NNI Public Webinar
Technology Pathways Toward Commercializing Nanotechnology

Wednesday, September 19, 2018
Webinar will begin at 10:30 AM EDT
Audio will be broadcast through your computer's speakers

PANELISTS

Katherine Barton
Nano-C
Laboratory and Production Manager

Doug Singer
Cerion Advanced Materials
Executive Vice President In Charge of Manufacturing, Development, and Commercialization

MODERATOR

Lisa Friedersdorf
National Nanotechnology Coordination Office (NNCO)
Director

This event will feature a Q&A segment with members of the public. Questions for the panelists can be submitted to webinars@nnco.nano.gov or through Adobe Connect from now until the end of the webinar at 11:30 AM on September 19, 2018. The moderator reserves the right to group similar questions and to omit questions that are either repetitive or not directly related to the topic. Due to time constraints, it may not be possible to answer all questions.

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Technology Pathways Toward Commercializing Nanotechnology
September 19, 2018
Subject: Quality Control
Key Takeaways from the Webinar Guests

1. In nanomanufacturing: fail fast. Have the mindset of fail fast, learn from it, loop back, and fix the problem.
2. Expect that anywhere from 25%, to the entire technical team of a small company will play a role in the quality control process.
3. Take advantage of the ecosystem in your geographic area; companies, research institutions and government-supported infrastructure. Engage NIOSH for access to environmental, health, and safety resources.

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September 19, 2018
Webinar Transcript

DR LISA FRIEDERSDORF: Good morning. My name is Lisa Friedersdorf and I'm the director of the National Nanotechnology Coordination Office. Our office, the NNCO, coordinates the nanotechnology research and developments efforts across the federal government under the National Nanotechnology Initiative or the NNI. There are 20 departments and agencies from the federal government that participate in the NNI and we coordinate these efforts through the National Science and Technology Council in the White House. More information about the NNI can be found at www.nano.gov, including the recently released Supplement to the President's fiscal year '19 Budget.

This document highlights progress towards the four NNI goals and of course lays out the budget and plans for the coming year. A brief overview of nanotechnology R&D by agency is also provided with additional information available on our website.

The webinar this morning directly supports the second goal of the NNI to foster the transfer of new technologies into products for commercial and public benefit. Objectives supporting this goal includes collecting and disseminating information on best practices and fostering the development of robust, scalable nanomanufacturing methods to facilitate commercialization.

This webinar kicks off a series that continues the conversation that started at the Technology Development Pathways workshop we held last fall. At this workshop, industry representatives shared details about the technical pathway they followed to take an idea from research through commercialization. We heard from the community that this was really helpful and decided to use this framework to continue discussions through a series of webinars that will be archived on nano.gov. We will likely have some in-person meetings as well so please keep an eye on our website.

Today we will focus on one of the critical and very challenging technical steps along that pathway: quality control. To share their insight, we have two guests today and I would like to welcome Katherine Barton the Laboratory and Production Manager at Nano-C and Doug Singer the Executive Vice President for Manufacturing, Development and Commercialization at Cerion Advanced Materials. Katherine, can you please tell us a little about yourself and Nano-C?

KATHERINE BARTON: Sure, thank you. I am at Nano-C, we're in Westwood, Massachusetts. Nano-C is a late-stage start-up that was founded in 2001, actually, by Dr. Jack Howard of MIT based on a patented combustion technology that produces fullerenes and carbon nanotubes in a very environmentally efficient manner. I've been here at Nano-C for more than 12 years. We've scaled from all R&D up now to, we're on the verge of scaling to, commercial production for a few of our customers that have grown in the technology. So it's very exciting for us. I work mainly with fullerene purification and derivative synthesis, but we also do carbon nanotube production and development here as well. Prior to Nano-C, I managed the materials lab at Raytheon Company. And so I was able to develop a background for QC by working with strict military specifications for process, product as well

as the materials that went into the products. So I've been able to use that now here at Nano-C.

LF: That's great. Thank you very much. Doug, can you please tell us a little about yourself and Cerion?

DOUG SINGER: Yes. My name is Doug Singer and I'm Vice President of Cerion Advanced Materials. Cerion is a research and full-scale manufacturing nanomaterial provider. Our space is mostly inorganic metals and metal oxide nanoparticles. The core competencies that we have are controlled size, size distributions and morphologies of those nanomaterials. Also the ability to stabilize those nanomaterials in a wide array of stabilizer solutions and chemicals that are compatible with our customers' applications as well as the carrying solution if they're in a liquid and we also deal in powder nanomaterials. The applications of Cerion's products are mainly catalysts, functional coatings, antimicrobial applications, therapeutic drug applications, and improvements in material strengths or selective reactivity. So it's a wide range of applications all based on our core competency to invent and manufacture at large scale nanoparticles that can be customized for our customer's applications.

We are mainly a commercial business-to-business supplier both to the commercial sector in which people take our materials and implement them into their finished goods and we also support the Department of Defense and their needs for transitioning invented materials up to a larger scale for implementation or transition to full scale applications in the defense industry. We are a commercial production company, not just research. We do both research as well as manufacturing nanoparticles on the hundred and thousand-kilogram scale. We have transitioned from small research to doing research and manufacturing. I personally have 28 years in the chemical research and manufacturing sector. Spent 17 years at Eastman Kodak Company where I got my Six Sigma Lean Manufacturing black belt and oversaw operations for inventing imaging products as well as the manufacturing operations. I'm also a part of the group that started Cerion 11 1/2 years ago and my responsibilities here are to oversee commercial operations, development and scale-up of products that come out of research and oversee our quality program and logistics.

LF: Thank you both. That's absolutely fantastic. I'm looking forward to the conversation today. You both have a lot of insight to share and I think I would like to just dig right in. So if quality control refers to the measurement of certain parameters against a specification, my first question is, what are you trying to measure and how do you measure it? Katherine?

KB: Okay. Well, because we're developing our materials for use in new and up and coming products for our customers, we do two things. First we have internal specifications of our own. We try to make our materials as pure as we possibly can. As well as to meet certain specifications by our customer. For instance, a material may be pure to a percentage, but then knowing what the contaminants are is sometimes important for the customer, rather than just the purity number. So we work closely with our customers to determine exactly what they need and exactly what they don't want in the products, and we measure that as best we can before we get it to them. Additionally, there may be other special criteria, besides purity, solvent content or sometimes particle size, and other things that may come into play that we will gear our testing for the customer.

LF: Okay. Doug?

DS: Yes. At Cerion we have a platform of a wide range of nanomaterials based on 20 to 30 elements in the periodic table and the kind of products we make are diverse based on that platform. So a lot of the quality measurements that we make, both with existing commercial materials and new ones that are under development are typical particle size, particle size distribution, X-ray fluorescence, X-ray diffraction, ICP, TEM and SEM[1], and as part of all that we're basically always trying to characterize the inherent properties that make nanoparticles special, whether it's a particular size that enables a certain chemical to do its job better than a bulk size material or whether we need to verify a doping structure of a doping element in the core shell. So different products require different measurements but we're always trying to assess and understand exactly what our nanomaterial that we're doing research on or is in constant production, exactly what are its properties that are important to the customer as well as understanding as we develop new products.

I think that SPC[2] and quality control and quality assurance is a general operation that has to be done in any commercial business, but what's different in nano is that we're making intermediate materials and finished goods that have a whole new class of analytical characterization that used to be done in laboratories for pure science and now you have to transition those pretty high tech measurements and characterization at the atomic level to a development and manufacturing platform and make them robust and understand exactly what your results are and how your intermediates and finished products are performing. Some of the challenges unique to nano for quality control is, instead of just measuring bulk properties that could probably be done cheaply and simply, you really are digging into the atomic level so we need to characterize our products for reactivity, filament levels, alloy composition as well as particle size and contaminant levels and such. I think for us the challenge on what we've been able to achieve is taking quality measurements, which tend to be very high-tech and laboratory-driven historically, and bringing those to measure very high tech products. So that, although the practices of quality control are all the same at table stakes, having these new high tech measurements, being able to characterize high tech products brings a whole new set of complexity to the manufacturing operation. So that's one of the focuses there.

LF: The answers to that first question has led to a whole range of things that I think we should kind of circle back and dive a little bit deeper into. I -- we'll come back to who sets the specifications. I think there's a mix based on your responses. But before we go there, I would like to talk a little bit more about the measurement systems. And Doug, you talked about how because nanomaterials, because of the inherent properties of nanomaterials, the reason why we're interested in them, it presents some challenges associated with the tools in order to do these measurements. So could you talk a little about -- you gave a list of the, of some of the techniques that you're using, but I'm interested in whether you have taken off the shelf laboratory measurement systems or if you've had to really design entirely new ways of measuring, whether it's for particle size, chemical composition or doping element or other properties that you're pursuing and you actually had to design your own systems or are you able to use what's readily available for labs, for instance?

DS: Yes. It's been a combination. We can do certain characterizations with commercially available equipment that we either own and support in house or that we partner with local

[1] Inductively Coupled Plasma Mass Spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy
[2] Statistical Process Control

Rochester businesses which have analytical capabilities as well. Those tests, some of the more basic attributes like sizing and morphology, that can be fairly off the shelf as well as ICP and XRF kind of measurements. That can give you answers and numbers that are off the shelf, based on off the shelf technology. The bigger challenge is understanding what those numbers and results and characteristic curves mean to understand what you've actually made and then take that part of it and transition it to how does that impact the performance of a nanomaterial in a customers' hands. And further we'll have to partner with customers who are the application experts who have measurement technologies that assess how our materials perform in their finished system. So this entire ecosystem from basic characterization that can be done sometimes with materials off the shelf has to be combined with our internal knowledge of how those parameters might, in a very subtle way, affect the performance of the product as we make it and how it meets our requirements as it goes out our door. And further work with customers to interpret how some very subtle variations might impact how well it performs in their particular process.

The equipment isn't necessarily the key component, because there are many types of facilities and laboratories including Cerion who can measure these parameters. Sometimes that requires some customization. It's taking the results and combining that with the knowledge of the chemistry and the products itself that really is the value add to understand how everything that goes out the door meets our customers' needs and performs in a unique way that nanomaterials can offer. I think that's the critical part.

LF: Thank you. That is very interesting. Katherine, do you find the same is true at Nano-C?

KB: I definitely do. I can't say enough how our experience sounds like the same as Doug's. Potentially at a smaller scale, but yes. One area that we are looking at is, as we scale, is being able to make our test results in-house as, you know, as they are, be able to translate into performance in the product that our customer is working with.

Right now in the same way as Doug is saying, our final test is still how our material performs at the customer. So that causes a delay and it causes, you know, just a constant question about our materials and our processes when we want to constantly be improving. So we're trying to tighten that time frame. And additionally definitely coordinate our test results to the results that the customer obtained so we can do -- can find hopefully a direct correlation and allow us to do QC here that can give the customer confidence that it's going to work on a larger scale for them. So we've had these conversations with customers extensively and we're working with them constantly to correlate the data that we get on each end to allow it -- to allow confidence in the results.

LF: That's great. And it sounds like the communication with your customers in order to use the results that you develop and communicate how that refers to the parameters that they're interested in, and also in developing specifications is very important. It also sounds like you both have your own internal measurements that you make in addition to what might be required or asked for by your customers. I'd like to take it in the other direction a little bit. When you are receiving materials from suppliers, do you -- does quality control apply there as well, or do you work with them in order to ensure that your specifications are met by the materials that are precursors to what you develop? Let's start with Katherine this time.

KB: Okay. Sure. Yes, we do expect our reagents and materials to meet certain specifications at time of purchase. We document traceability on our purchases, and there are specific --

there's a lot that's kind of standard and there are many particular materials that we pay strict attention to and do oftentimes test batches, test runs with certain specialty materials that, to ensure quality before utilizing anything, utilizing it in our final product. And that applies additionally to process materials. Certain materials we use for purification or just in the process in general we have certain type specs on those as well. So it's not just the materials going into our product, but also used on our product, because of the nature, the nano nature, every single thing our material touches could impact the final product, so there's certain areas that we have to pay particular attention to on that.

LF: And Doug, what about your interaction with your suppliers?

DS: Yes, in the same way Cerion makes sure we have an understanding with the different suppliers for the different criticality levels of raw materials. If there are certain ones that we need to pay much more attention to, which could have a much larger impact on the quality of the product we make, a much closer relationship and a much stronger tracking of what they're sending us and what they need to control and double-check what we do internally to verify that their C of A's[3] are correct and there's sort of a level of trust. Some particles require chemicals that are hard to obtain and can be slippery as far as the amount of quality in the materials, so we do need to be aware of that. But on the other end what Cerion does is during product development, we intentionally move across a different set of spaces in raw material quality or variability so that we can assess all the different variations in possible quality. In this sense, that kind of development of the quality measurements and the analyticals on raw materials can actually be an effective way to control cost. Because as we do with product development before it hits commercial scale, we can actually assess various levels of quality of raw materials from different vendors and different grades, when actually it can be a tool to reduce cost. Because if we can determine that during research only one or two types of chemicals or quality of chemicals were used as soon as it goes to development at a ten times larger scale, then we can vary the quality and the range of attributes and raw materials and if we can actually find a space that has lower cost or allows us to use lower cost raw materials that are slightly lower grade but do not impact the quality of the product, that is actually how we use quality and analyticals to improve our operation because that can reduce the cost, allow us to go to alternate vendors and ultimately have a product that we know is robust, raw material variation.

So that's where quality of raw materials can actually be a tool where it is not just making sure we're always getting the same thing, which is necessary, absolutely. But allows us to find out what the cheapest and simplest raw material that we can work with to support our business operations. So that's a slightly different take in addition to understanding making sure we get the right material every time but how can we get the most economically viable raw materials.

LF: That's great. And actually, that sparked my memory about a conversation regarding kind of challenges associated with developing integrated systems with nanomaterials and the question related to standards. You mentioned that looking at quality of your raw materials in different grades. Have you engaged with efforts regarding standards, this could be everything from the definition to the actual properties of -- I'm thinking particularly of a discussion we had in the graphene community where graphene is sometimes used to describe multilayer graphene which is different than single layered graphene. I would imagine that this is certainly true in the carbon nanotube space as well. I'm wondering in your work have you

[3] Certificates of Analysis

engaged in efforts to develop standards around nanomaterials, either from point of view where you want your suppliers to provide you with materials that meet certain international standards, or is that something that's being requested of you by your customers. And I don't care who jumps in first. Any thoughts on that?

DS: This is Doug. I think there's two sides to that. We go about it two ways. If a customer requires certain certifications of raw materials, we'll definitely work closely with our customer to make sure that, say if it's an FDA or EPA or REACH regulated product or raw material, we'll make sure that we work with our customer on the sales end and the raw material supplier on our buying end to make sure that entire flow through everything is met in terms of regulatory and good practices certifications if that's what's required by the customer or if that's what is required by a government regulation. So we will definitely work to have that understanding and see if we can find the right materials at the right quality, meeting the right specifications that maybe even beyond what we need to make a product, but something which is a more stringent requirement placed on us by the customer so that our entire supply chain has the appropriate country of origin, maybe it has the appropriate certifications from food grade or pharma grade standpoint. We don't necessarily develop those new specifications but there are times when the criticality and the customers' applications requires a supply chain that is certified by various agencies or to certain standards. So I think that might be one way to answer is that we will not necessarily try to create a new national standard for a nanomaterial or a supply of chemical that is made in a nanomaterial but we certainly have to follow them if the customer or an agency requires it.

KB: I echo what Doug said regarding the customer driving our need to meet different specifications or standards. As far as environmental standards and such in particular, we are encountering that right now and we -- while we're not setting the standard, we are trying to meet it because we just are discovering that our customer needs to meet a new standard that's being imposed on them. One other interesting thing that we have been doing is we are participating in a NIOSH study on exposure to nanomaterials, in particular carbon nanotubes so the entire company has been evaluated and now we're being tracked for exposure because that is such a -- with the nanomaterials becoming more common, environmental exposure standards are necessary to protect the user, the end user, as well as those manufacturing all the different nanomaterials. So it's kind of exciting to be involved in something like that where the standards are going to be verified and developed on that level.

LF: Thank you very much, for sharing that, Katherine. I think we hear very often from small companies that their engagement with NIOSH has been very positive and as you said, being able to participate in exposure studies and that type of thing, but we've also heard that it is often then helpful with respect to insurance and other aspects of receiving investment if a collaboration with NIOSH has kind of reviewed the processes and the worker safety conditions. So I'm really glad that you brought that up.

I just wanted to throw out before I ask the next question, since it came up on both exposure and some of the regulatory issues around nanomaterials, coming up the second week of October, October 9th and 10th and 11th and 12th, we are hosting two workshops here in the Washington, D.C. area. The first one is second in a series called Quantifying Exposure to Engineered Nanomaterials, and the second one is an annual meeting we hold for the US-EU Communities of Research in nanotechnology environmental health and safety. Both of these meetings will bring together an international research community that is addressing potential implications of nanomaterials and we're really trying to focus on what we know since we have

learned a significant amount about these materials and how they interact in the environment and in the human body over the past 20 years. A quick announcement for those of you on the line.

I would like to go back to -- go back a little bit to the technical aspects of quality control. We talked about how it's challenging to make these measurements, that laboratory scale measurements need to be modified in order to be effective in a manufacturing setting. My question to both of you is during the process of developing quality control systems at your companies, have you identified any potential gaps that you see that might be addressed in the research community? Of course NIST, the National Institute of Standards and Technology works to develop measurement technologies. I think there's interest in some cases in going from batch, taking a sample and doing the measurement like you would have to do for TEMs for example, into something that could be in-line in real time so you could monitor during the process as opposed to taking samples and measuring. I'm wondering if either of you have suggestions for the research community of things that you see are needed by industry in the scale-up and commercialization of materials.

DS: This Doug. I can go first. I'm not aware of any particular needs that we have come across for a novel new approach for material measurement and characterization. I know that our researchers would love to have all kinds of different tools for assessing and analyzing all kinds of different attributes about things that are being invented, understanding a different unique characteristic. As far as transitioning something brand new to a shop floor for a commercial operation, I think there's a challenge that would need to take some time. Because if our customers don't recognize the value of that measurement or the streamlining of that measurement, it would be hard for us to share the results and have it be meaningful. So as a commercial company, we would need to have new technologies probably go their course and go through a more -- become accepted so as a recognized technology so the results could translate widely among suppliers, customers and people who look at the results and say they understand what that means. Now, in the laboratory obviously any bit of information is key to understand something new that you've done and created. But as far as changing a certain measurement to inline, that would certainly need to be robust so that the quality measurement is not adding some unknown variability to your manufacturing process. So I would like to see something mature coming through that might do something that's currently done expensively in a laboratory that could be made more robust. But that I think is a challenge where how do you make that widely available and widely understood.

KB: I agree. I think that the key to avoiding the performance in say a device being our determining factor for quality would be kind of for our customer to be able to scale and be confident in their process enough that they can have parameters for our materials that are measurable in a reasonable way outside of their process. So whereas right now it's like give us a batch that's the same exact -- same exact as the last one you gave us, rather than that, have it be okay, we can work with something in this range. And so I think we're still waiting to get there, because every level of the use of our materials is still in development. And so it's just, we're still looking at the whole process rather than being able to consider our materials separately. Unfortunately, right now we can't pull out one test that we could say let's set a standard for this. But that's our goal. So it would be great to get there.

LF: Before I follow-up on your responses with a couple of other things that came to my mind, I want to remind those of you who are attending the webinar, that there is a box there that if you have any questions, we will try to get to them if we have time. So you're welcome to

submit those at any time and we'll try to cue those up. But so a reminder there. But I want to go back to, you mentioned several times now how the measurements that you take need to be meaningful to your customer. And I'm wondering if either of you are working with modeling or simulation or development of ways where you can -- you know, I think as a material scientist we're always after the structure property relationships. So are either of you using models in order to take the data and apply it into potential performance? And is that an area where the research community might be useful.

KB: Well I know in our research section, models are used constantly to, in our development of new molecules utilizing the building blocks of fullerenes and those models then can steer the way towards new molecules that might work, that might give an improvement to one customer or another for their device performance. And we've worked extensively in that type of development with several customers. And the modeling is used heavily in that area for us.

DS: At Cerion, we have used modeling over the years as we develop new materials. We have done that on selected items where perhaps the knowledge base that we currently have empirically is incomplete. In other places we don't use modeling because we think we have basically a good understanding of the space that we're working in and maybe a new product is a cousin of an existing product. So we already understand that space. So I would say it's hit or miss whether we use modeling and it would be unique to every individual product. So I don't think there's a recommendation on a certain type of modeling that would be useful in any particular situation because of the breadth of what the response you're trying to optimize is across a wide range of nanoparticles and customer applications, as well as all the different structures and ligands and add-ones that you can put on. We wouldn't have -- I don't think there could be one or even a few model solutions that could cover a big enough space. So we would only use them, or we have used them in a limited area where it provides value and it is usually pretty unique to that material or that customer's application. So that's very much on an as-needed basis where it does add value.

LF: Great. And I would like to take a question now from one of the viewers. The question is, and actually this is a great question. With respect to quality control, what is the investment in terms of time, cost, labor hours, however you would like to quantify it. I know that some small companies have told us as much as a quarter of their staff is devoted to quality control. And I would love to get your perspective on how much of your business really is focused on this issue.

DS: This is Doug. I would not disagree with a number that high. If you're going to get into any high-tech chemical manufacturing and research operation, it's not for the faint of heart who aren't willing to invest in understanding analytical attributes of raw materials, the process, equipment, the product itself and the customer's application. So a fairly decent 10, 15, 20-some percent of perhaps an operation could be dedicated to not just quality assurance, quality control, but analytical investigation, characterization. It truly can be an investment that is necessary, but it is necessary. We're not making table salt or pencils in our industry. So having that clear understanding is something you really need to be prepared to take on. Cerion has a whole host of that capability in house and that can even translate from the research labs all the way to the shop floor, all those fractions of those people can be considered part of a quality process and they all need to be. In addition, Cerion can partner to help defray costs with outside partners who can supply some of the capital equipment and technology we don't want to bring in-house. Either way you need to be prepared to understand at an in-depth level what your product, what kind of parameters and

characteristics it has, how it's affected by different raw materials and making sure to meet your customer's needs. So if you are thinking of getting into a new business from an existing commercial operation into a new nano operation or high-tech chemical operation or doing this for the first time, this is something that is a required investment and Cerion has had to make that so we can characterize all of our nanomaterials the way they need to be which is pretty nontraditional from a bulk chemical operation. That is a requirement I would have to say.

KB: Yes, I would agree. I would say because of the scale of our company right now and the nature of it, like Doug said regarding the fact that it's a new material, 25% is probably low. Basically everything, every step of every process involves ensuring quality. So technically every person that is working on the technical aspects of the business is involved in the QC. As far as interpreting and developing based on the data collection. I'm sure 25% is minimum of time that's spent by our technical staff on evaluating the quality of what we do. So it's very -- after safety, that would be number two on our priority list right now.

LF: That's great. I think that's really useful for people to understand. So as we talked about kind of in my opening comments, the purpose of sharing these stories is to provide best practices and some insight and to help others that are just getting started. I wanted to ask, Doug, I'll start with you, because you mentioned in your opening comments or early in the discussion today that for some of the measurements that you took, especially when you were first getting started, involved partnerships with other Rochester businesses. I'm curious if you could maybe share a little bit about the ecosystem and the advice and mentoring that you have received or where you found that advice.

DS: In a general sense, Cerion is based in Rochester, New York. And in general Rochester has a 100-plus-year history of being a technology innovation and manufacturing region. So the fact that we're head-quartered here is kind of a very large benefit that Cerion has. We can leverage the experience, I myself had 17 years at Kodak. Our researchers, our operations people generally have 15-25 years' experience, many of them at Eastman Kodak or other local high-tech businesses. So this area is very good for that and we can actually have a certain sized footprint of our company itself. But partnering with other operations here in Rochester and leveraging that is very useful. For instance, Eastman Kodak still has a presence here, which is both very large chemical manufacturing operations and facilities that we can lease out and make use of, as well as their analytical tools.

So partnering with large corporations that have excess capacity and analytical equipment, and defray some of the costs from having to buy that ourselves. We also have Rochester Institute of Technology and the University of Rochester and Cornell in the region. So using those in our earlier stages of product development to do the more in-depth analyses allows us to save capital by not having to support those directly in-house and yet it is an extension of our company, so to speak. So that is a good leverage as well as on the output end, having access to large manufacturing facilities and expansion capability and also using some of those other organizations to do some of the quality control measurements, where we might not want to buy a TEM but there are those available here in Rochester. Those guidances and use of those assets that are in our region have given us -- continually gives us an advantage over buying a building, all of that from a greenfield site. So the ability to consult with measurement experts doing GC and XRF[4], to understand subtleties and differences we

[4] Gas Chromatography, X-Ray Fluorescence

might not be fully aware of and how those results can be interpreted is definitely an advantage that Cerion has without having to have all of that in-house. So guidance from the general Rochester community, the companies that are here, the academic institutions that are here, is really a key leverage that we have. And we don't have to build all of that in house.

KB: Yes. We also at Nano-C being in the Boston area, we benefit greatly from the presence of so many universities in the area that do have more sophisticated equipment, for testing in particular, that we've been able to utilize and learn from them where to go with some of our testing. Particularly with developing new materials. We can utilize their heavy duty skills with their staff and not have to invest ourselves. And that's been incredible. And as well as working in the area several of our customers are luckily local, so there's a lot of back and forth where we can quickly bring a test sample to their lab or their partners' lab and use the equipment. So we really do benefit from being surrounded by so much academia in our state in particular. So that has been incredibly beneficial for us.

LF: Well, that's great. And I'm really glad to hear that. Last week I was at the annual meeting of the National Nanotechnology Coordinated Infrastructure, which is, I hope that you know, a program funded by NSF that provides support for infrastructural resources at 16 different sites across the country. And Cornell is one of those that Doug mentioned. And we often hear that these facilities are very useful, especially as companies are just getting started. And of course this is one of the areas that is listed in the priorities memo that was released by OMB and OSTP as a critical aspect for the research and development enterprise for the country. So I'm very pleased to hear that you make use of those resources. I'm wondering in addition to the infrastructure, the research infrastructure, have you engaged with the federal government or received support in other ways?

KB: We are currently actually in the process of pursuing several grants for our expansion of our quality programs to educate more of our employees on the strategic processes that we should be undertaking to ensure consistent quality of our products as we scale up. Additionally, we, like I said, we're participating in the NIOSH study, which actually is mutually beneficial, and utilizing the -- I suppose it's more on the state level, but I believe it ties in with the federal government as well with regards to support of our scale-up pursuit so that we can benefit the community as well as our materials' development.

LF: Well, great. Thank you very much. And Doug, have you engaged as well?

DS: Yes. I would say that Cerion's primary mechanism of engagement with the government is through the Department of Defense. And I would characterize that more of a partnership than direct support. But the partnership that we have with the Department of Defense agencies is to help develop new materials that can be based on nanotechnology that we have and our expertise in developing new kinds and flexible kinds that can meet different needs for different customers and the Department of Defense being a large user of technology and wanting to transition that to the field, that our partnerships with them, we have had past partnerships where we have developed tungsten-based materials to improve hardness and density and strength in novel ways that nanomaterial enables that bulk materials may not be able to enable.

We're continually looking to work on new contracts and new partnerships where we can bring our expertise of manufacturing scale of inventions that may have been pioneered at

Department of Defense agencies take that and transition that into larger scales and make it cost-effective. So in that sense it's a partnership between the Department of Defense agencies who perhaps have the inventive in the first stage ideas and they will ultimately be the end customers and in between Cerion can take that information and work on making improvements to the product, making it more robust and cheaper and ultimately making a large manufacturing scale to transition to the supply to Department of Defense for their application. Those partnerships tend to be a sharing of information, a sharing of technology and Cerion supplying some of the commercial part where we can develop, robustify and make a transition to full-scale manufacturing. That is in a full way we want to support the Department of Defense and continue to do what we have done in the past where this partnership benefits both sides.

LF: Thank you very much. That was really a great description. And I think that from our perspective, we're really looking to highlight not only the research and development that takes place under the National Nanotechnology Initiative, but also the activities that support the goal that I mentioned at the beginning of this webinar, which is really to foster the commercialization and that takes place with respect to the infrastructure that's available for testing and early stages of quality control, the expertise that exists with the universities that do research that's funded by the government. SBIRs and those types of early stage funding all the way through the environmental health and safety resources that have been developed by NIOSH and many of the other agencies that participate in the NNI. So I think it's important for us to tell stories such as yours as part of the entire NNI enterprise in the country and I appreciate your thoughts on that. I would like to ask a final question of each of you, and that would be, and maybe we'll start with Katherine. You know, we've talked a lot about different aspects of quality control and the challenges of working with suppliers and customers. I'm wondering if you had advice to share to a company that's either just thinking of getting started or just getting started, what final words or advice would you have to share with them?

KB: Okay. Well, I guess it could be challenging to insist on certain processes being followed consistently, particularly when you're going from an R&D kind of mind set to a production mind set. And to just really just stay the course. Just keep collecting the data, keep at it, keep educating the work force to understand the quality issues that are presented to you and that the customer has. And to just not lose sight of the fact that that's what's important to you. And to emphasize that each step is critical and important no matter how small it seems. So really just educating everyone that touches the material that you are making, just involving and communicating as much as possible with those people is the key. To collect the data, to allow you to examine it. I know it's kind of at a grassroots level, but that's how we've been approaching it and it's worked for us so far.

LF: Great. Thanks. And Doug?

DS: Yes. Whenever I give this kind of advice, I get quizzical looks and eye rolls. But my advice is fail and fail fast. Because you're going to fail no matter what sized company it is, whether you're a start-up or a large company that’s branching out into a new technology but you're going to fail. You're going to have an experiment that goes wrong. You're going to get thrown for a loop somehow. And if you're in regular manufacturing operation you're going to get a QC result for a batch or a process that is out of spec.

In any of those aspects, don't be afraid that you're going to fail because at Cerion we have the mindset of fail fast, learn from it, loop back, fix the problem. Whether that means change

the attributes in the formulation in a research project, or change the equipment in the operation of a production facility, but you're going to fail and you're going to get QC results that are out of spec. You're going to get analytical results while you develop new products that are different from what you expected. That may lead you down a whole new path of learning that you wouldn't have thought of in the first place. History is littered with lots of people who have made fantastic discoveries when things didn't go the way they thought they would. At Cerion we take that to heart saying you're going to fail, things are going to go wrong and two weeks later we're going to be on a whole different path and we are going to fix the problem and learn something new. So do not be afraid to try these things and every time you get a failure, investigate it, understand it, find out why you got a different quality result or a different analytical assessment of what you made and learn from that and move on. So don't be afraid of those things, because they can definitely help and speed up your development process or robustify your manufacturing process. Take those failures as an opportunity to learn something that you didn't know before.

LF: Well, that's great. And I think that I'm going to -- I'll certainly share that with folks that I talk to. I really love that. So thank you. I'm going to take the moderator's prerogative and ask you each one more question. And this is a broad topic that we could spend at least an hour if not days discussing, but I want to ask if you could provide just a quick answer about workforce and about ability to find the people with the skills that you're looking for. How is that going for you, and is there any lessons for us regarding education and workforce of the people that you're looking for. Doug?

DS: I think it's always unique to the project and the product of the customer we're trying to meet. We have a core group of very talented people because of the region we're in, and I'm sure Nano-C also has a breadth of people in the Boston area, I'll let her speak to that. But we have the luxury of having quite a resource, both in the upstate New York and Rochester region as well as being able to tap into people nationally. I think on a national level, that the skill sets for nanomaterials and material science, they are available, they just need to be selected pretty carefully and understand what skills you're looking for. But certainly I think that needs to continue and be developed and have people go into that field and continue supplying out of universities and getting work experience. We need those kind of people. That's who we would hire.

LF: Great. Thank you. And Katherine?

KB: Yes. Luckily, like Doug mentioned, we are in an area that has a large supply of well-educated individuals in many fields. Luckily our technical directors are very well-connected with the field and can draw on that, those connections internationally really. But also specifically from universities in the area. It does seem we have seen -- I've noticed the development of even new college majors in different parts of the country that specifically reference nanomaterials study, so that's very promising for the field. The one area we do -- that is a little tricky is in our actual operation where we need a certain skill set that doesn't necessarily pull directly from the academic environment that we're in. However, we do benefit as well from the presence of a lot of biotechnology firms. And so luckily the skill set is translatable in that, in the handling of materials which is very important for our production. So we are in a good spot for workforce.

LF: Thank you very much for your insight. I really appreciate that. That's an area I'm certainly passionate about and it's helpful to get your understanding. So I think that we are about at

the end of our time. So I would like to thank again our participants today. Katherine Barton of Nano-C and Doug Singer of Cerion Advanced Materials. I very much enjoyed the conversation and I also thank all of those who listened in. Please keep an eye on nano.gov for the archive of this webinar and the continuation of the Technology Development Pathways discussion. I wish you all a nice day and good-bye.