Dr. Ono: I'm Santa Ono, the President and Vice-Chancellor of UBC. On this season of the *Blue and Goldcast,* I'm speaking with the people who are leading some of the most innovative and creative work coming out of our campuses. Today, I'm joined by Karen Cheung and Lukas Chrostowski. Dr. Cheung is a professor in electrical and computer engineering in the School of Biomedical Engineering. Dr. Chrostowski is a professor in electrical and computer engineering, as well as a member of the UBC Quantum Matter Institute. They've been partners in developing a platform technology and biosensor that can be used as a diagnostic tool.

Recently, they were awarded $100,000 in funding from Canada's Digital Technology Supercluster COVID-19 program. Karen, Lukas, welcome to *Blue and Goldcast*. Thank you so much for being on the show.

Karen: Thank you for having us.

Lukas: Thank you very much, Dr. Ono. Pleasure to be here.

Dr. Ono: Let me hear a little bit more about both of you. I know probably more than the listeners, so let's start with Karen. Tell me a little bit more about you and how you ended up at UBC.

Karen: I didn't always dream of being in academia, but when I was finishing up my postdoctoral work and looking at my career options, I was so lucky that UBC was hiring. They were hiring in micro and nanotechnology, and so somehow, I scooted into the department of electrical and computer engineering because I did bio=-microtechnology. I've been at UBC since, and it's been a fantastic place to be.

Dr. Ono: Are you from around here? Where are you from? Just tell me a little bit more.

Karen: I'm originally from California. It's funny that Lukas and I both did our graduate school at the same place, at Berkeley, although we didn't each other at the time. When I came to interview at UBC, Lukas was the first person I met. He and his wife picked me up for dinner, and it's been a friendship since then.

Dr. Ono: Lukas, tell me about you. Are you also from that area?

Lukas: No. My family immigrated to Canada in 1980, from Poland. We started off on in the east in Laval, Quebec, gradually moving west towards Ottawa. I've always had my eyes on the mountains. I've always been a skier mountain person, and so as a child, I was always attracted to Vancouver. I went to grad school at UC Berkeley, as Karen mentioned. Then when I was finishing up, there was openings in there. There was a doubling the opportunity. This is around the 2000s or so. There was a big expansion in electrical engineering and digital technologies, so I was fortunate enough to get a position here.

My background in terms of what I work on, I guess, ever since I was a child, I was always playing with lasers. I remember when Star Wars came out, my dad was working at the national research council, and so he brought home the lasers when I was a kid. Lasers were always in the family. Now it's really exciting to actually be able to be working with lasers and silicon photonics and biosensors. It's been a pleasure working with Karen for so many years.

Dr. Ono: Well, wonderful. Karen, Lukas was the first person you met, but the collaboration didn't actually start over dinner. I understand this collaboration started when one of your students took Lukas's course. Can you tell me that story? Who was the student, and what happened?

Karen: Absolutely. Yonas Flueckiger was a visiting scholar. He was in Vancouver in my lab, and then he joined my lab as a PhD student more than 10 years ago. His project, at the time, was actually developing a gas sensor, a nanofiber-based gas sensor. He's a super creative and very curious person. He was interested in this silicon photonics training program that's led by Lucas. Yonas took some workshop courses and designing, fabricating, and testing photonic integrated circuits and part of the course, as I understand, it requires a project. Yonas designed biosensors and waveguides, and this worked out really well, because my own research is in microfluidics and tissue engineering. Putting the sensors together with the microfluidics worked out very well. Altogether, Yonas, Lucas, and I have published several research papers.

That was the first student, then afterward, another PhD student did my group, Samantha Grist. Her project was also on something different, on microfluidic technology for tissue engineering and controlling the microenvironment around tumors. As one of her course requirements, she was also interested in silicon photonics. She also took these courses, taught by Lucas. She followed in those footsteps, and we had more, further publications on silicon photonic biosensors. Since then, we've had a third student who also worked in Silicon photonic biosensors. It's been very, a great collaboration of these years.

Dr. Ono: Lukas, do you actually like teaching, you seem to have actually inspired all of these individuals that were part of the collaboration between the two of you. Do you enjoy teaching?

Lukas: Yes. It's funny that you ask, at the university, there's this almost like divide between, are you a teacher? Are you a researcher? I feel like those things are so closely connected. This course, in particular, has been such a flood in terms of research opportunity for me. I really enjoyed the teaching. Particularly, what I really enjoy teaching is courses that have research as an outcome. In these workshops that we're doing, that Karen was describing, it's actually a nationwide activity. Students come in from across Canada, we teach them the state-of-the-art and what's happening in the research, and then those students go on to write papers and theses and start companies and develop products and industries. That's been extremely rewarding.

Dr. Ono: If I understand correctly, I looked you both up on Google scholar, and I was just blown away by both of your productivities. I was also impressed because it seems like you've been working together for a number of years, eight or nine years, if I looked at that correctly, and you have published almost 30 papers together, is that correct? That's remarkable.

Lukas: Yes. This has been a great journey. The way we've been doing this is, as I mentioned, it was this create program where we had 450 students from across Canada, 70 institutions coming, and the way it's worked is, it's been a bit organic, in the sense that we teach what Yonas was doing. Then somebody listens to that talk, and then says, "Wow, that's really interesting". Students are invariably attracted to projects that are multidisciplinary with the lasers and bio applications.

Every year, we always get a few students who want to jump in on these projects. That's how we've been just doing it on the side, having a bunch of grad students do this as a course project, and eight years later it's like, "Oh my gosh, look at where we are".

We've done some funding through discovery grants, so there's been, as Karen mentioned, and the show is funded. To be honest, when I was to actually work for a startup company, Side X. Essentially, it's some of the work that we've been doing, with youngest is now being commercialized over there, and then Side X has sponsored some more research as well. It's been great.

Dr. Ono: How did it arise? Was work on COVID happening in either of your labs before this project, how did this happen?

Katie: Our labs were shut down with the on-campus curtailment last year. We're all told to work remotely, but through Lucas's contacts and connections, we were so lucky to be approached by a UBC spinoff. They're now known as Jemena labs, right at the beginning of the pandemic. They were looking for a way to validate what they were doing in a lateral flow assay. They wanted to test the effectiveness of their chemistry for detecting COVID and through conversations between Lucas and his connections there. They understood that we needed to really scale this up and be able to do this in a very quantitative way.

We obtained an exemption from the university so that our students could go back into the laboratories and use what they were already doing in developing microfluidics and the silicon photonic technology, but really applying it, with the chemistry, to something very relevant to the pandemic. The students were just excited to be able to participate in this project and feel like they were doing something relevant.

Dr. Ono: That's wonderful.

Katie: It is indeed funded by the Committee in Digital Technology Supercluster.

Dr. Ono: Wonderful, Lukas, your team just filed a patent for this biosensor technology. Is that correct?

Lukas: Yes, sure. I'd love to tell you about it and how it works. What we're doing is essentially developing a new, powerful low-cost platform technology. It's based on Silicon chips, so the same kind of chips that you have in your telephone and computers. The idea is that you could put 10, maybe even 100 sensors on this chip, and they could be configured to have different chemistries. Those chemistries would then allow you to measure different biomarkers or pathogens. We project the chips that UBC but then ultimately, these are going to go to a microelectronics foundry somewhere in the world, and you can make hundreds of millions of them.

Let me tell you about how the sensor works and then, in particular, what's on this new patent that we came up with. The measurement principle is based on measuring the optical index of refraction, which is, essentially, the density of the material as seen by light, and we're measuring the density of the material on the surface of its silicon. The material that we're measuring, in this case, might be something like COVID-19 particles, and the way we measure the optical density is using a resonator. It's just like a guitar string where you pluck a guitar string as a frequency and if you change the weight, then the frequency will change and so our goal is to measure the frequency of the light that resonates with a string resonator, and then correlate that with the frustration of the analyte.

The way that's usually done is you have a $100,000 laser, and then you sweep it across this resonance, and then you look for a peak where this resonator is humming, just like a guitar string. What we did was instead, we thought about, going back to this motivation in March was how could you possibly take that and make 100 million of those? There's no way we can use this 3000 benchtop laser. The idea is that instead of sweeping the laser, we think of sweeping the resonator. Imagine taking your guitar and so we have a fixed frequency, and then you take your guitar and you tune the guitar to try to match the source, rather than the other way around.

Then essentially what we're doing developing is circuits on a silicon chip side, which tune the resonance of the sensor to match our reference, and the reference, which is what's neat about this is that you can now purchase lasers for $1 instead of $100,000 because they're used in internet communications and fiber to the home, and so they're already deployed in hundreds and hundreds of millions a year.

In low-cost lasers, replacing a $100,000 laser, and we also are developing technology at UBC to integrate the lasers with a Silicon chip, and so ultimately, that results in something that could be really manufactured in high volume. Essentially, what we have is we're sitting on technology that replaces a lab of hundreds of thousands of dollars with something that could be a few dollars when it's manufactured. It would be just like conventional manufacturing, like electronics, and especially the potential of integrated photonics, and combining optics electronics on a trip for things that would be previously extremely expensive to do.

Dr. Ono: That's pretty amazing. This is a very new technology that helps. Have you already gotten the patent? Has it issued yet, or are you waiting?

Lukas: We filed a provisional in April, and then the way the process works is you have one year to file the full application, so we filed the full application roughly two weeks ago, and then now we're in the next period where we have, I think, it probably takes two or three years before the patent issued. Then in the meantime, we have more work to do.

Dr. Ono: This particular application is, if I heard you correctly measuring, maybe it was just an example, but the viral, I guess, the SARS cough too of viral particles, is it in the circulation? Is it in, let's say a lavage from the longest-- what are you measuring?

Lukas: We're measuring fluids or gases in principle, and we have to have a wet material that gets put onto the Silicon chips. Imagine a tiny little drop of blood that gets placed on the Silicon chip, and then you're measuring the binding to the Silicon surface. You have to have some sort of liquid, whether it's urine, saliva, blood, other of things like that. Then the big challenge there is how do you deliver, how do you extract a drop of blood, but how do you deliver that tiny drop of blood to the chip? That's the realm of Karen's work on the microfluidics.

Dr. Ono: Tell me a little bit about that, Karen. Tell me about the challenges in making microfluidics work in this setting, and is everything working just right now, or is there more technology development that's necessary?

Karen: There's definitely more technology development that's necessary. Microfluidics has been talked about for a long time. I'm not sure that there's been a standardization yet in the industry. Unlike integrated circuits, we can't just design a component and have it work for all microfluidic devices. It has to be customized for each application, and sample preparation, the chemistry is going to be really important, and as Lukas mentioned, how do we make it small and reliable and portable? Getting away, in this instance anyway, from the continuous microfluidics.

I think some of the challenges that we're having are that we are able to develop some of the fundamentals in the laboratory and that works out very well, but it's not quite ready in some cases to be spun out yet. We have a little bit of a gap, and so bridging that gap, I know that there are federal funding opportunities for that such as the answer guides I program. I know that other provinces have been very successful in supporting in Ontario and Quebec, some of this R&D work. We're looking for that kind of support to get from the fundamental to the scaler.

Dr. Ono: Let me ask both of you to just dream about-- You're putting all this energy into a new patentable technology, and you're focused on certain indications. What are your imaginations about how else you could use this platform in the future?

Lukas: A very good question. One of the goals that we have is for silicon photonics technology to become as ubiquitous as the computer microchips. Imagining a world where you have a million silicon photonic chips, a billion silicon photonic chips, and then it's a question of what are the applications? COVID-19 was one that, a year ago, really opened my eyes to the huge opportunities in terms of volume. Typically, I work on data communications, optical computing, quantum computing. These are very low-volume areas. This is a completely different world where there's high volume applications.

COVID-19 was really just the first one, but I think what I would imagine seeing is if we can develop this platform, then we can go and work with other disease researchers and companies developing things like sensors for cardiac biomarkers, arthritis, detecting lots of different diseases, and ultimately having the Star Trek, our Star Wars' high corner where you have a drop of blood, and we can find out the top 20, top 100 analytes that we care about. From a biomedical perspective, that's where I see it going. I think you raised lots of other fluids like the lung and things. I'm not a biologist, but these are the conversations that we're having these days, is asking lots of people where this could be used. Another conversation that we've been having lately is around greenhouse gas and climate change and so on. So what other kind of things can these small chips that are very low cost could be used. If you can have a million sensors doing something, measuring greenhouse gases, that's probably very interesting as well.

Dr. Ono: Absolutely. How about you, Karen?

Karen: In previous projects, we've discussed with companies interested in water quality monitoring, so contaminants or pollutants in water supplies would be very interesting as well, so environmental monitoring in general.

Dr. Ono: Tell me a little bit about your students. A lot of people view students as being at the very earliest stages of their career, especially if they're undergraduates. If you think about both of your teams, and you think about all the kinds of people who have been your laboratories, they could be fellows, they could be senior graduate students, or they could be completely novices. They could be first-year or second-year students who just send you an email and say, "I really want to do research," and you think about it and you let them in. Does it make sense to have, from your perspectives, somebody that's completely new in the lab that perhaps is not boxed into what's possible and what's not possible? What has your experience been about the newest members of your labs? What do they bring to your labs?

Lukas: I think this project in particular has been a good vehicle for having a wide range of skills and expertise. Unlike a very focused research only PhD topics, sometimes it's very hard to include junior people, but in here, we're essentially doing a lot of research, but also with a goal of commercializing something. We're building prototypes. There's a lot of hands-on things, so things like maybe preparing a circuit board and electronics and characterizing lots of chips, purchasing things, characterizing new laser sources. There's quite a lot of things that somebody who's never done before-- it's just as new for them as it is for a PhD or a postdoc student. I think that's been one area that's really nice, is that when you have this really big vision, "Look, we're trying to solve COVID-19. We want to make 100 million sensors," a lot of people can identify what they can bring. We have a host of people, biology, photonics, electronics, lots of people with different experiences.

The other part, I think, is in order to bring on junior people, undergraduates, and so on, is you need to have the capacity for training and supervision. For that, we've been fortunate to have excellent postdocs and research associates involved. That's a really key asset or human resource that's required to be able to do that. You have to have this team structure. Then the other part that we've also had is project management. I think Karen mentioned that earlier, that we've had a project manager that's been coordinating this whole thing, so that really allows us to identify, what are the specific pain points that we're facing, and then being able to identify something small that an undergraduate can take a bite over in the next two months or three months. That's been really effective, having this kind of big project.

Karen: Every summer, our group swells in size with the undergraduate summer students. While you mentioned, Dr. Ono, that they might be quite new to research, they also have many other experiences. Engineering students have experiences in design teams, or they've been part of clubs that develop 3D printers, so they bring all of that very useful knowledge and hands-on know-how. That's very complementary to what, perhaps, they will learn in our laboratory, but everybody brings in something new. When I build my team of graduate students, they're all from different fields, and I see that they're learning from each other and teaching each other. I think that the undergraduate students can learn how to do research and what the research enterprise is. The graduate students get help with the experiments, but they're also learning how to mentor the more junior students. I think it works out very well, and everybody grows.

Dr. Ono: We were all that first-year or second-year student that was stepping into a laboratory for the first time. Thank you both for spending time with me talking about this exciting project and all the possible applications in the future. Thanks for talking about how your collaboration grew from our very first meeting, and good luck in everything that you do. You are two of our stars. We have so many amazing faculty members at UBC, but I'm very impressed with what you have done and what you will do. Just wanted to give both of you an opportunity to say anything you'd like to say to the listeners today.

Karen: Thank you very much, Dr. Ono. It's been a pleasure to speak with you. I think that UBC is a really great environment. I tell this to two faculty candidates when they come to interview, that people here have been so willing to collaborate. I've never had anyone tell me, "I can't work with you, Karen, on this project." It's just because they're busy, but anybody I've approached about asking some questions about the science or possibly starting up some pilot project in an exploratory way, I've had nothing but positive interactions with my colleagues here at UBC.

Dr. Ono: Wonderful. Lukas?

Lukas: I would echo that statement and say, in recruiting students and faculty, that's the thing that comes up in UBC, such a great place for multi-disciplinary research and collaborations with people. It's a very open environment. I'm just honored to be an employee of UBC. I've been here for about 16 years, and it's just a dream job. We're recruiting, so all the listeners out there, if you're a parent and you have elementary school kids, please send them our way. I'm here for the next 30, 40 years. I'm looking for students at all ages and looking for collaborations, and I'm excited about our technology working, excited working with people on it.

Dr. Ono: Karen, Lukas thanks so much for being on *Blue and Goldcast* today. Dr. Karen Cheung is a professor in electrical and computer engineering in the school of biomedical engineering. Dr. Lukas Chrostowski is a professor in electrical and computer engineering and a member of UBC's Quantum Matter Institute. That does it for this month's episode. You can find links to our guests work that shows previous edition of the show at blueandgoldcast.com. You can also find us on your favorite podcast app. You can tweet at me @UBCprez, that's prez with a "Z." I'm Santa Ono. Thanks for listening.