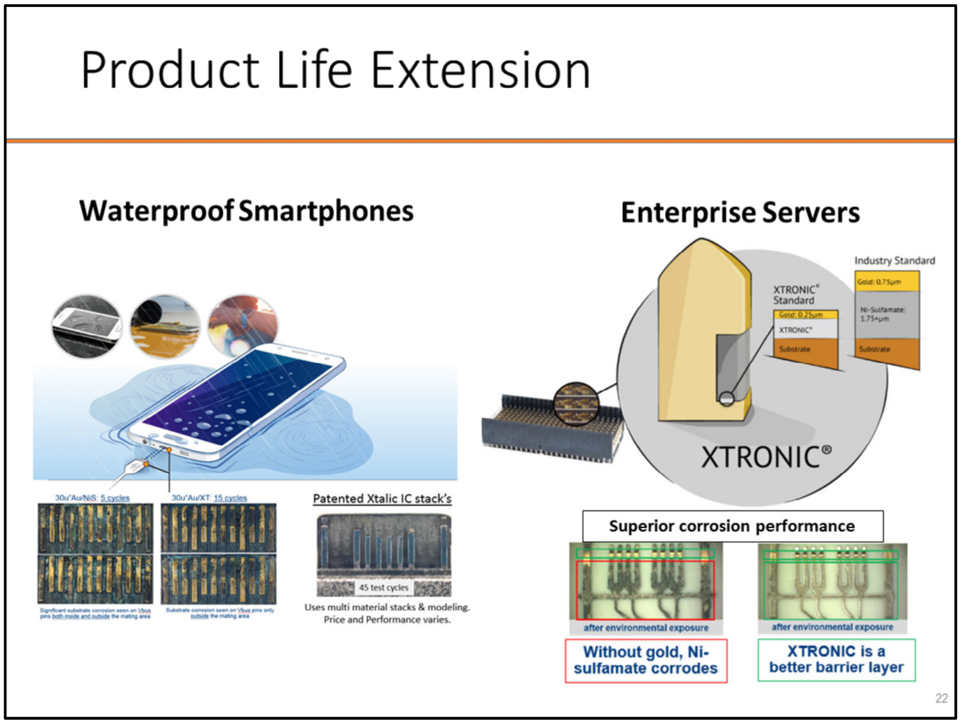
>> Christopher Schuh: When we started this company in 2005, our leading candidate material was an alloy based on nickel and tungsten. Unlike conventional coatings based on nickel, which were unstable, ours were nanostructured and very very stable. We could heat it to high temperatures, it had extremely strong properties and good environmental capabilities, and it was stable. When we first commercialized the process and scaled it, we were targeting all kinds of applications in industry: industrial wear components, automotive, and so on, for example, these hydraulic rods that have been coated with the material. These were technology wins for this alloy. But, what we found very quickly is that although we could win in a lot of technological situations, the real market opportunity was in a completely different domain.



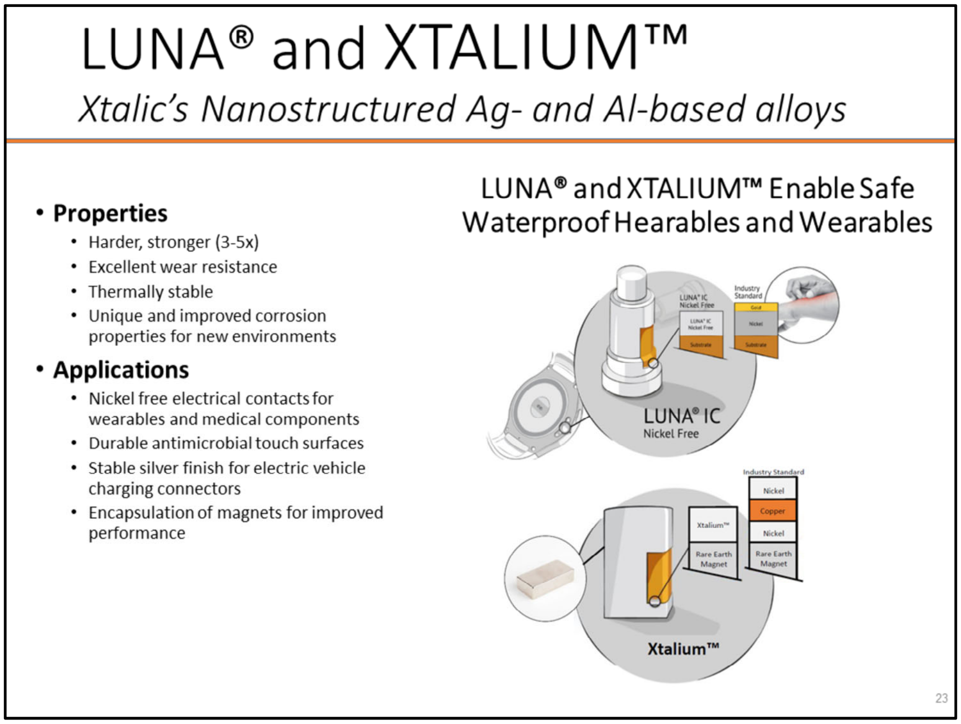
>> Christopher Schuh: That turned out for us to be in the electronics space. You also have a lot of metal components, like these server blades in the back plane of a server bank. These are where we plug server banks into the Internet, for example. All of those are metallurgical products that fail by wear and corrosion, much like automotive components, but in this case, the value proposition is just tremendously high. If you can improve the corrosion and wear of this component, you create a lot of downstream value, in particular, because these coatings involve a large amount of gold consumption. If you could improve the properties of this metal stack, you can save the world a whole lot of money, billions of dollars in gold consumption, which is used in this industry to butter over deficiencies of the metal. This was the first critical pivot, the market told us we could go into automotive, we could do industrial components, but really, the technology needed to be adapted to a different use, and we had to optimize and control it to address a very different market need.



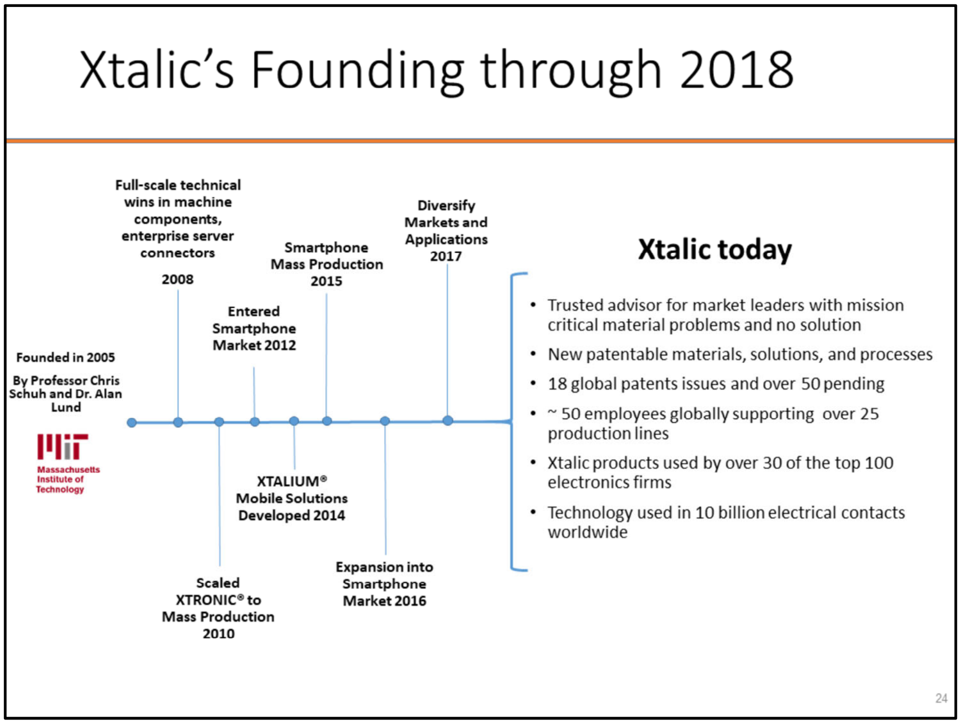
>> Christopher Schuh: Beyond that, we then began to realize that flexibility and adaptation were what enabled us to continually address new markets and broaden our platform. The story I just told was about optimizing an individual layer, a coating on top of a component, but once you've optimized one layer, now you can talk about optimizing many layers or gradient structures, or potentially mixing and matching different materials in a stack to evoke optimal performance and open new markets. At Xtalic, we address this by, first of all, putting a lot of resources into computational design of such coatings, and then very efficient laboratory work to screen such coatings and find the optimum. We also had work going on at MIT that allowed us to rapidly, computationally screen new alloys. On this map here, which is illegible, I'm looking at all combinations of a base metal on one axis, with an alloying element on the other, and searching for combinations that will form stable nanocrystalline metals.



>> Christopher Schuh: This allows us to emerge from a single market, where we successfully fielded billions of components, and address other opportunities. Early on, we went from enterprise electronics to the world of consumer electronics. Here, it's a similar type of application: we're talking about electrical connectors made of metal, but the conditions that are seen in service are dramatically more aggressive. A server will see corrosion from ambient air, whereas a SmartPhone will see corrosion from all kinds of fluids that humans bring in contact with their device. We adapt our technology and introduce new types of layering and new types of alloys.



>> Christopher Schuh: Beyond SmartPhones, we found if we wanted to enable wearable technology and hearable technology, we had to not only invent new stacks with our nickel-based alloy, and needed new alloys altogether. We needed to invent a precious metal silver-based nanocrystalline metal and aluminum-based material. These were invented on the same basic scientific platform, but deployed now in new spaces that allowed us to emerge into many different applications. Now we're moving into the wearable space, into medical components, into electric vehicle charging connectors and into functional materials such as magnets that could go into such devices.



>> Christopher Schuh: All of these points have involved the intersection of science with technology, and as a faculty founder, my role has been really focused on these pivots. It's about taking the science, making it flexible, adapting it to meet market needs, so you're constantly addressing something that is relevant.

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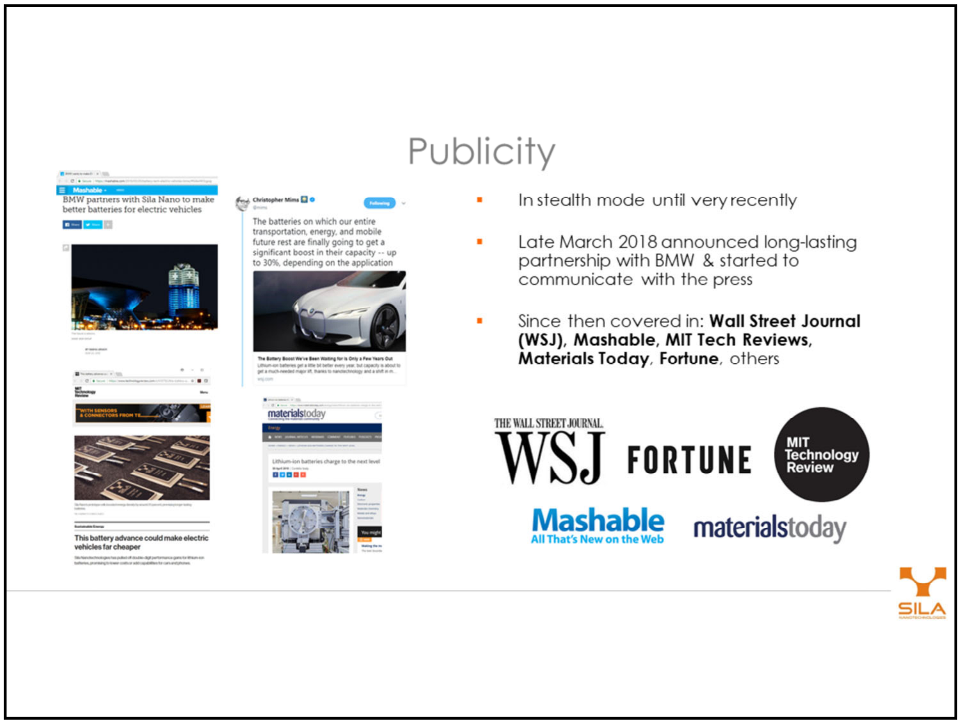
>> Christopher Schuh: That brings me to my conclusion. I'll just reiterate that I think it's a privileged space to work in materials and nanotechnology because these are platforms. They service many industries that can contribute to many products, and as a faculty founder, they're an excellent way to keep basic science relevant and focused on market needs.

>> Christopher Schuh: I'll stop there, thank you.

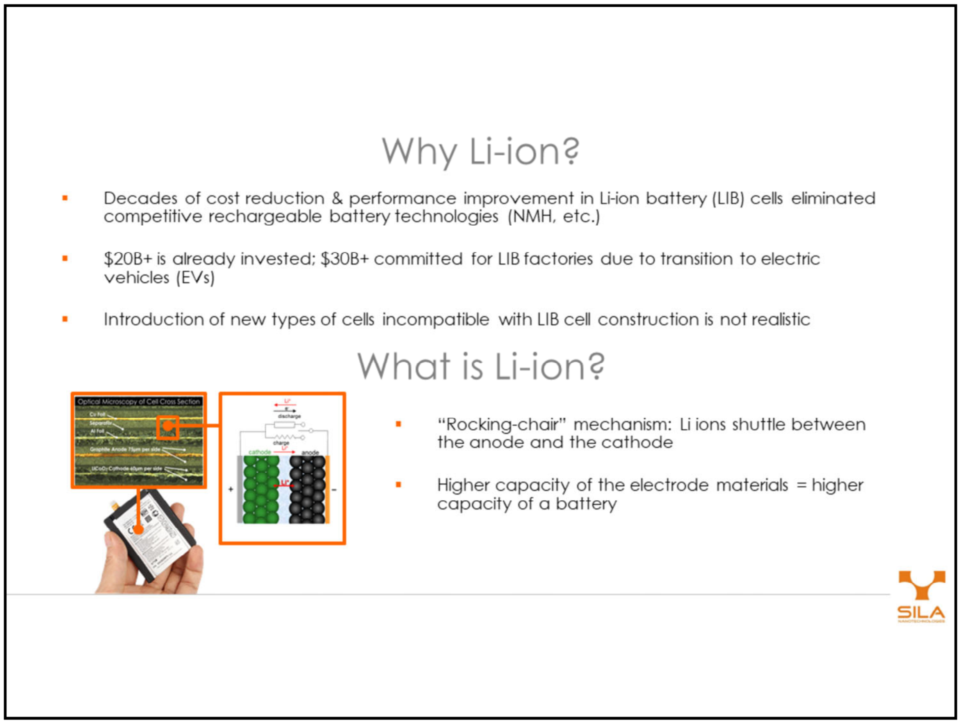
>> Lisa Friedersdorf: Thanks so much Chris. We are moving on to our final speaker of the afternoon, Dr. Gleb Yushin.

>> Gleb Yushin: Hello, thank you so much for the nice introduction. The previous two were wonderful talks.

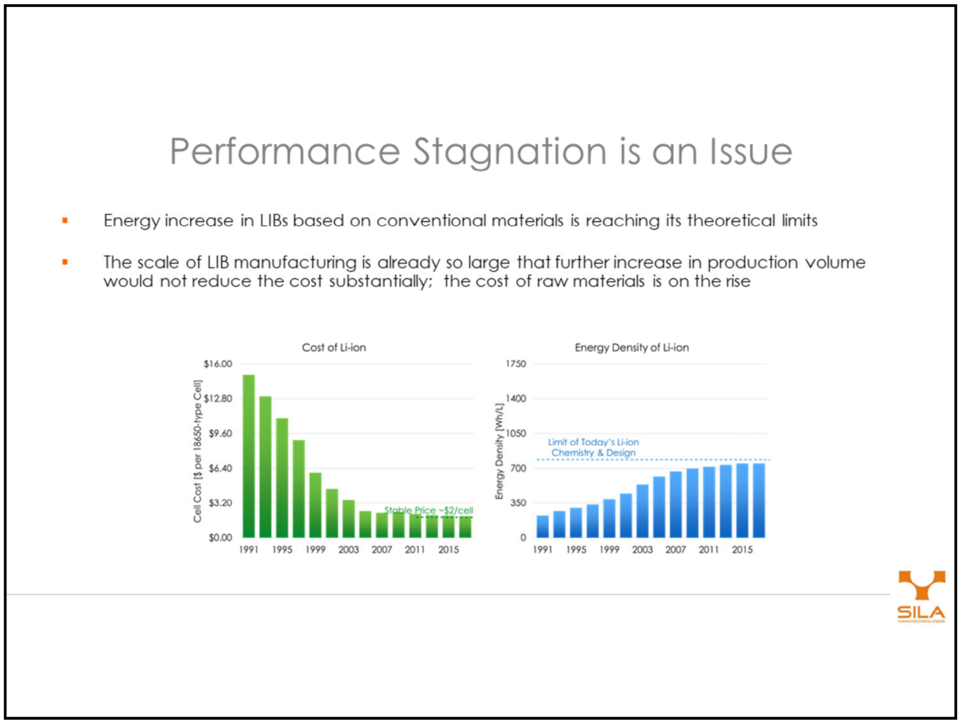
>> Gleb Yushin: I'll start with a little bit of the company history, and summarize the company first. What we do is develop and manufacturer materials that enable smaller, lighter, long-lasting batteries. The key feature of our materials: they drop products into existing manufacturing facilities. The company was founded in the fall of 2011, seven years ago, we achieved break-throughs in related technology, from technology incubators at Georgia Tech. Having a technology incubator was critical for our success. It was very close to my office; we had access to all the facilities at Georgia Tech, which is very important for a hardware startup company. At Georgia Tech, we were quite small, around ten people or so, but we grew rapidly. We employ now over 100 scientists, engineers, and patent professionals. We have over 30 positions available if anybody's interested on the website. We went from one building, shown on the left, to three buildings nowadays. They are located across Oakland and San Francisco. Our investors are tier-one venture capital firms, from Silicon Valley. We also have In-Q-tel as an investor. We have several industrial partnerships, including BMW, and we've won several grants from the U.S. Government. The most critical of these was the ARPA-E grant, which was quite substantial early on, and made a huge difference for us.



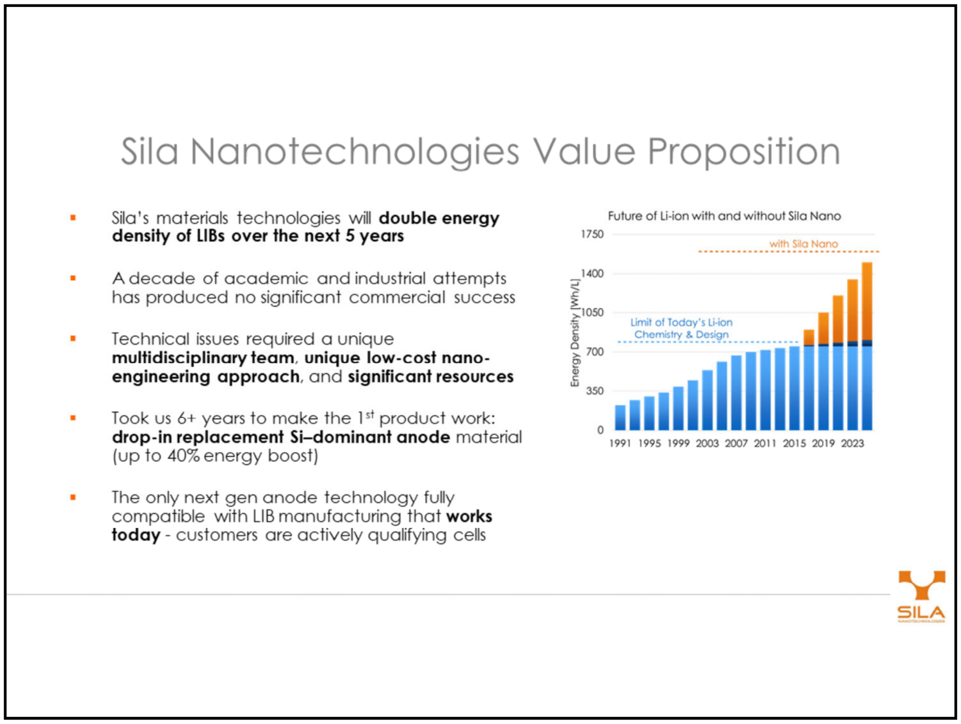
>> Gleb Yushin: In terms of publicity, until very recently, we've been in stealth mode, and then, late in March 2018, we announced a long-lasting partnership with BMW, and we started to communicate with the press. We've been covered in the *Wall Street Journal*, *MIT Technology Review*, *Fortune*, and received substantial press coverage.



>> Gleb Yushin: Let me pause a little bit and discuss why people are interested in lithium ion battery technologies and why other batteries might not be as attractive as lithium ion? Historically, in the last few decades, lithium ion battery technology has been reduced in cost, the cost was reduced quite substantially, and performance was improved as well. This almost eliminated all the competitive rechargeable batteries, metal hydrides and many others. Furthermore, there are already tens of billions of dollars invested in factories. This is because the transition from combustion engines to electric vehicles requires a substantial number of battery factories. Introducing new types of battery technologies, which aren't compatible with this type of manufacturing, becomes very challenging to enter the market. If you take a lithium ion battery and open it up, you can see multiple layers, foils coated with electrodes: anodes and cathodes and separated in-between. When you charge a battery, you move lithium from the cathodes to the anodes. When you allow discharge lithium comes back to the cathodes, doing some useful work, driving a car, powering your phone, and so forth. The key feature here is the higher the capacity of the electrode materials, the higher the capacity of the battery. So that if you develop battery materials that can drop into existing manufacturing, you can improve lithium ion battery capacity.

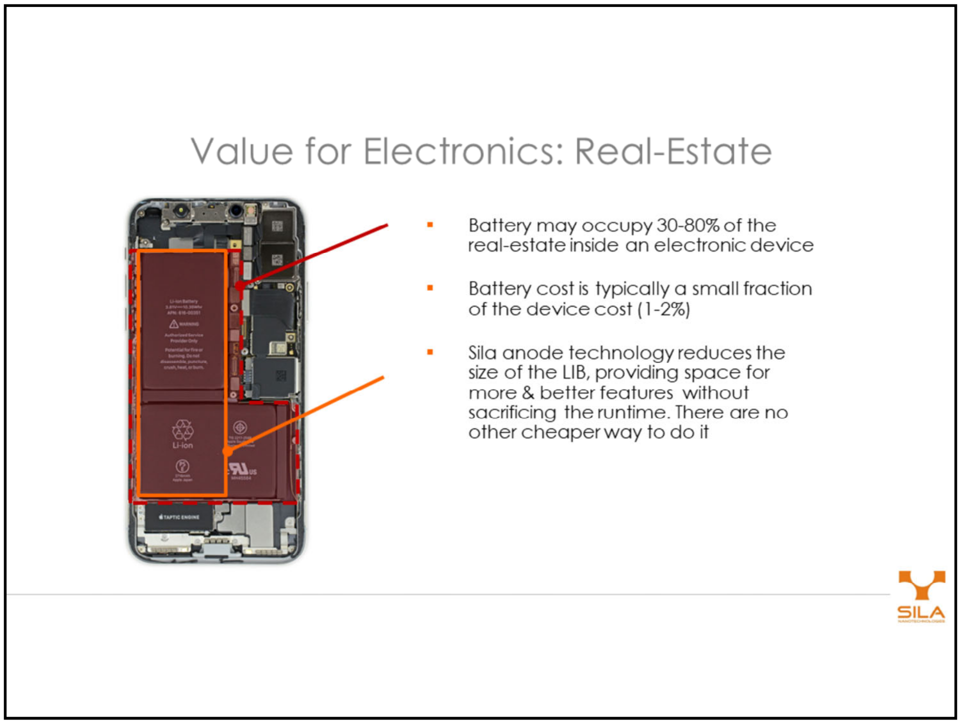


>> Gleb Yushin: While initially (for the first few decades), the cost of lithium ion batteries was reduced dramatically, and performance improved as well. In the last almost ten years, the improvement slowed down quite substantially. And then, because traditional materials used are reaching their physical limits, and the scale-up, the manufacturing already is at a very large scale, further increase in manufacturing scale, building more plants, doesn't reduce the cost substantially. Furthermore, the cost of raw materials used in lithium ion batteries is on the rise. Lithium prices are going up, as are cobalt and nickel and so forth. We're trying to address these issues. Our plan is to double the energy storage in lithium ion batteries in the next five years.



>> Gleb Yushin: People with new materials have tried to do it, but mostly unsuccessfully. We realized early on that the technical issues require unique approaches, but also unique teams. People from multiple disciplines of science—materials science, physics, chemistry—work together with different types of engineers: electrical engineers, process engineers, equipment engineers, etc. We also realize we need significant resources and time, and very patient investors. It took us six years to get to the first product. This is a drop-in replacement silicon-dominant anode material. In principle it provides up to 40% energy boost to conventional lithium ion batteries. The key feature we are proud of is that today, to the best of our knowledge, we offer the only anode technology that is fully compatible with lithium ion battery manufacturing and provides a significant boost in energy density. The quest is qualifying in multiple cells for introduction to the market in early 2019.

>> Gleb Yushin: Our market penetration approach: Before we produce huge amounts of materials to use in renewable energy and vehicles, we start smaller, with wearable markets, then move slowly to portable electronics, and so forth. There are multiple reasons for that, not only because it takes time to scale, and it's very important to start with certain materials to prove the market fit early on, but also, the cost of the materials is very different on different scales, and customers, they pay different values, they can afford different prices depending on the value the material provides. In wearable devices, the battery is very small. So if you provide 50 cents or a dollar of value, that's all the dollars peculiar to the material. While in electric vehicles, a very substantial portion of the price is the cost of the battery. The cost is a much more sensitive issue for the electric vehicle manufacturers. In addition, there are different performance requirements. For example, in wearable devices, 300 to 500 cycles is quite substantial, it's more than enough. In many electric vehicles you need more than 1,000 cycles, and for renewable energy typically and many other applications, you need 3,000 to 5,000 cycles.



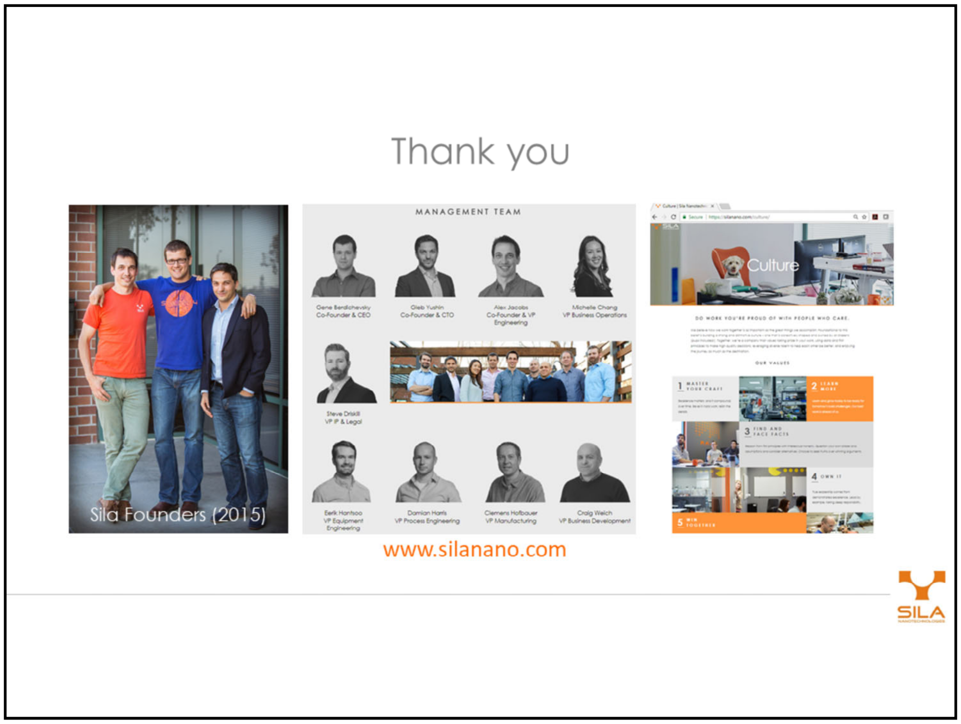
>> Gleb Yushin: The value of the battery for electronic devices is “real estate.” If you look at most electronic devices, the battery is sometimes 30 to 80% of the real estate inside the electronic device. But the battery cost is only small fraction, say 1 or 2% of the device cost. So with our technology, we can reduce the size of the battery and provide space for more features or better features without sacrificing the runtime. Essentially, there is no cheaper way to do it.

Value for EVs: Lower Cost & Better Performance

- Cost of active (Li-ion storing) materials within LIB cells: only 25% of the cell cost
- Fraction of the active materials' cost in battery packs is 30-50 % less - down to 12-18% (due to protection, control and cooling costs)
- The anode material cost < 5% of the battery pack cost (further raw material cost reduction won't reduce EV battery cost by much)
- Increasing LIB performance (energy density) will require fewer cells & smaller cooling / protection system, leading to cost savings
- Faster charging

SILA

>> Gleb Yushin: In the case of electric vehicles, the cost of active materials is small fraction of the cost of the cell. So the cost of the cell is also a fraction of the cost of the whole battery. So if you look at the cost of the material in place and cost of the anode material, it's only 5% of the battery part cost. So if you reduce the cost of the anode material down to zero, you can reduce the cost of the battery pack only by 5%. However, if you improve performance of the battery, say if you provide 30% more energy, then you can have substantially high boost in cost, in cost reduction. Essentially, if you make better batteries, if you make better cells that store more energy, you require fewer cells in the battery pack. Furthermore, the battery pack is the smallest, you require smaller cooling and protection systems, and cost savings. Furthermore, this high energy density anode material allows you to get faster charging, which is an additional benefit.



>> Gleb Yushin: This is my conclusion slide, with some pictures. The management team is here pictured also is the website. If you are curious about our company or the company culture, there are multiple videos available on the website. I encourage you to look at it. Thank you so much.

Q&A/Discussion
[no slides]

>> Lisa Friedersdorf: Great, thank you. And thank you to all three of you for really great presentations. You hit on a number of the topics we were hoping to address today. I'm going to start with some questions to drill down a little bit on some of these issues. I think this question applies to all three of you: I was wondering if you could talk a little bit about the entrepreneurship ecosystem that you are involved in as you are taking this technology from a university and turning it into a company. Could you talk a little bit what that experience was like, and the ecosystem at your institution, how it developed and helped you? Angelique?

Q&A/Discussion
[no slides]

>> Angelique Johnson: I started the company as a graduate student at the University of Michigan. I actually would not have started the company, except that they had a really high-energy ecosystem and spirit around entrepreneurship. There was lots of student organizations, grad student organizations; there were centers being formed. And so, that was really helpful in terms of having somebody vet the idea, have investors vet the idea, I did the business plan competition as a student there, and that was a good experience, because you got to get the idea out in front of investors and to get feedback and continually refine your business model as you went. Once I left the university, the other ecosystem that was really good was the National Science Foundation's inaugural I-Corps class. We had not only other scientists and engineers spinning out companies, and having Steve Blank, the founder of Mophie, and entrepreneurs in some cases that had no scientific background, but had an entrepreneurial background. That was good to have a mix of both. Now that I'm in Kentucky, it's really been good in terms of the support that we've been able to get on the finance side from the state. We had an advanced manufacturing company in the medical device space. A lot of what we're doing can be very impactful, beneficial, to a state like Kentucky, kind of in the south and west, trying to increase innovation around manufacturing. That plays in, of course, locally in the city of Louisville, there's a lot of entrepreneurs; and having the ability to bounce ideas, business ideas off somebody is really important, and then, at the same time, being able to go to a university and bounce scientific and engineering questions and ideas off that realm is also very important.

Q&A/Discussion
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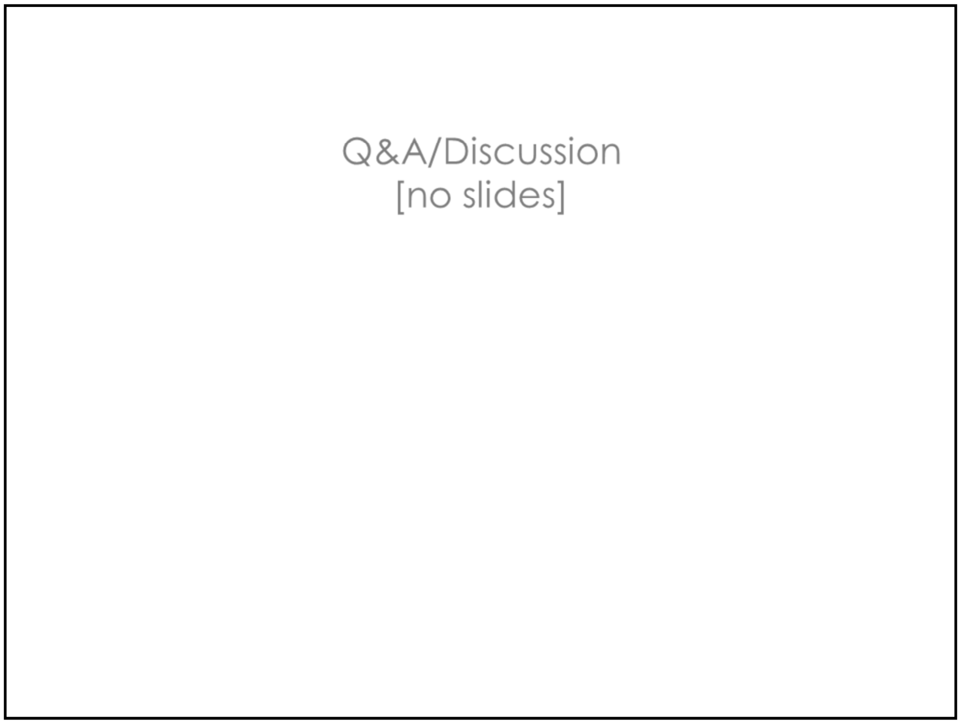
>>Lisa Friedersdorf: Sounds like a really productive environment. Thank you for explaining the kind of ecosystem in those three locations. That was really great. Chris?



>> Christopher Schuh: The ecosystem where I sit is, of course, the MIT greater Boston entrepreneurial ecosystem, which is, from where I sit, a remarkable place to do this translational work, because there's an incredible community of technology-oriented people. The one aspect of faculty entrepreneurship, which I found very refreshing, and which I think is underestimated by a lot of faculty, the aspect of starting a new company is very daunting, and there's a chance of failure, a probability of failure. But unlike the academic environment, failure is something that is embraced by the entrepreneurial one. You're surrounded by people who are resilient and who have failed and who know how to fail gracefully and will gladly teach lessons about how not to fail. It includes people of every type. It includes, of course, technology people, it includes business people, angel investors, venture capitalists, even part-time financial people will share their wisdom on what it means to fail and how to pivot at a failure point. I think that's a very important aspect of it. Another thing I found very heartening is that this is a community when one goes out and pitches, there's a low coefficient of success. One pitches to many people, looking for the right fit for funding, for contracts and so on. It's a game where there is a lot of failure, even when there's a success. There's a lot of failure that goes along with it. Even though one talks to people and is rebuffed, and one fails frequently, nobody really is rooting for your failure. I think that's a special thing. In academia, in the publishing world, in the science world, I think it's a little snarkier. I think we're often used to seeing peer reviews that are blind, and which often feel like they're merely obstacles to our forward progress, whereas in the world of entrepreneurship, everybody wants you to succeed, even if they're not able to support you by giving you funds or active support. They're all willing to help. So I found it to be an ecosystem, at least in the Boston area where everyone understands what's entailed in entrepreneurship, in terms of balancing success and failure, and everyone is generally supportive. No one will lose if you win.

Q&A/Discussion
[no slides]

>> Lisa Friedersdorf: That was great, thank you very much. Gleb, do you want to add your perspective?

>> Gleb Yushin: In Georgia Tech, there are multiple exciting technologies, but we're less successful as a university compared Stanford and MIT in terms of commercializing these technologies. But the theme seems to be changing. We received tremendous support from Georgia Tech. Having the ability to have a start-up incubator right here on campus, for me, was very critical. At that time, I didn't have tenure, so the ability to walk from my office to the incubator space within five minutes was very helpful. The overall support has been tremendous. As we grow and move the company to California, the support in terms of understanding and documenting my travel arrangements was wonderful. Everybody from the department to the college and university, supported this in all possible ways which was very nice. Which was the right attitude. If it was different, it could have been much more challenging.

Q&A/Discussion
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>> Lisa Friedersdorf: Thank you, between the three of you, you mentioned a lot of the things in the ecosystem that helped you. Some was energy and support, part of the community that supported the possibility of failure. People to bounce ideas off of. I wanted to drill down a little bit about some of the technical resources and stresses that have impacted us a little bit; a question that has been posed that talks about quality control and characterization. I'd first like to leave it a little broader and then perhaps we can get into the specifics. Gleb, do you want to talk about some of the technical facilities or resources that were useful to you as you were transitioning your technology?

Q&A/Discussion
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>> Gleb Yushin: Absolutely, when you have a start-up company, early on, they don't have much funding. So access to all of the state-of-the-art equipment for characterization was very critical for us. On campus everything was in walking distance; it was very helpful. Nowadays we buy more and more instruments, in house, it seems obvious how people can’t do without it. Having an incubator off campus would be much more challenging in terms of access, in terms of the time it takes to do the characterization. In many cases, when you start a new business, when you have an idea, you have to improve it. There are multiple iterations, and the faster you can go through iterations, the faster you move in terms of performance improvements. For that, you need feedback, and the feedback you need is a characterization. So that was a tremendous value.

Q&A/Discussion
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>> Lisa Friedersdorf: Great, thank you. Chris, do you want to go next?

>> Christopher Schuh: I agree with what Gleb just said. Early on in the start-up, you need a lot of skills that the founding team might not necessarily have in themselves: financial support, business support, marketing support, training on intellectual property, and so on. So I find that a big part of the ecosystem being supportive is having access to professionals who willing to offer small parts of their time, high value add, small parts of their time, as part-time employees or as contract employees to help stand those things up, until such time as the company can afford and can sustain a professional executive team. So that's something that I highly value in the ecosystem in Boston, how much such professionals there are available for small amounts of their time to do very high-value activities.

Q&A/Discussion
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>> Lisa Friedersdorf: Great, thank you, Angelique, do you want to add your perspective?

>> Angelique Johnson: I agree with everything that's been said already. I think that for us, especially in terms of what Gleb was saying, we use microfabrication facilities and those facilities are very expensive. As a start-up, you don't have $100 million to build even the most basic of a clean room so that was helpful for us, both University of Michigan and now in Kentucky to have access through the University of Louisville to high tech equipment we can use on a fee-for-service basis. As we move forward, in terms of our own manufacturing capabilities and being able to take over that quality control aspect, it’s still really important to be around other companies as well as universities that have some experience in certain toolsets that you're using—that can cut down on that time. And then, again, surrounding the business community, with individuals who could really talk about scale and how you look at the finances of scale, when to make equipment purchases, things like that, vendors, selection, it's really critical too.

Q&A/Discussion
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>> Lisa Friedersdorf: Great, thank you.

Chris, I'm going to come back to you. There was a question specifically regarding the pivoting of your technology and looking at the application of your materials in a variety of different sectors. The quality control required in the testing that your customers want to see, how did that vary as you pivoted your technology?

>> Christopher Schuh: It's a good question. It's very domain and customer-specific. In the space of functional coatings, for example, hard metal coatings that go on automotive components and so on, the quality control is of a different flavor than it is in the electronics industry, in part because the specific components are different. You're plating much larger components for automotive than you are for electronics, but the volumes are dramatically higher in electronics, where we would produce, literally, billions of parts. So there's no simple answer to this question other than to say that part of pivoting and entering a new market is having really good customer relationships so that you know exactly what they're looking for and you stand up the team that can put in place the proper quality control processes to address the specific problems of interest to that market and that application. It's true that every single time, every time one moves into a new market space, there's learning to do about that.

Q&A/Discussion
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>> Lisa Friedersdorf: That's great. Angelique or Gleb, would you like to add to that discussion about quality control or markets?

>> Gleb Yushin: For sure. In terms of quality control, it's obviously important everywhere. In batteries, it's particularly important. You hear many stories about batteries exploding in devices, leading to billions of dollars of losses in device manufacturers. So quality control is key. In terms of trying to address different markets, fortunately for us, the materials are similar, and so I'd say the technical barrier is very high, to achieve the breakthroughs. But once you're there, you can serve multiple markets by tuning the properties of a few materials. So, this is easier for us to address.

Q&A/Discussion
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>> Angelique Johnson: We are a platform technology. For our strategy, we actually chose, intentionally, to focus on the more challenging application space in terms of quality control. Because we wanted to go after the other markets, we knew if we addressed quality control in the cochlear implant area, it'd be a lot easier for adoption to happen in some of the other areas, whereas we couldn’t go backwards. Medical device companies do not like risk, and quality is very important, quality control is more important because lives are at stake. For us, if anyone else is doing a medical device company, it's a lot of routing through FDA, through market approval files, talking to the companies, your customers, as well, sometimes, depending on the space you're in, it's hard to get as much information from there. And then we do a lot of looking at other countries, companies in the European Union, some of their requirements there, to get a better feel of what we should be doing in terms of quality control. First and foremost, talking to your customers, they'll always tell you, this is where you need to be in terms of quality control on the manufacturing side. But then the FDA has its own requirements that have to do more with safety and effectiveness.

Q&A/Discussion
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>> Lisa Friedersdorf: Great, thank you. We have a number of other questions that have been posted. Is it difficult to collaborate and protect your intellectual property? Angelique?

>> Angelique Johnson: Yeah, it's difficult. Yes, and no. If you're collaborating just with, say, a vendor, that's not difficult. There's some toolsets that we look to purchasing where it requires prototype development, prior to purchasing a toolset. We've had wonderful working relationships where you have legal agreements in place, and you know who owns what, as development's going on. But then you also interface with international companies, and in that case it's a little more difficult to protect IP and to really narrow and fix that out. So on the international side, you pay a lot of money in legal fees, but if you're dealing in the U.S., it's a little bit easier, but the key is to make sure nobody is shy about saying this where our IP lies, and also understanding your market space and understanding the nature of IP for the particular partner that you're working with. So if you're working with a partner, and you know that in that space, you know that by the nature of the relationship, that you won't own the IP, then you have to know that going in, to know what to negotiate against. So it can be a little bit challenging, but in the U.S., it's a lot easier. When you get to the international side of it, it becomes very tricky.

Q&A/Discussion
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>>Gleb Yushin: I can comment from my side. In many cases, it's a balance. You have to choose the partners properly; you have to make sure that there’s mutual trust, and there's discussions about what you can or cannot share. In many cases, you have to go beyond your comfort zone. In many cases, for example, in the automotive space, it takes over six years to qualify materials, to qualify batteries. So in many cases, it does involve close very relationships with the end customer. In our case, it's the automotive partner. So typically, you can have multiple milestones, at which you open up information that is required for the company to qualify the cells, to control quality and so forth. I'd say, it’s a gradual process, you have to be open more and more over time.

Q&A/Discussion
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>> Christopher Schuh: Everything that has been said is perfectly correct from my perspective. I'd add one other very important collaboration, in my experience, is the collaboration between the university and the start-up. That's an area where care has to be put into the legal agreements that go into the licensing. If this is done well, I have to say, it's been a very positive experience for me. If one writes the licensing terms appropriately, it sets up a really good alignment of interest between a basic research lab at a university and the commercial goals of a start-up, which are all kind of working on the same theme, but they have very different goals. A well-written licensing document enables the research to go on, on the basic side, and to have a roll-in right for future technologies, when they become ready for commercialization, to go over to the start-up company. At the same time, this can also clean up any potential conflicts that may arise from the divergent interests of those two parties. So that's one that I'd pay a lot of attention to for anyone thinking of starting a new start-up out of a university environment.

Q&A/Discussion
[no slides]

>> Lisa Friedersdorf: Great, thank you very much. I want to ask each of you… I noticed on Dr. Yushin's slides that he articulated 30+ open positions. I wanted to have you speak to workforce, and finding qualified people to help you as you're growing your companies. Gleb, would you want to start?

>> Gleb Yushin: Can you clarify the question? How to find people? How we attract candidates? Or what the process involves?

>> Lisa Friedersdorf: I'd say if you're actively searching for candidates, are you finding the workforce that you need and how do you go about doing it?

Q&A/Discussion
[no slides]

>> Gleb Yushin: It takes typically a much longer time for us. So we can’t grow as aggressively as we would like, but on the other hand, it warrants that our culture stays the same. It means that we don't make bad decisions because of the risk all the time. So we go through multiple iterations, trying to make sure that the experience of candidates is still positive while we go through our diligence very carefully. Especially if you are a small company, but given that we have a small, but growing, company, any person has a very large influence on the outcome, on the success of the company. And so if you have a wrong hire, it might have a much more negative impact compared to the same hire in more established companies. We use all possible resources, different recruitment techniques, to recruit talent. We use our own networks, we use LinkedIn and other resources and in the end, we do find people that are awesome, that are a great fit for us. But it does take a very long time. Initially, people get frustrated, but I think it's a right decision to take our time.

Q&A/Discussion
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>> Lisa Friedersdorf: Chris, do you want to comment on your experience?

>> Christopher Schuh: I'm not sure I have any general principles that are particularly useful here, but I will say I've seen companies at this stage of a few employees. I've seen them grow to the stage of a few dozen employees. I've seen them grow beyond that to having 50 to 100, and I've seen them grow to be 200 or 300. One thing I will say is that it's a very different type of person who is willing to join a small company and take a big risk than it is someone who will join a more mature company. I think that the pipelines of people who are psychologically aligned with those different scales are quite different. So as a company grows, I think one needs to change the strategy accordingly and think about recruiting in a different way. Early on, it's very much about forming a close-knit culture that is in line with the vision of the founders and which can rapidly advance a technology with virtually no planning and no certainty. In the later stages, it's more about quality, reproducibility, and so on. And it really does speak to different psychologies and different personalities. So to stick with a single recruiting strategy throughout the life of the company is probably not the right recipe.

>> Lisa Friedersdorf: Thank you. Angelique?

Q&A/Discussion
[no slides]

>> Angelique Johnson: We do have a bit of a recruiting challenge because we are in Kentucky; it's a different beast here. So we really rely on our network out of the state. We've had people that have worked with us coming from Boston, to come work for our company. So, there's a lot that goes on there, with bringing somebody in. But one lesson I have learned is that there is a team, just as Dr. Schuh said, that you want to have when you're thinking of innovation, and there's a whole other team you want to have when you're thinking of quality control, scaling up, and things like that. We have made the mistake of having the wrong employee positioned into the innovation versus the scale-up side. And so that is something to be wary of, and just know that, when you're recruiting somebody, what's the core thing you're trying to get out of them. The other thing is I had a tip early on from another start-up founder that I thought was really good and I continue to use it. When you're starting out, it's good to bring in everybody, almost under the same job title, in some cases, because it gets them in the mindset that when you are in a start-up, you have to be a jack of all trades and can't have a mentality that "I work on this little part of the widget and that's all I'm going to do." Because everybody has to move across the board. That's when you're a young start up like we are. When you get to become a much bigger company, then you can afford to have people working and focusing on one thing. For us, that helps to set the tone of "all hands on deck" for all aspects. Of course, people have specialties and they focus on special products, but at any given moment, if we have a deadline to meet with a customer, people can crossover and it keeps people aware of all aspects of the work going on so they don't get so siloed that they're not able to step in where we need them.

Q&A/Discussion
[no slides]

>> Lisa Friedersdorf: That’s a great tip. We're now swiftly approaching the end of our hour, and I want to take this opportunity to thank the panelists for sharing their insights and sharing some time with us this afternoon. I mentioned at the opening of the webinar that we have a number of activities planned to support entrepreneurship. So please keep an eye on nano.gov. We're working towards the establishment of a community of interest around nano-entrepreneurship, and more details will be coming forward this fall. Once again, thank you very much for your time. This webinar will be archived; I hope that this was a useful webinar for the many attendees this afternoon. Thank you very much and have a nice afternoon.