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Faculty Spotlight: An Interview with Dr. Christian Zorman

AN INTERVIEW WITH

Dr. Christian Zorman

By Omar Ali

Dr. Chris Zorman is the associate Dean for research in the Case Western Reserve University School of Engineering and a professor in the Department of Electrical Engineering and Computer Science. His current research interests include microsystems and nanosystems.

This interview has been edited for length and clarity with Dr. Zorman's consent.


Photo: Credit: Dr. Christian Zorman

Q: Looking at your history, I see that your undergraduate and graduate degrees were in physics, but now you're a professor in engineering. Do you want to tell us a little bit about this transition?

A: Pretty early on, I decided I wanted to pursue a career in research, and at the time when I was an undergrad, it wasn't clear which direction to go in. I didn't have clarity. In fact, when I started as an undergrad, I was intending to become a lawyer. I actually have a BA in economics, which is kind of reflective of the fact that at one time I was an econ major with the idea of going to law school. But through influences from some of my closest friends who were engineering majors, I decided to make a pivot towards STEM. I was already in the College of Arts and Sciences for the economics degree, so it was kind of natural for me to pick physics over engineering since I had a lot of the general education requirements finished for the econ degree. I got an undergrad degree in physics, and then I decided, 'OK, I definitely want to do research." That came about through undergrad and work experiences, when I was an undergrad at Ohio State working at the Byrd Polar and Climate Research Center where I analyzed data on weather patterns over the Antarctic continent, and from working in the summers at a Nestle research facility in my hometown where I worked in food science. Obviously, I didn't go into food science and I didn't go into meteorology, but those experiences led me to a career in research. I still liked the physical sciences better, so I got a PhD in condensed matter physics here at Case. My dissertation was on surface science associated with diamond thin films, and when I graduated, this new field called micro-electromechanical systems (MEMS) was starting up. MEMS involved semiconductor materials like silicon, but instead of making electronics, which was the conventional way then, the field of MEMS involves the fabrication of mechanical structures from these semiconductor materials. I thought that looked like it was a promising area. It wasn't owned by any one discipline. You had electrical engineers working in MEMS. You had mechanical engineers working in MEMS. You had physicists, chemists, and chemical engineers, all working in MEMS. I thought, "that would be a good place to go." I did an extensive postdoctoral research experience here at Case in electrical engineering in the MEMS field. Then, when I decided to go into academia as a profession, and in particular at a research university like Case, I knew that it would probably be a better fit for me to be in engineering than in physics, so I pursued faculty opportunities in engineering. I had one in biomedical, one in electrical, and then a couple others in material science that I pursued at the time. Ultimately, Case made the best offer, so I decided to stay here.

Q: You had experience and academic work in both science and engineering. What do you feel are some of the similarities and differences between doing research and academic work in science as opposed to engineering?

A: I think research is research, right? Research involves the discovery of new information, new knowledge, and, in my case, experimentation. If you're in the pursuit of knowledge or information, whether it's science or engineering, it depends upon the starting point. From a scientific perspective,

> "If you want to know where the action is, you make yourself active in all of these events where information is exchanged."

namely a physicist's perspective, the pursuit of knowledge is in fact, the principal endeavor. So you engage in research for that purpose– to learn new things. Engineers do the same thing, but there's an additional component to engineering-based research in that it's typically guided by the desire to learn something that may have, or at least has the potential for, practical application. Both research-oriented scientists and engineers apply the scientific method to gain new knowledge, but where they choose to do their research may depend upon whether they're engineers or scientists. The engineer looks at gaining new knowledge that might lead to new processes, new devices, new software, or something along those lines, whereas maybe a chemist or physicist would be in pursuit of new knowledge for knowledge's sake, and that knowledge could then be utilized by research engineers to make new things. They're pretty close-coupled, and in fact, in the most interesting research areas, even in ones that you would classify as heavily weighted towards science, that research doesn't happen without engineers participating. And, on the flip side, in research that is oriented heavily towards engineering, practical applications don't happen unless there is participation by scientists. We often say in engineering that we're engaged in engineering science when we're talking about our research, so it's kind of a blend of both.

Q: Speaking of the scientific method and approaching open problems, how do you approach difficult and open problems in your work as a researcher??

A: I guess the first step is to discover what the problems are. Generally, if you're engaged in your scientific or engineering community, the problems of the day are widely discussed through conference participation, journal publications, conference publications, meetings, and seminars. If you want to know where the action is, you make yourself active in all of these events where information is exchanged. There are problems put out by companies, governments, and foundations. There's no lack of challenges and problems available for scientists and engineers to address and solve. Once you get motivated by one, you develop a plan to address that problem, and for faculty at universities like Case, we need to seek funding for the problems that we want to solve. We write proposals in which we clearly articulate the issue, the reason why that issue is important to solve, and we develop a research plan that will address that issue in some way or form along with the resources needed to do that. That involves specifying the equipment, time, and personnel, including graduate students and undergraduate student research assistants, and so on and so forth.

So that's what you do to develop a plan. If it's going to be funded by the federal government, it's often subject to peer review. Your ideas have to pass muster as they're evaluated by experts in your field.

How do I find these ideas? Usually in a place like Case, I have colleagues who are also looking to solve problems and I may be one who has a problem that I'm interested in solving, and I seek collaborators, or more often than not, because I'm a device developer, I have colleagues that have vexing problems that merit solving, and they're looking for those who can help develop the techniques and tools that may help solve that problem or perform the research.

Since I'm a device developer, I'm somewhat sought after when there are colleagues that realize they could use a device that does this, or a process that does that.

Before I move on, I don't want people to think that we're engaged in a service activity. For me to be excited about it, there has to be something new or novel about the device design or the materials that will go into whatever device we're going to make so that we're furthering knowledge in terms of device technology while simultaneously addressing a problem that might have scientific merit.

Q: Looking at your record, you've worked with physicists, biomedical researchers, and materials scientists and engineers. What are some reflections upon your experiences of working in different and unfamiliar disciplines, from the point of view of device making?

A: A long time ago, when I was a newly minted PhD, we would make a device just for the sake of making a device, to prove that we could make something that hadn't been made before-like a rotating disc on the microscale or a flexing beam on the nanoscale. You didn't really have to have an application picked out for that because those kinds of structures had not yet been made at the dimensions that we were making them. We were engaged in an activity to show potential, and those were really exciting times because you could just think of something that hadn't been made and make it. MEMS has matured, and it has matured rapidly. In fact, some of the chips that make your phone sensitive to position, angle, and tilt are gyroscopes or accelerometers that are made using MEMS technology.

The field has advanced to making commercial products, which means a lot of the research issues that were identified early on had been solved. For folks like me that work in the device area, we have to now find compelling applications where MEMS technology could be a key approach to solving a problem, so I need collaborators. The collaborators will provide for me and my group the technical specs for a device that has purpose. As opposed to a device for "devices sake," we have to have a device made for "purpose's sake."

I need a broad base of collaborators, as you pointed out. I have collaborated with biomedical engineers, with aeronautics engineers, and many more. Material scientists are important collaborators for me because part of my research is to identify materials that haven't yet been used in micro devices, but might have really compelling properties that might make significant advancements in micro device tech, and we want to figure out how to get those materials into a micro device. Often, there are serious challenges associated with materials, such as compatibility or processability.

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You have to ask, if you are going to process it, are you going to lose the properties that you might have measured in bulk? Do the processing conditions change the properties of the material as you're making a device? Is the material compatible with the other materials in the device? These are the kinds of challenges that excite me and the people in my group. We're often looking for collaborators who have identified areas where microdevice technology could be a key enabling tech, but you have to make devices from non-conventional materials to make it happen.

Q: Is there often a learning overhead?

A: Sure. When you work within an engineering domain, it's not so challenging. Engineers may not use the same vocabulary, but they speak a common language. But if you go into the life sciences, for instance, there is definitely a different language that's spoken and a different vocabulary. And surprisingly, the technology that one finds, at least that I've encountered, is not as advanced in the life science area as it would be for a similar problem not in the life sciences- and there's a good reason for that.

If a technology is going to be adopted for something like human health, it has to be quite robust, so technological advancements aren't as rapidly accelerating in life sciences as if they were commercial products or something like that. That's great for device engineers because we're like, OK, we can go back and look at how things were done. We don't necessarily have to push ourselves in some aspects as hard as we would in others.

But there are two different vocabularies, two whole different dictionaries even, when you're talking to a clinician than if you're talking to someone like an aerospace engineer. That's challenging at first. Because I have very little functional knowledge of anatomy, and many of the devices that we worked on over the years are going to be implantable devices, I learned early on not to worry about things that I don't really need to know, and let the clinician handle that.

If there's going to be a collaboration, we work hard to distill down the critical bits of information necessary for the engineering students to come up with meaningful designs. Essentially the collaborators will create a set of technical specifications of what they want the device to do, what the device is allowed to do and not allowed to do, what it cannot possibly be made of to the best of their knowledge, among other factors.

Then, my students and I will come up with proposed designs based on that and turn the devices back over to the collaborators. Initially, both my students and their students will do some testing. We'll get data that my students can use for their thesis or dissertation and papers, and then we'll turn the devices over to the the clinical researchers, and then they can do their clinical research- if the device works of course- and then they have a way to generate data that they couldn't do if they were going to buy a similar device from a commercial vendor. By doing it locally, we can customize the device for a specific need as opposed to pulling a more generic device out of the catalog. It's quite exciting. You learn a lot!

Similarly, I had a couple collaborations with physicists, and of course my training is in physics, so I was a bit excited about that at first, but then I was a bit intimidated because I had migrated away from the field and they were asking me to collaborate. They were interested in a material that my group was producing for microdevices and they saw potential applications. One collaboration was about a metamaterial, and metamaterials have interesting optoelectronic properties. This one allowed you to make a focusing lens from a flat sheet. Another one was in the area of defects related to quantum computing. I didn't have to do much of anything other than produce the material, but the material that we had produced had these interesting properties, so I was able to learn about my material in a way that I would never have even thought of if I hadn't had those collaborations because I wasn't focused on those properties at all. I didn't even know they existed. When you're in materials and devices, it can open up doors that you could never anticipate.

Q: Going back to your own research, you are definitely interested in MEMS. Describe more about what MEMS are to the readers.

A: MEMS, short for microelectromechanical systems, has a couple of key components. Micro implies microscale or micron dimensions. Electromechanical indicates that the devices have both electrical functionality and mechanical functionality. A classic device like this would be a micro machine cantilever that could be put into mechanical motion by the application of an electric field. That's just one example. There's plenty of other ones. And then systems implies that the devices themselves don't provide much functionality unless they're connected in some way to a bigger component or a bigger system. For example, maybe the MEMS device functions as a sensor or actuator because it's made on the microscale and often, but not exclusively, made from semiconductor materials so it can be integrated with integrated circuits to create a full system where you have onboard electronics for something like control and then you have the MEMS for sensing and actuation.

Historically speaking, MEMS was born from the semiconductor industry and MEMS were constructed from the classic common semiconductor materials like silicon, silicon dioxide, silicon nitride and the metals that are used in integrated circuits. My speculation is that the main reason that happened is that the semiconductor industry had already figured out the techniques needed for miniaturization, and the MEMS community wanted to leverage that so researchers adopted the materials and the materials fabrication toolset to make the devices. The main difference is that an integrated circuit has no moving parts and some clever scientists and engineers figured out how to do selective etching such that some semiconductor materials, when properly fabricated, can actually have degrees of motional freedom.

Q: Do you mind sharing with us something about the future of MEMS that excites you, such as notable and novel applications?

A: Before I get to the future, let me give you a little evolutionary pathway. Silicon was the dominant material, and, here at Case, there were some visionary faculty who said "MEMS shouldn't be limited to silicon as a material and to applications where silicon is well suited". These researchers, including my mentor Professor Miron Margani- he was the leader and the thought leader on this- looked at areas where MEMS could be applied, but silicon was not well-suited. There are a number of aerospace applications where the environments are too harsh for silicon-based MEMS, but the device technology would be highly enabled. This includes gas turbine engine instrumentation where the temperatures are at 500°C or higher--high-wear, high-radiation, high-corrosion environments where silicon would just break down. Silicon's, for lack of a better word, cousin material, silicon carbide, is well-suited for that. When I came into the MEMS, we put significant effort in developing the materials and fabrication approaches to realize silicon carbide, which we still work on today.

MEMS really took off when groups including Case and other places figured out that the microfabrication techniques used in silicon could be applied to a whole bunch of other different material systems, including polymeric materials. Medical implants based on them were then developed, and then many of the devices used flexible and stretchable polymeric materials rendered on the microscale to make devices using very similar fabrication approaches. Most of those are subtractive in nature. They take positive film and use photolithographic patterning to create structural patterns, which is then followed by etch to render a structural shape into the originally deposited film.

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Then printing techniques began to emerge, in part enabled by MEMS. Some of the most high fidelity printers use MEMS-fabricated printheads to do printing because printing is additive. The MEMS community picked up on that and started to develop approaches for additive manufacturing of MEMS devices through 2D and 3D printing. I've migrated towards that because the printing approaches are attractive as a low cost alternative to fabricate devices, especially from non-silicon materials like polymers and metals. Stretchable and flexible electronics leverage heavily from MEMs tech, and that's what I spend at least half of my time working on these days. The application areas are largely in the biomedical engineering space.

What I just described involves adding materials and processes to the MEMS toolbox, which enables use of many different silicon-based device types with properties that silicon does not have. This broadens the application space. The Internet of Things, for instance, is enabled by sensors and actuator systems that are miniaturized, and now the Internet of Things is much broader than it would be if it was reliant solely on silicon.

The other avenue that I think is equally exciting, both on the engineering and scientific side, is to go down to smaller dimensions than the microscale: the nanoscale. There is an approach to realize the nanoscale, which leverages the microscale through subtractive processing, but with lithographic pattern patterning techniques that are on the nanometer scale. We did some work in silicon carbide NEMS. The offshoot of MEMS, when you go to the nanoscale, is NEMS, which is short for nanoelectromechanical systems. I did some collaborative work with Caltech more than 20 years ago to realize one of the first NEM structures made from silicon carbide, and in the collaboration, fabricated the first-ever mechanical resonator that oscillated with a fundamental frequency of over 1 gigahertz. That had not been realized before. You get to a gigahertz and even higher frequencies by shrinking the dimensions down.

It was a simple beam anchored on both sides that could be excited into resonance, but because two of the dimensions were nanoscale dimensions, the excitation frequency was over a gigahertz. It hadn't been figured out how to do that so successfully in silicon up to that point.

The other offshoot is then to take MEMS technology and head towards the nanoscale. The exciting thing there is that when you go to the nanoscale, you start to get further and further into the domain of science, and to a generation of new knowledge; but coming from an engineering perspective it's science with a pathway, or at least a potential pathway, towards applications because it's enabled by engineering!

Q: Do you say this is a generation of new science because of the quantum effects?

A: You go to the nanoscale to realize quantum effects, but to get to the nanoscale, if you use engineering principles, then potentially, if you identify some quantum effect, you have a pathway to exploit it. Practical exploitation of anything like a quantum effect or a nanoscale effect means we'll have to transition from nano to micro to macro.

We live in the macro world, right? To exploit quantum mechanical behavior while we exist in the macro world requires bridging through the various key dimensional scales. MEMS technology microfabrication provides that pathway. So it's not just knowledge for knowledge's sake without a way by which we could envision exploiting it. The systems necessary to gain that knowledge are engineered systems that are already providing the bridge from the macro world to the nano world.

Q: Do you feel like these advances in technology are requiring more emphasis on science education of engineers at the level you would expect from the natural science community?.

A: I can say with certainty that the natural science component to an engineer's education is critically important. The questions that come up are "how much?" And "at what cost?" Ultimately, there's a limit to how much we can expect the student to learn in a reasonable period of time, and if we pack more of the natural science topics in the time to achieve a degree, what do you lose?

I have thought about this a lot, and I'm pretty happy with where we're at for a couple of reasons. For one, I think an interesting research area, be it in science or engineering, is one that happens at the intersection of disciplines and requires the practitioner to be collaborative. Why? Because any one person can't be in command of all of the information necessary to be successful- they need to leverage the partnerships and the knowledge that comes through these interdisciplinary partnerships.

So then the question is: what makes for a good collaborator? A good collaborator, in my opinion, is one that has a strong drive, great communication skills, and knows how to work effectively in a team, especially within a team of varying personalities. That needs to be learned, and it can be developed. Some of those skills are developed by taking courses that have nothing to do with the natural sciences. I think that's where the liberal arts component of an engineer's or a scientist's education becomes important.

I came about it through a really weird way because, as I told you, I have a BA in economics, which is, at best, a soft science like social sciences, where collaboration and interactions and stuff are definitely part of the training. And then I also have this really hard science stem education. Because of that, I do see the value in the training I received from the former. My research success would not be where it is today if I didn't know how to collaborate. I actually credit my BA in the advancement of my career as much as my BS, MS, and PhD because without those collaborators, I wouldn't be where I'm at today for sure. I'd probably have a very narrow research pathway with limited productivity. My research success is amplified by my ability to collaborate. I'm a proponent of balance in education. There are a lot more of us STEM people out there today than there were 50 years ago, but I think that there will be no loss of knowledge. They'll just be working more on team science than we would have 30 years ago.

Q: Speaking of resources, you're the Dean of Research for Case School of Engineering, so what are some of the research directions here at Case School Engineering that you're most excited about for the future?

A: Well, first I should state that the School of Engineering and the Dean's office does not decide the research agenda. Our job in the Dean's office is to facilitate world class research that's performed by our faculty and teams of faculty, both within the school and with our faculty collaborators in other schools and colleges outside. We are basically trying to make our faculty as productive as they can be. The research topic areas that are prominent within the school are those that have been fostered and developed well.

The faculty incubates and fosters those good ideas so they can be successful. We rely 100% on our faculty to come up with the great ideas, identify the vexing problems, and come up with the teams to solve the problems. I'm really excited about the Human Fusions Institute because it leverages three or four areas of research strength within the school- our long history of neuroengineering combined with our fruitful history in robotics and electronics.

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It really is a classic example of multidisciplinary research. The Human Fusions Institute recognizes that there's a bioethics component to what they do, because it's that it's really at the edge of where humans and technology are interfacing, so they've incorporated bioethicists in the project. It's a comprehensive approach to that topic area of human machine interfacing. I think that's exciting. I think our excitement is justified by the recent press coverage. Dustin Tyler and Bolu Ajiboye were on 60 minutes, as well as a number of Case students, and other researchers that didn't get called out by name.

We have strong research activities in energy, and in particular, energy storage. Within energy storage, we have a focus on those that are enabled by electrochemistry. I'm really excited about those. I'm excited about the work we're doing in the application of data science techniques as it relates to materials and materials degradation. I think we're second to none in that area. In device technologies as it relates to human health, our point of care technology research that is coming out of mechanical, aerospace, electrical, computer, and systems engineering is really exciting. What we've done in the school, through faculty input, is identified a handful of thrust areas where we know we already have world class research and we are going to push those topics and research areas into preeminence so that when people think of Case Western Reserve University, they're going to think of human fusion and the other big topics mentioned.

Q: I feel like this interview would be missing if we did not talk about your teaching. You've taught many core engineering classes at Case, including Introduction to Circuits and Instrumentation (ENGR 210), Semiconductor Electronic Devices (ECSE 321), and more. Can you share with us some aspects of your teaching philosophy and what shaped it?

A: As you know, I don't have any formal engineering training. My degrees are in economics and physics, so I have to approach the classes I teach with that in mind. My colleagues were wise enough to give me an intro circuits class. There are some circuit classes that are beyond my knowledge. Eventually I could teach them if I had enough time to prepare, but there are only so many hours in the day. I had an instrumentation class when I was an undergrad physics major, and it was different compared to the circuits class that we have to teach as part of the core. Instrumentation class was to prepare physics majors for experimental physics where instrumentation was key. So it was less about circuit solving techniques and it really didn't align itself to developing circuit designers, because that's not what physicists tend to do.

We can design some circuits, but we're designing circuits to make a measurement or do some experiment. Efficiency is not necessarily the driving thing. We're not going to be designing circuits as a primary component of what we do. When I picked up the circuits class, what I recognized is that most students there probably aren't eager to take the class. If they had the choice, they probably wouldn't. For those students, my primary objective, in addition to exposing them to the necessary information to understand circuits, is to sharpen their problem solving skills. That is the thing that has a lasting legacy.

For some, circuits is just another chance to hone their problem solving skills. For those who are interested or will be working in areas that require circuit solving techniques, I want them to have a full toolbox so if they get into an advanced circuit class and the professor says, "reduce this circuit to a Thevenin equivalent," without hesitation, they could go do it. They might have to look up to refresh their memory on how to do it, but that refreshment would not take that long.

Then there are some that I want to inspire. Maybe they haven't made their decision yet and I want to inspire them to consider electrical engineering as a major, but I don't go into it thinking that I should convert everybody who is taking the class.

I do want to demystify electrical engineering somewhat. I tell the students that they need to recognize that engineering does not happen in the modern world without electronics. There's not an engineering discipline that does not use electronics, electrical systems, or measurement systems that are based on electronics, in one way, shape , or form. It's important that they understand at least a little bit about how those things work.

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My teaching is now limited to the circuits and the semiconductor class because I'm in the Dean's office, but I used to teach a class in nanotech, a class in microfabrication, and a couple of other classes. I now teach the required semiconductor device physics class in the electrical engineering curriculum. Similar to ENGR 210, I think it's important for electrical engineering students, and those who are interested in electronics, to have a class like this. The core of modern electronics is the silicon-based transistor. You could be a successful engineer, and even a successful electronics engineer, without knowing how the transistor works on the inside, but to appreciate where electronics is going, and it's getting there rapidly by the advent of new materials and nanotech, and maybe anticipate where you might want to be in this ever evolving field, knowing the fundamental device physics behind the transistor is key.
When they're out there five years from now, and somebody's saying, "here's a new transistor design, and it's enabling this that or the other thing," I want students in the class

> "Technologies may have contributed to the problems we have, and since we're not going to give up on technology, we have got to seek technology-based solutions."

to understand that at least a high level how that transistor works by leveraging the knowledge about the classic transistor so they can engage in meaningful discussion with somebody who might be talking about this. And who knows? That might lead to a job that they wouldn't otherwise have if they couldn't have engaged with that person.

We take a scientific and engineering approach. I'm not teaching advanced math at this stage. I'm challenging students to assimilate quite a bit of information and apply that information to problems associated with semiconductors. It is teaching new vocabulary and new language, and presenting problems where students have to decode the information given. The math that is necessary to solve the problems that we'll address in class is pretty straightforward math, but that doesn't mean that the class isn't challenging. Math in the context of information can often be very challenging. So I enjoy that class.

Q: Considering you have explored quite a broad range of interests through your career, what advice do you have to help younger people explore their interests and navigate them meaningfully?

A: I came to research by a really non-standard path. First, I was going to become a lawyer. Then I worked in a food science lab. Then I worked in a meteorology research lab at Ohio State. I worked at Nestle. And then I ended up in physics. When I reflect back on why I started my undergrad career thinking I should be a lawyer, it's partly because I was told that I should be an attorney and I had a firm that was in my family. It seemed to be my destiny. If I had not explored other options and opened my mind to whatever else could be out there, I'd be an attorney. Maybe I would be a successful one and maybe I would be happy, but somehow, I explored other options.

The job that I got in the lab for meteorology was simply because I was looking for a paid position while I was in undergrad that was something other than working security in the dorms, which I was doing at the time. I needed something different, and I said, "I want to work in a lab." In physics, all the lab jobs were taken, but I needed something in a lab, because I didn't want to work in food science or security. I happened to find a posting on a sign board out on the Oval for a researcher looking for a research assistant at minimum wage. I was like, OK, let's go check it out. Meteorology. Let's see what it is." I figured it would be better than sitting by the front door of my dorm checking people in.

That was a life changing experience. I published 2 papers from that experience. And I said, "what skills do I need? I know nothing about meteorology other than watching the weather report on the nightly news." The guy asked me my major, and I said I was a physics major. He goes, "that's good. Nobody comes in here with the skills we need, but we need you to be STEM-oriented." I asked what they were going to have me do. He says, "we have these photographs that the Navy has taken over the Antarctic Plateau, and in these photographs of snow fields, there's information about wind direction. We're basing our work on a 1918 paper published by some Russian scientists that did work in Siberia on weather patterns. We're going to figure out if we can use that same method on these photographs. For the task, you just need to be halfway decent in geometry and you need to be persistent," because there were around 5000 of these photographs.

From these photographs, we constructed the most detailed map of that region of Antarctica that had ever been made at the time. This was pre-satellite imagery. We came up with the data set that was used for a simple model of wind patterns over the Antarctic, and its influence on sea water temperature in the Southern Ocean, which feeds the ocean currents in the mid latitudes that are associated with El Niño and La Niña events.

I would never have thought in a million years that's what I would do. I stayed at that job for 2 1/2 years. In the summers, I worked at a research facility in my hometown. It was again a summer job where I had started cutting the grass, and then they told me they needed some summer help in a lab. They asked me if I wanted to move into the protein synthesis lab, and I agreed.

Through those experiences, I began to see that a career in research seemed pretty interesting. So I guess the advice is to walk around with your eyes wide open, and don't be afraid to explore. Always test that the vision you have for the future is your vision and not a vision imparted on you by somebody else simply because you were good at this or good at that. And usually if you're good and you like to interact with people, good things will happen. I mean, I didn't even come into MEMS with that focus. After my PhD I was going to do a postdoc, and I was actually exploring a postdoc at a university in Australia at the time, but it wasn't clear whether they were going to have funding for it. It would have been in diamond surface related research. I had another lead as a postdoc at NASA Glenn, but none of them were solid, and then this one in MEMS came up. They were looking to hire somebody immediately, so Idid a little bit of research on what MEMS was and I thought "that sounds pretty cool." I'd better go with what I have at hand because at the end of the day I need a job. So I took the one that was readily available and I've never looked back.

Q: What advice do you have for your future engineers and researchers?

A: I will say that I don't think there's ever been a better time to be a researcher or a research engineer, because there are some significant challenges that humanity faces. Problems that we need to resolve, and then particularly for engineers, technologies that are necessary to solve those problems. Technologies may have contributed to the problems we have, and since we're not going to give up on technology, we have got to seek technology-based solutions. If you're passionate about those things, then get started. I will say this for Case: I think the education that you receive at Case will prepare you very well for a future in whatever you choose to do. It might not seem like that at the time because there are the challenges of education, but I have run into many graduates who said their Case education prepared them so well that they are on par, or even better than, their colleagues that came from higher-ranked schools.

So as for advice- you're not going to learn about the great opportunities unless you extend yourself. Talk to people, engage with your professors, engage with other people who are doing interesting things. Oftentimes when you can get some professor to free up some time, they'll be more than happy to talk to you about your research. So knock on doors, I guess.

A Selection of Dr. Zorman's Work

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