NARRATOR: Complex manufacturing processes of semiconductors and growing demands along the global supply chain for computer chips is impacting numerous industries—from defense and intelligence to consumer electronics and the Internet of Things. In this episode of Intersections: The RIT Podcast, Robert Pearson, professor of microelectronic engineering, and Steven Carnovale, assistant professor of supply chain management, discuss how the semiconductor supply chain has been disrupted and provide insights about current trends and possible solutions to this complicated business and technology challenge.

ROBERT: So, semiconductors are the replacement for the old-fashioned vacuum tubes that were used in all kinds of early applications like televisions and radios. Then we went on to the integration of computers: personal computers that were on your desktop to laptop computers to your cell phone being wireless to your cell phone being a computer and entertainment device. Now, semiconductor chips or circuits are basically in everything that you could conceive of at this point. But it's a very intricate manufacturing process. So what happens is, with chips in everything now, everything depends on the chip manufacturing in some way, shape, or form. And RIT created the first undergraduate program in the nation, if not the world, to educate bachelors level engineers in microelectronic engineering. And we probably have more alumni working in the semiconductor industry than any other university.

STEVEN: One of my favorite science fiction writers is Isaac Asimov. He says, "I do not fear computers, I fear a lack of them." And it's interesting because you think about that now. And how would he feel about my refrigerator having a microchip telling me the temperature of my milk and things like that? So, we talk about the supply chain challenges related to what's going on with microchips. I mean, because they're in everything, there isn't a supply chain, it's like the end theory of supply chain, you have these concentric, intersecting, chaotic, connectivity where the semiconductors that would make your display chips and then we have the ones that are doing the actual computing. I mean, the production of these things is distributed globally, concentrated in certain areas. But one of the most amazing data points that I read was when this all kicked off back in COVID, by the way, I mean kicked off back in 2019-2020. In Wuhan, there was something like 9,000 component suppliers that dealt with, broadly speaking, semiconductors. Wuhan got shut down, semiconductor chip manufacturing and every other related industry got shut down. There was this spigot that was flowing at a decent rate and got crimped. And so, we can get into that too, but I mean I'd be interested from a manufacturing standpoint, Rob, what you think about that.

ROBERT: So, it's interesting that you bring up Wuhan and the pandemic as a sort of a root cause of some of the semiconductor supply issues because China is not a major player in semiconductor supply. It's mostly Taiwan and the U.S. But the semiconductor industry in general is considered to be essential, and people came to work there pretty much right through this whole pandemic. What was more of an issue, I think, was the pandemic caused people to project some shifts in what people were going to consume. For example, everybody's going to stay home, they're not going to buy cars. And the automotive industry, being like a kind of just in time type of manufacturing, did not keep

a huge inventory of electronic semiconductor parts. And so, they had a lot of orders in with Taiwan and U.S. manufacturers that they pulled back. And the semiconductor industry then shifted to, like you said, they're making chips for other things that were going to go up in demand like displays and computers and routers for networks and communication and so on. They shifted away from the previous automotive-centric orders. And it takes months, like 6 to 8 months to restart an order. And then when the automotive industry found out that because interest rates were so low people were still buying cars, they said, "Woah, woah, woah. We should not have cancelled all these orders. Can you put our chips back in the pipeline?" And the semiconductor industry said, "Well, we just recommitted to this other sector, so six or eight months from now, we'll get back to you." And the automotive industry says, "Well, we've got cars sitting around that can't go anywhere without these chips." So, it wasn't a supply chain issue so much for the semiconductor industry – we need gases and chemicals and silicon wafers – it was more of a supply chain production planning issue for the industry consuming the chips, at least that's my feeling.

STEVEN: And then the crazy part of it from the supply chain standpoint was: what are the types of chips that we're talking about? As I recall, one of the big issues were the driver chips in the beginning. It wasn't necessarily the real brains of the operation, it's the little stupid things that are so important that make displays pop up and things like that. So, who would've thought that that was going to be the thing where there was a dearth of inventory? And you know, the capacity planning problem, there's an opportunity cost to inventory which is why we try to keep that stuff low, particularly in automotive. I'd be curious, Rob, to see what you think about which chips in particular are causing the biggest problem?

ROBERT: You know I think one of the things is that the automotive industry kind of tends to view a lot of their parts across the spectrum of the automobile as being very similar. A fender and a chip are both a part. They both have a part number. They both go into this vehicle. A lot of the chips, like you say, for display drivers for the touchscreen, that's not going to change from year to year very much. Yeah, every couple of years maybe you'll put a new type of display in or something like that, but if the chips are not going to be changing – and some of the sensors for the brakes and things like that, those are not things that they upgrade every year. I would argue that you could have a little bit more robust store of those chips on hand. But on the other side of the coin is nobody predicted a pandemic of this sort and all these shifts going on.

STEVEN: It's true and you know the other thing, too, is it goes back to what you said in the beginning. It's like everything has a chip, and if everything has a chip and now everything has a touchscreen, everything needs a chip and then a driver chip for that chip to work on the touchscreen and so it compounds. So, the interesting thing there from a supply chain standpoint is the indirect consequences that we end up facing. I just talked to this guy about school supplies, and it was like three tiers away from anything meaningfully related to semiconductor manufacturing necessarily. But the implication was Chromebooks, laptops, new phones, they're all going to be in short supply because either the chips are scarce, the capacity is being reallocated, or there's major shifts in

the market. So, what I think all of this is going to ultimately end up leading to is a re-regionalization in supply chains. And I don't mean it in the way – you know, if you look at the auto industry let's say in the '50s, '60s, and '70s where I made it in Dearborn, Michigan and I got my tires from Sandusky, Ohio and I got my brake pads from Akron, you know, all that kind of thing. I don't think that's going to happen necessarily but I conceivably could see NAFTA (North American Free Trade Agreement) or regional trade agreements or USMCA (United States-Mexico-Canada Agreement), whatever you want to call it, blending together with South America and having kind of this regional conglomeration where you have really established relationships in similar time zones where English is spoken commonly and we're not necessarily worrying about always going to China. We're going to sacrifice to a certain degree on the labor cost because we're getting access, logistics efficiency and things like that.

ROBERT: There's a lot of things going on of where these chips go and how they're produced. And mostly it's a result of the issue of having a foundry to produce a wide, wide variety of the chips. So, the major foundries are in Taiwan, in Korea, so in Taiwan it would be TSMC, in Korea it would be Samsung, and in the U.S. it's probably Global Foundries. And there are other suppliers, Texas Instruments, a variety of things to mention just a few. A foundry like TSMC might be producing tens of thousands of parts for thousands of different customers. And so the idea of how do you have the allocation of production resources to satisfy somebody on the other side of the world outside of your region, is very important. So, let's say that we wanted to have a North American production zone for our supply chain. Global Foundries, it's got global in its name, and you're a U.S. based customer and you say to Global Foundries, "I'm in desperate need of these chips, I want you to bring my production to the top of this." You know, what leverage do you have? It's all based on how much money you bring to the table. Another thing that I think is kind of interesting about this whole supply chain issue is with semiconductors and everything, people are looking for the level of customization of the chip to the particular application. So it was years ago that microprocessors, let's put those into everything, they were very similar microprocessors. Now they're customizing everything for every individual application and they want to do more of that through artificial intelligence. So that makes the production of all of these things slightly different from one another. So, we're moving away from sort of generic chips that could be used in many applications to specific customizing chips, which again makes you more vulnerable.

STEVEN: Especially in auto, then you add on the fact that the EV (electric vehicle) push and the tech emphasis that these vehicles have, you know the Teslas, the GMs of the world with their Volt. So, if we're thinking about being able to have a charging infrastructure to support EV technology basically nationwide, the way that we do with cell phone coverage, that's going to put a huge demand on the tech needs, going to put a huge demand on the chip needs, both the boring old driver ones that you're saying don't change and the ones that need to be customized because they're going to be very different, right? I mean it's going to – it's just, you know, we're playing three-dimensional, four-dimensional chess here and it's just going to be really interesting to see what pans out.

ROBERT: One of the major suppliers of the power electronic components that go into EV vehicles is Cree Wolfspeed, and Cree has got a wafer fab under construction in Utica, New York. That wafer fab is going to be specifically producing the kind of chips that are going to be in most demand for electronic vehicles. They're going to have a good efficiency of manufacturing because they're going to be doing this on 200mm wafers of new material, gallium nitride. But we already have here at RIT a couple of students that are co-oping there. And they haven't even opened the door to the fab. They're working in the Albany area right now on developing a process that's going to go into that fab and helping with the equipment set up and what the recipes are that are going to be used to produce these chips. So, that's really exciting from a New York point of view because that means that with Global Foundries in the Albany area producing conventional, analog, and digital electronic processors and that kind of stuff. Now we've got the power end of things there.

STEVEN: I'd be interested to see if we end up generating a regional expertise. Lord knows we've got the water, right, with all the Great Lakes. That's a big manufacturing advantage and that's, you know, of course it's huge.

ROBERT: And we have the electric power in the Buffalo-Niagara Falls area. So, it turns out that there's a 1,200-acre fab-ready semiconductor site between Rochester and Buffalo. We're hopeful that sometime in the future a major chip manufacturer will locate in that site and we'll kind of have semiconductor manufacturing distributed across the state. Getting back to the original issue of kind of the shortage of semiconductor chips or electronic circuitry in various industries, you know there's the volume of the manufacturing. It turns out that these wafer fabrication facilities, you have to put about 15,000 silicon wafers a week starting through that facility, which is like one foot in diameter, so you can figure out the area of silicon that has to go through in a week. And it takes four months or so for that wafer to be processed start to finish before it could be even packaged and go off into a product. And so, these wafer fabs now cost in the $10-15 billion range, so what companies can afford to build a $15 billion fab on their own? But there's very few companies that can build these expensive fabs, so now there's a lot of interest in what state incentives can be. So, in the Phoenix area, Arizona has put a lot of money into luring TSMC to build a fab. So, it's a Taiwan company building a wafer fab in Arizona. Can we get Samsung, who has a wafer fab in Austin, to build another wafer fab in Austin? Can we have, you know, more wafer fabs in New York State? So, it's a state-by-state economic development effort, but it's very provincial. It's what's best for my state. There's no coordinated government effort, so that makes it interesting when you see Chuck Schumer coming with this CHIPS Act and like a $50 billion investment to help the semiconductor industry. But $50 billion is like maybe four, five fabs if you were to just like build one and say, there, that'll help the capacity and will ease the shortage. But who's going to run these fabs? Who's going to manage this? Who's going to exert control and do they know what they're doing? And that's the real question. So, I'm hoping that here at RIT we can produce people that know what they're doing inside the fab, but understand these issues from the business side like you,

Steven. And so, could we produce this super microelectronic, business, international finance, etc. major? And I think we could do an awesome job of that.

STEVEN: I like it. I think the solution there is to either have them major in supply chain and minor in microelectronic engineering or major in microelectronic engineering and minor in supply chain.

ROBERT: I agree.

STEVEN: What we're doing and talking about right now is working on the fire that exists today. The question really is what's going to be the fire that blazes tomorrow? So, if today it's the semiconductors and the availability of materials or it's the foundry or it's the capital to get it going. I mean, a number of the issues that we talked about are certainly hot button issues and rightfully so, but what's the next thing? You know, what's the next microchip shortage? Is it going to be the water issue, is it going to be the silicon issue, is it going to be – I don't know. But if I'm asking how do we solve it, I think the prescription that solves the current problems, exactly what Rob said, and then say, "Okay, during that time what else can we anticipate?" Do we build an excess capacity if this happens? Do we invest in research and development? Do we develop a center of excellence to figure out what's going to be the next semiconductor, flat surface, this, that, I don't know what? But that's how I think about it, it's a two-pronged approach. It's solve a problem today, prevent it from happening tomorrow, this problem that we know about, and then get really smart people, hopefully from RIT, to figure out what on Earth is going to happen tomorrow and the day after tomorrow, and so on.

NARRATOR: Thank you for listening to Intersections: The RIT Podcast, a production of RIT Marketing and Communications. To learn more about our university, go to www.rit.edu and to hear more podcasts, subscribe to Intersections on iTunes, Spotify, TuneIn, or Soundcloud or by visiting www.rit.edu/news/podcasts.