



Live with Rodney Lake January 2022

The Semiconductor Industry

Note: This transcript has been edited for content and clarity

[Slides are available on our website.](#)

Rodney Lake: This is the [GW Investment Institute](#) show Live with Rodney Lake. Today is January 20, 2022 and it's 6:30 p.m. Eastern. A disclaimer up front, this program will be recorded and we plan to post this recording online so we will not use names of the audience members to protect their privacy.

My name is [Rodney Lake](#). I serve as Vice Dean for Undergraduate Programs at the GW School of Business. I'm also Teaching Instructor of Finance and the Director of the GW Investment Institute. I also have an additional responsibility, I serve as Faculty in Residence here.

The GW Investment Institute teaches students how to think about investing and how to invest. Undergrad and grad students serve as our analysts and portfolio managers. Our students are managing approximately eight million dollars of university endowment funds. We cover equities, real estate, venture capital, and quantitative investing. They learn by doing. We link students to the industry by bringing professionals as guest lecturers and we are a platform for our alumni to connect with the school and with our students.

A quick overview of today's agenda. Today we're going to do a workshop around semiconductors. We're going to do a quick overview of the economy through the lens of semiconductors, including: increasing demand, supply chain disruptions, and inflation. We'll cover the semiconductor industry geographic changes - there are some things happening in the business that I think are worth knowing about, especially if you're going to invest in these companies. Then a little bit of company and industry news - what's happening on the consolidation front and the capacity increase for semiconductor production in the U.S. and then, if there's time permitting, we'll have a little bit of Q and A.

So let's go over semiconductors at a very, very high level. This is not intended to be an engineering class and also by no means is this investment advice of any kind, we're not promoting any investment advice so please do not take it that way.

What are semiconductors? This is a product that's somewhere between an insulator and pure conductor. They manage the flow of current. They're typically made of silicon, hence the term Silicon Valley, I'm sure you've heard of that. It's the amount of conductivity that can be changed by adding other materials/impurities, something called doping. They are sometimes referred to as chips (microchips, I'm sure you've heard about that). They are essential for many products. So in your phone, gaming consoles, medical equipment, cars, almost anything you can think of, now vacuums, you name it it's in there. So they're all over the place, pervasive, in all of your

technology. They're getting into things that could be more simplified, like a refrigerator, dishwasher, all those things are starting to have chips in them now especially if they're considered smart appliances. The world is changing pretty rapidly on this end and now there's technology and there's computing power being put into all of these things. The industry has to continue to innovate to keep up with the changes and the desires of their customers. People want more computing power, they want smaller, they want cheaper and so like many other businesses they have to continue to innovate to stay relevant.

A little bit about the economy through the lens of semiconductors. I have a [graphic](#) here that shows the revenue of worldwide semiconductors since '96, but I want to zero in on the year-over-year from November '20. You saw year-over-year increase from November '20 to '21 of 23.5% percent, so a big surge in revenues. A bunch of that can be driven by things that you can probably guess, demand for products while people are in Covid situations where they need access to more gear, they need more machines, all those things have chips in them and so the demand for products that can help people work remotely, do school remotely, all the things that started to happen during Covid. These demands translated into underlying demand for semiconductors and you can see this sharp rise from November '20 to '21, again nearly 24%.

This also then created some supply chain issues. When you couple the increased demand that some people talk about has been pulled forward a little bit with the fact that some of these things were constrained by being shut down and other factors. There's a graphic here plus survey, [the survey here](#) is saying 83% of the firms surveyed faced disruptions in operations, research and development as a result of coronavirus, primarily due to government closure of facilities. This is a March 2020 survey by the [Semiconductor Industry Association](#). Two things here: has your company experienced supply chain disruptions? 43% said no, 57% said yes; and then if you had disruptions what were they? Transportation and logistics, maintenance, gases and chemicals, wafer materials, and workforce all were factors cited. A variety of different things happening, but you can see how when demand is high but the supply chain is constrained you're getting a situation where people can't get their chips and that also has consequences. If you were trying to get a washing machine, by the way there was a smart washing machine, you're probably not getting it.

Semiconductors are important for automobiles. So we've picked this to demonstrate how this issue flows through to a specific industry. You may not think about semiconductors especially with traditional internal combustion cars but it's still very important and there are a lot more chips, a lot more computing power, going into these cars. This is from the Federal Reserve Bank of St. Louis, [this graph](#) shows how domestic auto production in the U.S. dropped to nearly zero in the spring of 2020. The idea here is that because they did not have the chips they needed to go into these vehicles they could not produce and deliver. You may think, well how important are these chips, they're a small dollar value but if they're needed to run the vehicles and the vehicle has been built around this and these companies don't have a way to create a simple work-around and they can't re-engineer either the software, the hardware, well that leads to stoppages in production. Again, you saw a very pronounced sharp decrease in the spring of 2020, and then a sharp increase but declining production over that time between 2020 and September 2021. Again this could be not only because of semiconductors but it certainly was a big part of the story and demonstrates how important the semiconductor business is to the automobile business. Maybe before Covid you weren't thinking that okay this is a weak point in the supply chain for automobiles, but obviously that was demonstrated here how important the semiconductor business is, and moving forward I think that has a lot of implications.

Now shifting gears a little bit to inflation, I think a lot of people are paying attention to this so this is probably not news to you if you've been following the markets or if you're following business in general. Here's a [graphic from the Bureau of Labor Statistics](#) from 1965 all the way through 2021. You can see that there have been spikes in different times for inflation. When people often talk about inflation, you talk about the 70s and 80s being very inflationary periods. Paul Volcker had to come in and raise interest rates as Chair of the Fed at that point. You had things in the 14% in the year-over-year change in the Consumer Price Index. We haven't really seen much of that after Paul Volcker came in and really put a lid on inflation by raising interest rates, you really saw inflation drop dramatically. So from the mid 80s all the way through, let's say 2019, you saw a pretty steady trend decline in inflation, starting at like plus four percent year-end changes in the CPI all the way through two percent and a pretty steady decline - with a lot of variation in between, but a general downward trend. Now fast forward to 2021, you're seeing a very sharp increase, seven percent in December. We haven't seen these types of increases for decades really, again back into the 70s and 80s. And 5.5% without food and energy, so year-over-year change again for the Consumer Price Index ending in December of seven percent - that is really dramatic. Again, you're talking about declining from four to two and now we're up to seven so that is a very dramatic difference and this is a reason why people are concerned about inflation.

So what does that mean? Well it could mean that a lot of things get more expensive. It erodes the purchasing power of your investment portfolio. As an example, for the GW Investment Institute, how does it affect the purchasing power of our payout? You want to invest in things that have pricing power to guard against inflation - that's a topic possibly for another day.

To connect high inflation with the semiconductor business, [here's a chart](#) that demonstrates the difference between if you're dependent or you're not dependent on semiconductors and you can see that there's a pretty significant difference here between these two lines. From January 2019 through January 2021 you saw they were pretty consistent. And then between January 2021 and July 2021 there is a divergence. The average price change has increased more steadily for manufacturing industries that are dependent on semiconductors and so that has moved past 10 percent while manufacturing industries not dependent on semiconductors has gone up but not as dramatically. So if you're not dependent it's moved over five percent but not yet ten percent but if you are dependent it is on its way to fifteen percent. This is just something to think about. These companies that are dependent on semiconductors, the average price change is going up pretty dramatically for them in a very short period of time. This has implications again, where is that cost going to be borne? Is it going to be the producer / the manufacturer, are they going to try to pass this along to consumers, the people that are buying from them? If they can do that, they can preserve their margins but if they can't pass along those price increases that's going to hurt their bottom line (takes it right out of their margin) so that puts a lot of pressure on the businesses. Again, this is specific to the semiconductor business but you can see how inflation can be a problem.

All right, a little bit more about the semiconductor industry here. Let's get into some [geographic changes](#). The global semiconductor market share by major country is what we're looking at, and again if you're just listening I'll do my best to describe these graphics. The market share is really dominated by the U.S., and this graphic is from the Semiconductor Industry Association, thanks to them. You can see how the U.S. is nearly 50%, it's come off a little bit but it's obviously a big player in the semiconductor business. Japan has decreased, in '03 was 30% and now it's down under 10%, so it's become less relevant over time. Places like Europe are relevant, Korea, and Taiwan. You're really talking about China, which has grown considerably. It has gone from almost nothing and now it is approaching 20 percent, with a compound annual growth rate of 20 to 30 percent over just the last few years. You're talking estimates of 30% percent into 2024 and

so China has shown a very dramatic increase, again going from near zero to being 20% of the overall market with rapid growth from really '19. Again, the U.S. remains a dominant player, Korea remains a significant player - starting sort of a little bit less than 10 percent in '03 and now is 20% of the market. So really when you think about the three dominant players right now you're talking about the U.S., you're talking about Korea, and you're talking about China. Not that the others aren't significant players, they are, but certainly those would be the big three when you think about the market share.

So now, [we talk about foundries](#), these are the companies that make the chips. So Apple doesn't produce their own chips, as an example, Taiwan Semiconductor produces a lot of their chips. So that's the fabricator or the foundry, they produce chips for other people. They don't compete with their clients, so Apple designs a chip and uses ARM architecture and then Taiwan Semiconductor produces that for them in their fabrication facilities. To give you an idea how concentrated the fabrication is, Taiwan Semiconductor is 54% of fabrication so really a consolidated business, followed by Samsung at 17% so the top two really dominate here. Geographically, Taiwan Semiconductors is in Taiwan and Samsung is in South Korea so a really high concentration in Asia and really within two countries. And then UMC, which is also in Taiwan, is number three here at seven percent. GlobalFoundries, which is a U.S. based company at seven percent. Again, you can see the high degree of consolidation here: Taiwan, South Korea, Taiwan, and the U.S. sort of the top four there and then China starts to come in at number five with SMIC at five percent. And so again, the shifting landscape is happening, China is becoming a more important player in this and so we'll have to see how that turns out. We can see right now, very much dominated on the fabrication side by Taiwan Semiconductor and Samsung.

A little bit about industry and company news. We mentioned earlier about consolidation; I think this is important and it's hard to really read where regulation might go here, it's affecting one of these which I'll mention. A little bit about the consolidation, AMD, which you might have heard of, acquired Xilinx. The deal, announced in October of 2020, is an all stock transaction valued at 35 billion dollars. It was delayed by regulatory review but it's now expected to close sometime early this year.

Another one that was very significant, I'll just say a few things about this one, Nvidia is acquiring ARM. Many of you might have heard about this. The deal was announced in September of 2020, so now we're approximately 18 months past. The deal was valued at 40 billion dollars in cash and stock and now it's delayed by a pretty intensive regulatory review this has to go through four different sets of regulators in the U.S., U.K., Japan, and China and so that's a lot of jurisdictions to review this deal and there's also a lot of concern from different companies. The U.K. has mentioned that they don't want to lose one of their flagship technology companies, ARM's based in the U.K., and we'll have to see how this plays out. A lot of companies who might be considered competitors in some categories with Nvidia use ARM architecture. You can think of companies like Apple that use ARM designs, which I mentioned before, they license an ARM design to build their chips. What does it mean if Nvidia owns that? Maybe that makes them a little bit less comfortable? But certainly there's consternation within the business. Does this transaction create some sort of anti-competitive setup or slow the business down in some way or will it become difficult for companies to access the types of technologies that they need to grow and innovate? And so this has been held up, it looks like this deal may not get done at this point. We'll be at two years, and so you know certainly it's not swimming along here without any back currents. It's very difficult to predict exactly what will happen here but this transaction doesn't look like it's going to happen. These are two dominant players in the business, again just demonstrating the importance of the semiconductor business.

The last one on this page, Analog Devices, acquired Maxim Integrated Products. The merger was completed in August 2021, an all stock transaction valued at 20 billion dollars. This is obviously not a comprehensive list here but it just gives you some idea about how the business is consolidating.

There are obviously new companies coming online all the time but it's really dominated by the big players. One of the reasons is the capital intensity of the foundry business, it's very difficult for people to come into that business. So if you're gonna say "I'm gonna actually produce the chips", that takes time and expertise to do that. You obviously need a lot of money but building three nanometer chips, even if you had all the money, doesn't mean you're going to be able to get it done. So that obviously has some implications for what the future looks like. A company like Intel, which does both fabrication and design in-house under one umbrella, is a little bit different than what we talked about on the fabrication-only setups. Intel has made a big push into adding additional capacity offering actually foundry type businesses to customers, such as Amazon Web Services and Qualcomm as an example, and so that's changing this landscape as well.

A little bit here on [increasing the capacity in the U.S.](#) The U.S. has always been a big player here but a lot of the manufacturing has gone offshore and a lot of that has gone into Asia and so we're talking about the global capital spending on semiconductors by region and the increasing capacity in the U.S. So, Samsung is putting 17 billion dollars into a factory in Texas, Intel is spending 20 billion dollars on two plants in Arizona and a three and a half billion dollar expansion in New Mexico, Taiwan Semiconductor is building a 12 billion dollar plant in Phoenix, and Texas Instruments 30 billion dollars for plants in Texas. So the Southwest is getting a lot of love here for sure, but you can see those are big dollars and those are real dollars going into this and so real capacity is being added and not just U.S. companies, Samsung, Taiwan Semiconductor as well putting a lot of money to work in this space. So just a small graphic here about these changes and where this money's going. A lot of the money's going into Asia. The capex spending on semiconductors from 2019 to 2021, you're talking about 100 billion overall going up to nearly 150 billion and Asia is growing at 30 percent over that period. But you're also seeing how Europe and the Middle East and Africa are growing by 44% over that time period and now the U.S. is growing at 52% so the mix is starting to change. Asia continues to be a dominant place for capex on this and a dominant place for manufacturing, and likely that's going to continue to be the case, but you're definitely starting to see how - especially because you had supply chain issues - people are trying to mix up their supply chains to be more diverse. So you're now seeing Europe, again plus 44%, the Americas plus 52%, and so that mix is changing and people are trying to make their supply chains more resilient over time.

Just a little bit more about increased capacity in the U.S. GlobalFoundries Inc., If you're following the markets, the company IPO'd at the end of last year, October 2021. It supplies silicon wafers to customers like Qualcomm and Samsung. It has factories in Singapore, E.U., and the U.S. It was created from a spin-off from AMD back in 2009. It is not yet profitable. The Mubadala Investment Co., which is part of the Abu Dhabi Investment Authority, retains 89% of the shares after the IPO, so it is still a big investor.

So these are the sources, we cited them here. And now I think we'll get into Q&A now. We have just about five minutes for questions. So if you have any questions, send them in.

Question: First question here: some analysts have postulated that China wants fabrication to move away from Taiwan so is there going to be some sort of military intervention here? Does

this create a geopolitical situation? And will this affect the semiconductor fabrication industry concentration?

Answer: It seems like the answer is yes. Pretty straightforward, right? China has been much more aggressive in being a bigger part of the semiconductor business. They're trying to produce those high-tech chips in China. It's proven more difficult than they expected. Taiwan Semiconductor is the leader in that. Probably all of us know about the tensions between mainland China and Taiwan and how that ends up resolving itself is unknown but I think what you're seeing from these investments into other places like the U.S, like Europe, big dollars are being spent putting facilities in other parts of the world outside of Taiwan and really even just outside of Asia as well, I think is a direct result of these tensions that you're seeing, or that's at least a piece of it, between China and Taiwan. Again how that resolves itself we won't necessarily know, but companies are obviously trying to de-risk themselves for any eventuality and making sure that they're diversifying the supply chains and I think that's at least in part a big push for putting plants in the U.S. Thanks for the question, any other questions?

Question: So I know it's really hard to know what's going to happen with inflation, but if this continues to be the case, how does that impact semiconductors?

Answer: You know, it depends, obviously, like anything else. But one of the items that I mentioned earlier in the conversation is if you have pricing power then you're going to be able to raise prices. And so if we have inflationary environments and the Fed is really raising rates to try to stamp down that inflation, what are the companies that are going to do well? If you're a semiconductor business where you have the ability to raise prices and the people who want your products are willing to pay those prices, then you're going to be able to pass on that price increase. So as an example, if your chips go into automobiles and they're only a small fraction of the price but they're a big part of the value creation - let's say then a small change, you know 5, 10, even 15% change in that one input doesn't have a dramatic increase in the overall price of the vehicle but you're able to protect your margins because you can raise prices. In this case you saw these automobile manufacturers clearly needed that to ship. And so you have some pricing power there. And if you have pricing power and people want your chips, you're the most innovative. For example, Nvidia has been well known to be one of the leaders for GPUs, which people are using for machine learning, and there's a lot of applications for that. If we do have inflationary periods and really you're the leader in this area and people are willing to pay up, well you're going to be protected. Now if you're fabricating, obviously input materials are going to be important. So it will affect different groups differently. But if you have the ability to pass on those price increases then you're going to be able to protect your margins. So Taiwan Semiconductor, for example, controls a lot of the capacity of the market. Very likely they're going to be able to pass on at least some of their costs, not guaranteed, but again you want pricing power and you want to stick with companies that have pricing power during inflationary periods.

Question: Next question, this is probably the last one as we have just two minutes left. Do you think major chip company consumers like Apple, Tesla, and Microsoft will attempt vertical integration in the semiconductor industry?

Answer: That's a great question. I'll start with Apple here, and then Tesla and Microsoft. So you're already starting to see this. So Apple, full vertical integration, it's difficult to say. I'm not sure they would want to go into the fab business. But you can see when they ended the partnership with Intel and said we're designing our own chips - so the M1 chips, and the Mplus chips, and the expected M2 chips that they put into their laptops and and now will likely go into PCs, those are internally designed chips. So they're using ARM architecture but they're Apple-

designed chips. Whether they continue on that path for vertical integration, I don't know but they're clearly spending a lot of money on the design of the chips in vertically integrating more of it. So it again was reliant on Intel and now bringing that all in-house, will they make the next step for fabrication? Tough to know. Taiwan Semiconductor has been a very reliable partner, anything's possible, Apple has a lot of cash on the balance sheet.

Tesla has done something similar. So they were using Nvidia's chips for their self-driving and they built their own chip. So they hired a team, actually away from Apple, and then they built their full self-driving chips in-house and Samsung is the fabricator there. So do they extend that and do vertical integration for fabrication? Hard to know, that's again a super expensive business and very technical. But they're obviously vertically integrating more of the business.

Microsoft has announced that they're starting to design some of their own chips. Again whether they then get into fabrication I think is difficult to say. But you're definitely seeing that more companies are taking more vertical integration under consideration. Tesla, Apple, Microsoft all are doing it in some way. Whether they fully integrate for semiconductors, it is very difficult to say. I think they'll look to other fabricators to actually do the fabrication and especially if they have another alternative where Intel now is saying that they're going to be opening up their fabrication facilities to third parties and they announced Qualcomm and AWS as their first two big customers there. So because it's so cap intensive and so technically oriented, I think that piece of it is probably likely to stay on the outside at least for now. Great question.

We're at 7:01, so I just want to say thanks to everybody. Mark your calendars, the next show Live with Rodney Lake for the GW Investment Institute is February 17th at 6:30 p.m. and then March 17th at 6:30 p.m. as well, the third Thursdays. I hope to see everybody there. Thanks for joining.

If you are interested in connecting with us, our email is invest@gwu.edu, or connect with us on [LinkedIn](#) (GWInvestmentInstitute), or [Twitter](#) (GW_Investment). Thanks for joining tonight.