A multi-trillion-dollar revolution is happening in the semiconductor industry—The Great Semiconductor Shift—and nobody is even aware of it. Most analysts and industry experts are missing quite possibly the biggest semiconductor trend of this century. Big tech companies like Apple, Google, Microsoft, Tesla, Amazon, and others are designing more of their semiconductors in-house, rather than relying on chipmakers like Broadcom, Qualcomm, Intel, and even NVIDIA. Why? The tech giants have the scale and capability to design application-specific chips, at lower costs, that dramatically improve the quality of their products when compared to products that utilize chips designed by third parties. This massive Revolution is already well underway. The question is: is your portfolio prepared for it?

In this book, you will find detailed analyses of 46 of the most valuable semiconductor companies on the planet. We provide our outlook for each company, incorporating decades of combined experience analyzing technology stocks, and picking winners like Apple, Tesla, Meta, Google, and NVIDIA years before they went mainstream. As industry outsiders, our insights and analyses are distinct from the conventional wisdom of Wall Street. Don't hesitate, start reading, and more importantly, start making money right now!

Cody Willard is the manager of 10,000 Days Capital Management and a former TV anchor. He is the publisher of TradingWithCody.com and the author of the #1 Amazon best-seller, "Everything You Need to Know About Investing" as well as several other books. Cody was an anchor on the Fox Business Network and CNBC and the Wall Street correspondent for *The Tonight Show with Jay Leno*. His stock picks and analyses have been featured on ABC's *20/20, CBS News, The Today Show, Financial Times, WSJ, New York Times*, and many other outlets.

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THE GREAT SEMICONDUCTOR SHIFT

Smith and Willard

THE GREAT SEMICONDUCTOR SHIFT

Bryce Smith & Cody Willard

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Cover Design by: Bryce Smith and Cody Willard using OpenAI's DALL-E 3 Model. Prompt: Photo of a detailed circuit board. On the board, there's a semiconductor designed in the shape of the US Flag, intricately crafted with red, white, and blue circuits. Right next to it, another semiconductor is shaped like the China Flag with its red background and five yellow stars. Both semiconductors are interconnected with golden traces, symbolizing technological collaboration between the two nations.

Artwork throughout this book was generated by the authors using OpenAI's Dall-E 3 Model. Certain portions of text generated by ChatGPT with heavy editing by the authors.

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PART I – BACKGROUND

Introduction

Dall-E 3 Prompt: Photo depiction of a colossal tidal wave approaching a coastline. What makes this wave extraordinary is its composition: it's made entirely of computer components like graphics cards, processors, and cables. The sunlight reflects off the metallic parts, adding depth and realism to the scene.

A multi-trillion-dollar revolution is happening in the semiconductor industry—what we have dubbed ***The Great Semiconductor Shift (or GSS for short)***—that is slipping under the market's radar. While there are many trends in the semiconductor industry that are well covered—such as the move to more advanced materials like Silicon Carbide (SiC) and Gallium Nitride (GaN), or the development of new transistor designs like gate-all-around (GAA)—most analysts and many industry experts are missing quite possibly the biggest trend of all. Big tech companies and other major semiconductor buyers are designing more of their semiconductors, colloquially known as chips, in-house. Why? These big tech companies have the scale and capability to design application-specific chips, *at lower costs*, that

significantly improve the quality of their products when compared to the same product using generic off-the-shelf chips designed by third parties. Moreover, moving silicon design in-house enables technology companies to offer more customization, shortens a product's time to market, and increases control over intellectual property. This massive Revolution is already well underway. The question is: is your portfolio prepared for it?

The Critical Need For ICs

Somehow we take sand (which is largely silicon), melt it down, process it, and somehow that allows us to watch golf training videos on YouTube? That is hard to wrap your mind around. Yet, the underpinnings of modern life—be it smartphones, computers, cars, televisions, data centers, Wi-Fi networks, cell towers, automated factories, and even the electrical grid—owe their very existence to advancements in semiconductor technology. Almost all of our modern technology is possible only because of the amazing advances in integrated circuits (ICs), aka chips, that we have seen over the last seventy years. The ubiquity of electronic devices is largely a result of Moore's law, which in 1965 predicted that computing power would essentially double every two years while the cost of computing power would roughly halve over the same timeframe. Moore's prediction proved to be correct, and today we live in a world that is entirely dependent on semiconductors to function.

The chip shortage experienced during the COVID-19 pandemic unmasked our global dependence on semiconductors. A vulnerable global chip supply chain led to acute shortages affecting everything from cars to cell phones. For many consumers, the chip shortage was perhaps the first time they ever considered how these extremely important products were

manufactured. And for many companies, the supply-chain shortages resulting from the lack of chips drastically limited their sales.

This recent lack of chips showed the world that the constant supply of chips it had grown accustomed to was no guarantee. The design, production, testing, and distribution of chips are extremely complicated processes and require hundreds of parties around the globe to work together to make them happen. Chips are largely designed by American companies, but the equipment used to make chips is designed and manufactured in Europe. The chips themselves are mostly produced in Taiwan but are then shipped to China and other Asian countries to be integrated into products used by consumers. Even amongst geopolitical adversaries like the US and China, the technological interdependence caused by semiconductors is staggering. Today, the chip industry generates over half of a trillion dollars in revenue, employs more than one million people, and has a combined market capitalization of about $4.5 trillion. A disruption at any point in the chip supply chain has a global impact.

The AI Revolution

Now, the burgeoning Artificial Intelligence (AI) Revolution is bringing unprecedented demand for the most advanced chips. Tech giants are racing to develop AI applications with the hopes that they will make the world dramatically smarter, safer, more creative, more productive, and more efficient. OpenAI's ChatGPT can pass the Uniform Bar Exam and most other professional licensure tests. Tesla's Optimus robot is teaching itself to sort objects based on color, unlike existing robots that must be programmed by humans to complete tasks. These are just a few examples of how the promise of AI is becoming more

real every day. It's not hard to imagine a day where AI-powered robots clean our houses, do our laundry, sweep our streets, and build our cars. The change in our quality of life will be extraordinary.

The AI Revolution brought with it increased demand for specific computing workloads that are served better by purpose-built chips. Demand for NVIDIA's graphics processing units (GPUs) has skyrocketed because these chips are great at performing parallel computing tasks for machine learning. However, companies that utilize machine learning in their systems are building custom chips that better serve those specific needs than off-the-shelf semiconductors. Google, for example, built its own chip known as a TPU (Tensor Processing Unit) that is optimized for Google's AI training and inference. By developing its own hardware, Google achieved better system-wide performance than it would have even if it used the leading-edge NVIDIA chip at the time.

Accelerating Chip Demand

The world's largest tech companies are not only voracious consumers of semiconductors, but their rate of procurement is growing at an accelerated pace. Apple, Google, Microsoft, Meta, and Tesla purchase billions of dollars of chips each year to run phones, PCs, data centers, cars, etc. And now they are buying more chips than ever as the amount of data that needs to be stored, analyzed, and used grows at an exponential rate. Tech giants purchase chips from a huge swath of semiconductor designers like Intel, NVIDIA, Broadcom, Qualcomm, and Advanced Micro Devices. Many of these chip designers are "fabless," meaning they outsource the manufacturing of the chips to third-party foundries like Taiwan Semiconductor (TSM) or GlobalFoundries (GFS).

The momentum for in-house chip design among big tech giants is not merely a trend but an accelerating paradigm shift. For example, nearly all of Apple's products come with chips designed by Apple in California (they never let you forget that). Apple cut Intel and its x86 architecture from its Mac computers starting in 2021. Apple is actively trying to cut Qualcomm's Snapdragon modem from the iPhone. Tesla designed its own CPU to control its cars as well as its own AI chip, known as the D1, which powers its Dojo Supercomputer. The list goes on.

The Beginning of the GSS

We began to see the underpinnings of the GSS way back in 2019 when Google, Amazon, and Tesla first announced their decisions to design some of their own chips. At that time, our analysis led us to begin buying TSMC stock, and we sent out a note to TradingWithCody.com subscribers when the stock was around $39 per share. Here was our analysis back then:

"TSM, is by far the most dominant and advanced semiconductor foundry. Trading at 15x next year's earnings, the stock will pay us a 4.3% dividend if we hold it the whole year. But more importantly, there's a big trend of companies designing their own custom chips and outsourcing their making to TSM -- as evidenced by Google's and Amazon's new data center chips and Tesla's new in-house-developed Full Self Driving chip. If TSM were based in the US, it would probably be one of my top 3 favorite stocks here to own for the next 30 years. Because it's based in Taiwan, I can't say it's a top 3 favorite, but I do think at these valuations it's a good risk/reward scenario for the long-term anyway."

TSMC has been a great investment for us thus far, and we think that following the playbook presented in this book will lead us to more investments like TSM. It will also help us avoid investing in companies that will lose value because of the GSS. Plus we think we found a few companies we can short to hedge our semiconductor longs.

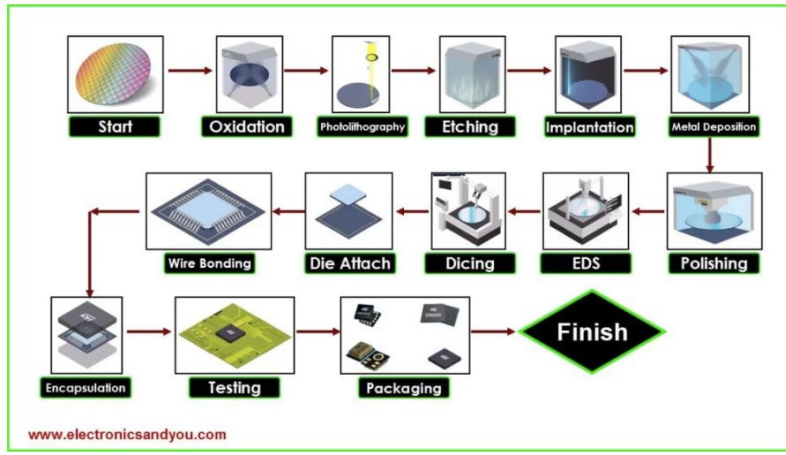
In the pages that follow, we embark on a meticulous analysis of close to 50 pivotal semiconductor firms to evaluate their preparedness for the GSS. At a surface level, it is often hard for investors to distinguish between different semiconductor companies and truly understand their business models. We have done that hard work for you. In this book, you will find detailed information on the background of each company, including when it was founded, where it is headquartered, what products it makes, who its customers are, who its competitors are, and what the company's strategy is for the future. We then provide our outlook for the company, incorporating fundamental analysis and decades of experience analyzing technology stocks. As industry outsiders, our vantage point provides an alternative lens, offering insights and analyses distinct from the conventional wisdom of Wall Street. The book concludes with a 27 page glossary of key industry terms so you don't get lost in the jargon. Don't hesitate, start reading, and more importantly, start making money right now!

Chapter 1 – The Development Of The Most Important Industry On Earth

Dall-E 3 Prompt: Photo of a cozy bedroom setting. In the foreground, a humanoid robot with a sleek design meticulously folds laundry on a bed. In the background, two five-year-old children are engrossed in play, laughing and sharing toys, adding a lively touch to the domestic scene.

The advent and widespread application of semiconductors arguably represents the most transformative technological milestone in modern history. But what are semiconductors? All materials can be categorized based on their ability to conduct electricity. Most metals, like copper, gold, and aluminum, are excellent conductors of electricity and are used for exactly that purpose in electronics. On the other end of the spectrum are insulators, such as rubber or wood, which do not conduct electricity at all. A semiconducting material can conduct or resist electricity depending on its chemical composition. Silicon stands as the primary semiconductor material under scrutiny in this book and is the material for which Silicon Valley got its name. Silicon is used to make transistors, which are essentially switches that can control the flow of current through an electrical circuit without any physical movement. For an

insightful visual explanation of the physics that govern transistors, check out How Does A Transistor Work? [1] on YouTube.



Pictured: The Chip Manufacturing Process[2]

What revolutionized our modern world was the invention of the integrated circuit (IC), more commonly known as a chip. In 1959, engineers at Texas Instruments and Fairchild Semiconductor developed the IC, which connected transistors, resistors, diodes, and capacitors onto a single silicon chip. Before this invention, transistors were built one at a time and wired together manually. The invention of the IC, combined with what is known as the "planar" manufacturing process (the process that allowed chips to be mass-produced), would open the door to massive technological developments such as the internet, personal computing, and eventually the smartphone and AI.

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[1] Veritasium, How Does A Transistor Work?, YouTube, July 9, 2013, https://youtu.be/IcrBqCFLHIY?si=R3gZvAfRD6VHi8U2

[2] Santosh Das, Semiconductor Manufacturing Process – Steps, Technology, Flow Chart, NOVEMBER 26, 2022, HTTPS://WWW.ELECTRONICSANDYOU.COM/BLOG/SEMICONDUCTOR-MANUFACTURING-PROCESS-STEPS-AND-TECHNOLOGY-USED.HTML

Chapter 2 – Moore's Law

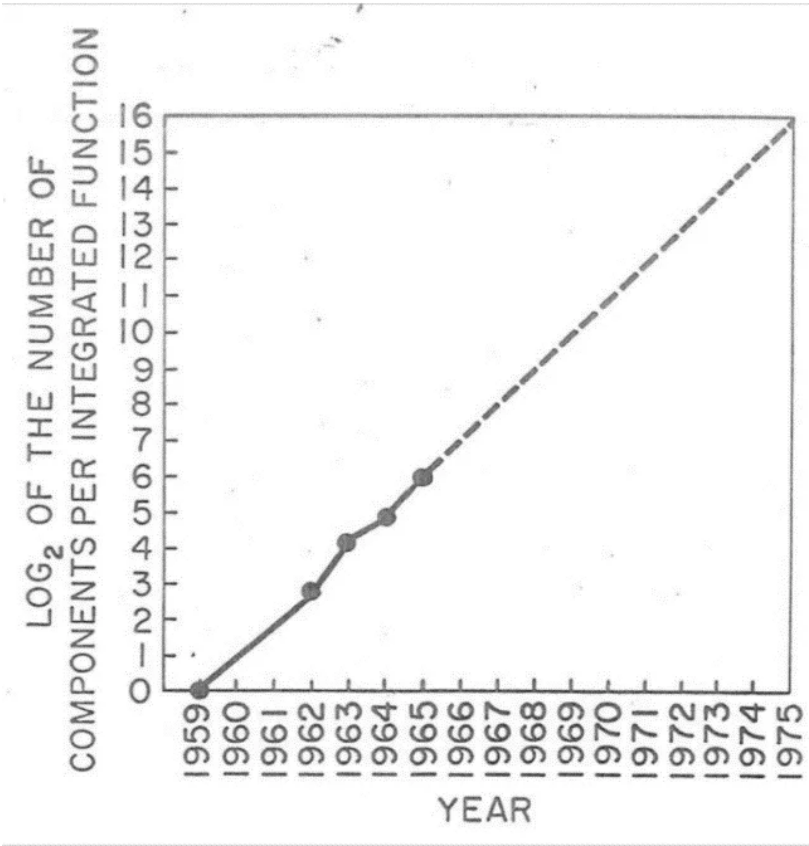
Dall-E Prompt: Vintage 1950s photo of a young boy in his backyard, engrossed in the melodies coming from an old-fashioned transistor radio. The surroundings reflect the time period with retro garden furniture and a picket fence. The overall tone of the photo should be warm and reminiscent of simpler times.

Not long after the invention of the IC, Gordon Moore, one of the founders of Intel, made a prediction that turned out to be so accurate it would later be referred to as law. In 1965, Gordon Moore wrote an article for *Electronics* magazine titled "Cramming More Components Onto Integrated Circuits,"[3] wherein he posited that advances in chips "will lead to such wonders as home computers, or at least terminals connected to a central computer, automatic controls for automobiles, and personal portable communications equipment." Moore made this prediction because he observed that the number of transistors on an integrated circuit doubled every two years, while the price of the integrated circuit was cut in half. Originally, he forecast that this trend would continue for at least

[3] Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics*, pp.114±117, April19,1965, available at: https://www.cs.utexas.edu/~fussell/courses/cs352h/papers/moore.pdf.

a decade; however, 58 years later, this trend largely holds, albeit with a slowing rate of improvement.

At the time of Moore's famous prediction, a single chip housed about 50 transistors. Fast-forward to today: the most advanced microprocessors, like Apple's M2 Ultra (used in its latest Mac computers), contain as many as 134 billion transistors on a single chip.



Excerpt from Cramming More Components Onto Integrated Circuits.

How has this relentless pace of development been possible? A lot of factors are involved, but this is attributable to advances in manufacturing, software, and materials.

One key factor was the development of the dedicated foundry and the fabless business model. In order to cram more transistors onto the same piece of silicon, the size of the transistors themselves had to get much, much smaller. In 1987, Morris Chang founded Taiwan Semiconductor Manufacturing Company (TSMC), which was the world's first dedicated chip foundry, meaning it would act as a manufacturer of chips designed by third parties. At that time, almost every semiconductor company designed *and manufactured* their own chips. When TSMC came on the scene, it allowed chip designers to dedicate resources to research and development instead of manufacturing, while TSMC focused on improving its manufacturing capabilities.

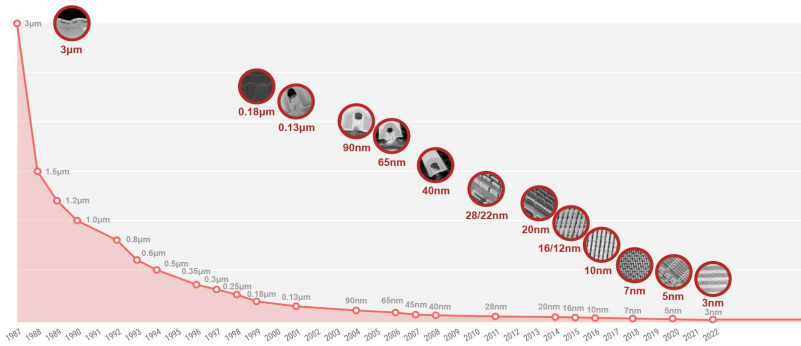


Image Source: TSMC[4].

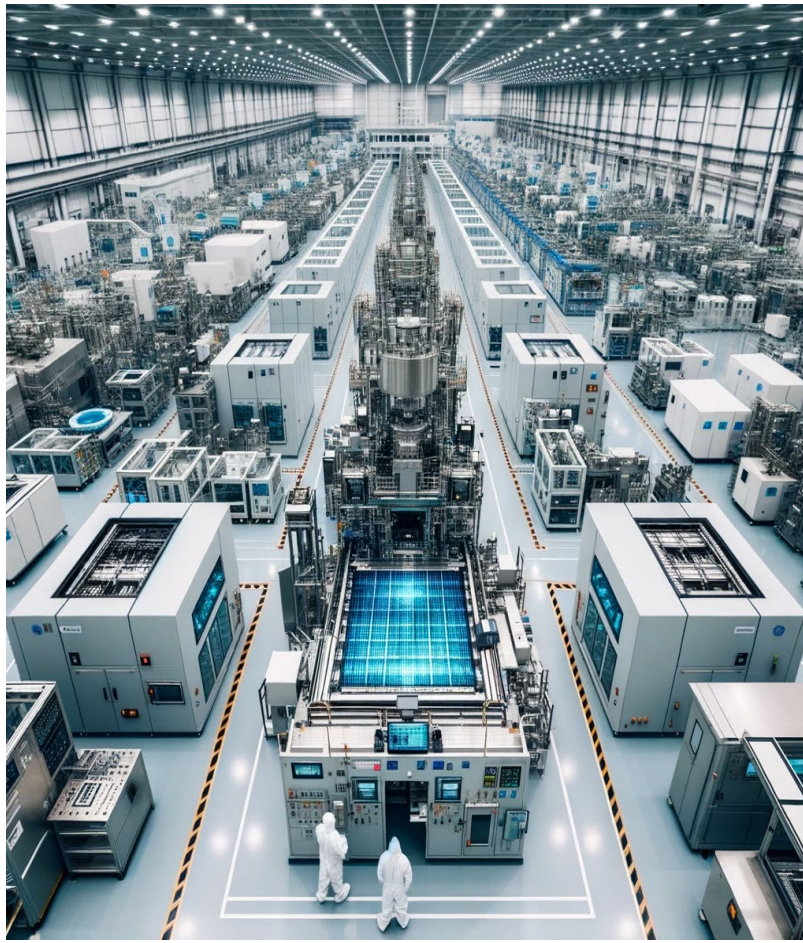
Over time, this would lead to massive advances in manufacturing technology that allowed fabs to produce smaller and smaller transistors. In the chip world, the various sizes at which a fab can produce transistors are known as "process nodes." The smaller the node, the smaller the transistor,

[4] Taiwan Semiconductor Manufacturing Co., Ltd., Logic Technology, accessed October 24, 2023, https://www.tsmc.com/english/dedicatedFoundry/technology/logic.

allowing for more transistors to be packed onto a single silicon wafer. Today, the most advanced process node is 3nm available from TSMC and Samsung. For reference, a human hair is about 100,000nm in diameter.

Chapter 3 – To Fab, Or Not To Fab, That Is The Question

"Real men have fabs."
-Jerry Sanders, AMD co-founder



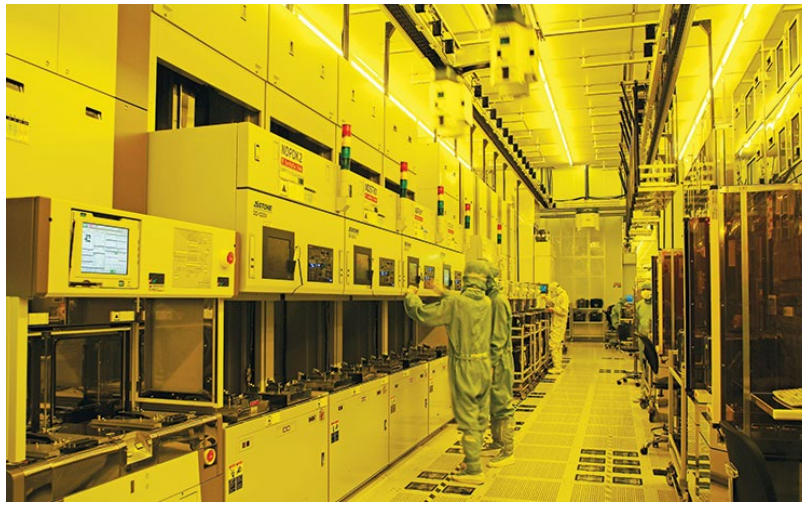
Dall-E 3 Prompt: Photo of a semiconductor manufacturing facility with a bird's eye view. The expansive factory floor is filled with state-of-the-art equipment. Engineers in white protective gear are monitoring the processes.

The idea of a “fabless” semiconductor company emerged alongside the founding of TSMC in 1987 and the advent of the foundry business model. TSMC revolutionized the semiconductor industry and opened the door for new companies to design semiconductors without having to invest billions of dollars in manufacturing capabilities at the outset. Major companies like Qualcomm (founded 1985), NVIDIA (founded 1997), MediaTek (founded 1997), Marvell (founded 1995), and Monolithic Power Systems (founded 1997) probably would not have been created if they had to build their own fabs to get their chips to market.

Without the need to invest in manufacturing, fabless companies were able to invest billions of dollars in developing new chip designs. These companies also started building software specifically for their chips that opened the door for ease of integration with other platforms and in some cases, like NVIDIA, entirely new applications.

Dall-E 3 Prompt: Vector depiction of a tectonic plate floating on molten magma. The twist is that the plate, instead of earth and rock, is made completely of semiconductors. Volcanoes erupt with glowing LEDs and circuits, and the plate boundaries shimmer with electronic components.

The overwhelming success of the fabless model led many vertically integrated chipmakers, today known as integrated device manufacturers (IDMs), to either completely or partially divest their manufacturing capabilities. For example, AMD, whose founder famously pushed back against the fabless model in the early 1990s stating that "Real men have fabs," divested its fabs in 2009 and went to an entirely fabless model. Additionally, as companies transitioned to more advanced process nodes, the costs of building a fab surged dramatically. Today, building a single fab could cost upward of $10 billion.



Source: The Inside Of A 12-inch TSMC Fab[5].

Currently, only a handful of chip makers remain true IDMs, namely, Samsung, Intel, and the memory makers, Micron, Western Digital, and Seagate. And even Samsung and Intel utilize third-party foundry services to produce certain products. Most semiconductor companies have switched to a fully fabless

[5] Taiwan Semiconductor Manufacturing Co., Ltd., Multimedia Gallery - Fabs Inside, accessed October 24, 2023, https://pr.tsmc.com/english/gallery-fabs-inside.

or a “Fab-Lite” model (meaning they outsource the manufacturing of nearly all but a handful of their own chips). The companies that do produce at least some of their own chips still depend on the big three (Samsung, Intel, and TSMC) to produce chips using advanced nodes.

While the fabless model has clearly been the preferred business model over most of the last 30 years, the business is not without its drawbacks. First, fabless companies are reliant on the foundry to improve its process technology. For most of modern history, this was not a problem because the largest foundry, TSMC, constantly led or co-led the industry in process technology. Fabless companies (like AMD) were able to jump ahead of IDMs (like Intel) who could not upgrade their fabs as fast as TSMC. Samsung and Intel have nearly reached parity with TSMC and by all indications will pass TSMC in the next year. So for nearly the first time since TSMC’s founding in 1987 (it started two nodes behind Intel but caught up within 5 years), TSMC will not be the outright leader in advanced process technology, placing the fabless semiconductor companies at a disadvantage.

Second, the fabless companies do not have control over the actual production of chips and are at risk of losing sales if their foundry cannot produce chips fast enough. This is largely what caused the chip shortage. During COVID, Taiwan was under extended periods of lockdowns and even after the lockdowns were lifted, the fabs would still have to shut down at times if workers contracted COVID. Obviously, this is a problem that afflicts IDMs as well, but they have much more control over such anomalies than a fabless company that is waiting for chips to arrive from halfway across the world.

These issues, among others, have led companies to begin reconsidering the purported brilliance of the fabless business model. We have witnessed a similar phenomenon in the auto industry with Tesla. For years, American automakers bragged about how "just in time" manufacturing and an outsourced supply chain led to greater efficiency and profitability. But when Tesla came along, it showed the world the advantages of vertical integration when trying to manufacture technologically advanced goods. Tesla produces many of the components for its cars and even designed its own full-self-driving (FSD) chip. Because of this, Tesla was far less affected by the chip shortage than most of the automakers. Now all of the legacy auto companies are trying to vertically integrate because they simply cannot produce products of the same quality, level of profitability, or as quickly as Tesla. The fabless semiconductor companies are starting to learn the same lesson as the traditional automakers.

The final problem with the fabless business model is a geopolitical one, which warrants its own chapter.

Chapter 4 – Taiwan's China Problem

Dall-E Prompt: Photo capturing the vast semiconductor factory taking shape in Phoenix's backdrop. In the forefront, on an unconstructed dirt plot, a diverse group of company executives in formal attire and protective gear stand with local politicians, symbolizing growth and partnership.

Taiwan is an island with a land mass of roughly 14,000 square miles, only slightly bigger than the state of Maryland. This small island, which produces about 60% of the world's semiconductors and over 90% of the most advanced chips, sits just 100 miles off the coast of the People's Republic of China (PRC).

In case you are unaware of the issues between Taiwan and China, let's briefly hit on the history so we can properly place the issues between these two countries in context. In 1911, revolutionaries in China overthrew the ruling Qing Dynasty (who had governed the nation for 267 years) which led to the creation of the Republic of China. After a short period under the new government, a civil war broke out with the Nationalists and the Mao Zedong-led Communists competing for power. After a pause in hostilities during World War II, the Communists finally gained control of mainland China (officially the People's Republic of China, or P.R.C.) in 1949, and the competing Nationalists retreated to the island of Taiwan (officially the Republic of China, or R.O.C.) where they set up an independent government.

The rift between the Communists and the Taiwanese never went away and China continues to claim Taiwan as part of the PRC. Taiwan, on the other hand, is now a thriving democracy and does not recognize the PRC as a legitimate authority over Taiwan. This has led to major tensions between the two countries, which have continued to build in recent years.

The threat for the US and the rest of the Western world lies in their dependence on Taiwanese chip makers to build almost all of the most advanced chips, which are critical for both economic reasons and national defense. Thus, there has been a major push by nearly every Western country to move chip-making westward. In the US, Congress passed the Creating Helpful Incentives to Produce Semiconductors (CHIPS) Act, which allocated around $72 billion in funding to incentivize domestic chip-making. Outside of the US, major European countries like Germany, Poland, and France have approved subsidies to encourage investments in new fabs.

The Taiwan problem leaves most of the fabless semiconductor companies in a major predicament. On one hand, they would prefer their supply chain to be free from the constant threat of the Chinese Communist Party. But if they move away from TSMC, they will lose access to the most advanced chipmaking technologies. Only a few companies, notably Intel and Samsung, produce their chips without relying on Taiwan.

Because of the threat of China, Intel, TSMC, and others are making investments in US and Europe-based fabs. Intel is also starting to make chips for fabless companies, when for years Intel's fabs exclusively produced Intel chips. While Intel's foundry business is just now getting off the ground, the company has already seen significant interest from fabless companies that want to diversify their supply chain away from Taiwan. Additionally, the geopolitical issues between Taiwan and China have slowed the trend of fab-lite companies divesting their manufacturing capabilities.

Dall-E 3 Prompt: Photo showing a group of Google engineers in a lab, immersed in the intricate process of semiconductor design. The atmosphere is one of concentration and collaboration, with engineers examining silicon wafers and sharing insights.

The most advanced microprocessor currently in production was not designed by a chip company. It was designed by Apple. With 134 billion transistors, Apple's M2 Ultra chip (which is available in its latest Macbooks) is the most advanced chip available in a consumer product. Apple's previous Mac processor, the M1, cost about one-fifth the price of the Intel chips that Apple formerly used in the Macs. It's been reported that the switch to in-house silicon in the Macs saved Apple

about $2.5 billion per year. The fact that Apple could design and produce the world's most advanced microprocessor for significantly less cost than available alternatives does not bode well for the historical leading processor companies like Intel, AMD, Qualcomm, or MediaTek. The proof of the benefits of in-house silicon design is in the Apple pudding.

Application-Specific Integrated Circuits, or ASICS, have long been a major part of the semiconductor industry, but they are becoming even more important as discrete use cases become increasingly reliant on specially designed chips. Major tech companies have extensive expertise in software design, and in many cases would prefer to design a chip that is designed to integrate with their in-house software designs. These companies are always looking to gain a competitive edge over one another, and moving silicon design in-house is a primary way for tech companies to improve and differentiate their products.

The story of Apple silicon is a sign of things to come. In 2023 alone, nearly all major tech companies have announced plans to develop in-house silicon:

Google Has Developed Its Own Data Center Server Chips (published February 14, 2023)[6]

Meta bets big on AI with custom chips — and a supercomputer (published May 18, 2023)[7]

[6] Mark Tyson, "Google Reaches Self-Developed Data Center Server Chip Milestone," Tom's Hardware, February 14, 2023, https://www.tomshardware.com/news/google-reaches-self-developed-data-center-server-chip-milestone.
[7] Kyle Wiggers, "Meta bets big on AI with custom chips — and a supercomputer," TechCrunch, May 18, 2023

Amazon is making its own chips to offer generative AI on AWS (published August 15, 2023)[8]

If Microsoft is looking into its own ARM chips that could set off alarms at Intel and AMD (published May 02, 2023)[9]

Microsoft developing its own AI chip (published April 18, 2023)

As this trend continues to accelerate, we are concerned that many, if not most of the fabless chip designers may find themselves losing some of their biggest customers in the years to come.

The Fabless Value Proposition

We see four key attributes of the fabless companies that encompass their value proposition:

1. Intellectual Property
2. Software/Integration
3. Talent/Know-How
4. Distribution

https://techcrunch.com/2023/05/18/meta-bets-big-on-ai-with-custom-chips-and-a-supercomputer/.

[8] Ameya Paleja, "Amazon is making its own chips to offer generative AI on AWS," Interesting Engineering, August 15, 2023, https://interestingengineering.com/innovation/amazon-making-own-chips-generative-ai-aws

[9] Reuters, "Microsoft developing its own AI chip", April 18, 2023, https://www.reuters.com/technology/microsoft-developing-its-own-ai-chip-information-2023-04-18/

The reason that the big tech companies are starting to replace third-party chips with in-house silicon is that the relative value of the generic chips provided by the fabless semis is diminishing as big tech continues to grow in scale and capability. Apple clearly has enough talented engineers and capital to design chips itself. Apple and the other systems companies can also design the software needed to integrate their own chips with existing hardware and operating system(s). They do not need chips with features designed to be used across devices and operating systems, they need chips designed specifically for their devices and operating systems. A NVIDIA GPU needs to be compatible with many different applications, end users, and OSs, but a Google TPU only needs to be compatible with one application, one end user, and one OS. With big tech companies possessing nearly all of the same qualities that support the value proposition of the fabless companies, the time is ripe for big tech companies to eliminate fabless companies to the maximum extent possible.

The In-House Silicon Decision

As the Apple/Qualcomm modem deal makes abundantly clear, switching to in-house chip design is in no way a walk in the park. Despite a clear indication from Apple that it wants to stop purchasing Qualcomm modems (and Qualcomm's apparent belief in the same), Apple nevertheless re-upped its contract with Qualcomm recently for three more years. Thinking about what is preventing Apple from leaving Qualcomm led us to identify the factors that go into the decision to design chips in-house versus relying on chips designed by others. In our view, a chip buyer evaluates at least five considerations when making this decision:

1. Scale

2. Capability
3. Specificity
4. Efficiency/Power Consumption
5. Cost

Let's discuss each in turn. The first factor is scale. A chip buyer needs to consume enough chips to justify the cost of hiring engineers and dedicating resources to chip design. Product improvements alone may not be enough to justify the added cost of hiring your own chip designers if you do not have adequate scale.

Capability is next. The big tech companies are in a prime position to cut out the chip designers because they already have the talent, capital, and much of the IP required to design a chip. Even if they do not have the IP, they can largely license it and/or use ASIC services from fabless companies to help them get their in-house silicon efforts started. On the other hand, less sophisticated chip buyers like the traditional automakers (Ford, GM, etc.) do not have the capability to design their own chips. However, we think the ratio of sophisticated/capable chip buyers to incapable buyers as a percentage of semiconductor revenues is higher than ever before, thus leaving more and more customers assessing the possibility of bringing chip design in-house.

Next is specificity. The specificity analysis takes place at the application level, rather than at the company level. Standardized chips do not offer equal utility across applications. A chip selected to run a car's operating system is not typically going to be the same chip selected for a phone, even if they have equivalent computing power, because the application and operating environment in the two scenarios are so radically different. Tesla demonstrated this when it opted to design its

own self-driving chip, rather than rely on existing technology from a third-party chipmaker. For certain applications, off-the-shelf semiconductors will likely be good enough, especially if they are readily available for lost costs.

Efficiency and power consumption are the next factors. Going back to Tesla, it did not need a super-tiny, powerful, and power-efficient chip, because it is not limited by the same constraints faced by Apple or Dell when selecting chips for phones or PCs. Apple and Dell, on the other hand, are both looking to optimize battery life and space in the much smaller hardware that houses the chips, so they focus much more attention on size and efficiency than say Tesla does in the car chip it designed. The largest operating cost associated with running data centers is electricity. NVIDIA A100s and H100s are extremely power-hungry, and the hyperscalers can likely develop ASICs that are maybe less powerful but more efficient and tailored for the needs of specific data centers than the expensive NVIDIA chips. If the hyperscalers can create a chip that not only costs less upfront but also saves them electricity in the long run, you can bet they will do everything they can to design it. The bottom line is that when efficiency matters, chip design becomes that much more important.

The last is cost. Apple reportedly saved billions of dollars by switching away from Intel CPUs in its computers, because Apple's chips cost about one-fifth the price of Intel's processors. Tesla is making its D1 chip for about 1/6th of the price of NVIDIA's H100. It's the same old story of cutting out the middleman. Why would Tesla, Apple, Google, or anyone else pay chipmakers 50%, 70%, or 90% gross margins (looking at you NVIDIA) if they can feasibly do the design themselves?

When these factors are considered, we think most of the big tech companies have both the incentive and the capability to move to in-house silicon design for a large portion of their chip needs. The growth in data centers, nearly all of which are owned by big tech companies, is one of the main drivers of semiconductor revenue growth currently. The hyperscalers have the scale, the talent, the need for specificity, and the desire for cost savings to design their own chips. This is one example of a high-growth area that will probably flatline and/or decline for many fabless companies as their largest customers do everything in their power to stop buying their chips.

The GSS Fallout

So why does this multi-trillion-dollar shift in the semiconductor industry matter? We think that the market is largely overlooking the potential risk to the scores of multi-billion-dollar fabless semis (with trillions of dollars in collective market cap) that are at risk of losing in some cases up to 75% of their revenue as their largest customers decide to start designing their own chips. Just think what would happen to Intel and AMD if Microsoft designed its own CPUs that shipped in all of future PCs? We are not saying that this scenario will play out overnight, but these companies (Microsoft, Apple, Google, etc.) are already taking major steps in that direction, and yet most of the semiconductor companies have not even acknowledged this shift in demand, much less altered their company strategy. This trend should only accelerate as we believe many, if not most of the major chip buyers today satisfy the four criteria above and have the incentive to move silicon design in-house.

We think this multi-trillion-dollar shift in the chip industry further highlights the strategic importance of the foundry businesses. Regardless of who designs the chips, somebody has

to fabricate them. However, building fabs is extremely expensive, and there are no major companies investing in fabs other than TSMC, Intel, and Samsung. The process of building fabs takes a lot of time and A LOT of capex. TSMC and Intel will each spend about $30 billion this fiscal year on capital expenditures. For reference, this combined spend ($60bb) is roughly equivalent to the entire market cap of KLA (KLAC), the 15th most valuable semiconductor company in the world. In our view, the lack of fab investment from the remainder of the semiconductor industry is representative of the misdirected focus and the lack of recognition of the trend discussed herein.

Intel's old CPU business has been on the front end of this trend, with its chips (the demand for which was red hot for decades) being designed out of many applications (e.g. the Mac). We think Intel learned the lesson of the GSS the hard way, but perhaps Intel learned it early enough to make a strategic shift before the rest of the market realized what was happening. Intel is now hyperfocused on developing its dedicated foundry division and we expect that Intel will spin out this business line in the next two to three years once it reaches sufficient scale.

The GSS Will Take Time

To clarify, we don't anticipate big tech abruptly shifting to 100% in-house silicon overnight. This transition will take time, most likely decades, not years. Designing chips from scratch is no easy task, and we expect many tech companies will continue to rely on ASIC services to help them get their silicon designs off the ground. After nearly five years of work and billions of dollars spent, Apple still has not developed a suitable alternative for Qualcomm's 5G modems. However, Apple is not giving up, and we think that the company's demonstrated

success with its microprocessors bodes well for the company's ability to eventually develop its own modems.

Furthermore, we don't foresee in-house designs replacing every chip created by fabless companies. To begin, big tech does not have the incentive to design in-house many of the chips it uses. As you will learn in the pages that follow, many semiconductors are relatively low-tech, and in some cases sell for pennies each. These low-margin, commoditized chips are not the target of the GSS. What big tech is looking to design in-house are the mission-critical chips that are usually the most expensive in their systems.

Additionally, the fabless companies have significant IP and know-how that big tech cannot replicate overnight. Some companies, like NVIDIA, have built software platforms around their chips that are used to develop the applications that run on those chips. Software widens the moat for fabless companies and makes it that much harder to replace the products. Other fabless companies like Marvell are offering ASIC services for big tech companies and leveraging their IP and know-how to help big tech design their own chips. These types of companies might benefit from the GSS even though they are fabless.

For these reasons, we do not want to be overly aggressive in repositioning our portfolios for the GSS. There are some great companies in the fabless category that will continue to do well for years, but the key result of the GSS is that we think much of the secular growth story for most fabless companies is coming to an end. While we are still in the early innings of the GSS, we do think companies like AMD, Broadcom, Qualcomm, etc. may see revenue growth stagnate as the demand for their chip-designing services plateaus.

On the other hand, companies like Intel, TSMC, and Samsung stand to benefit. No matter who designs the advanced chips, fabrication still depends on these foundries. With that in mind, we are looking to invest in the best semiconductor companies like some of the foundries and IDMs mentioned that will benefit from the GSS in the long term, and hopefully avoid and/or slowly short those stocks that will see stagnation or secular decline for years to come.

PART II – COMPANY ANALYSIS

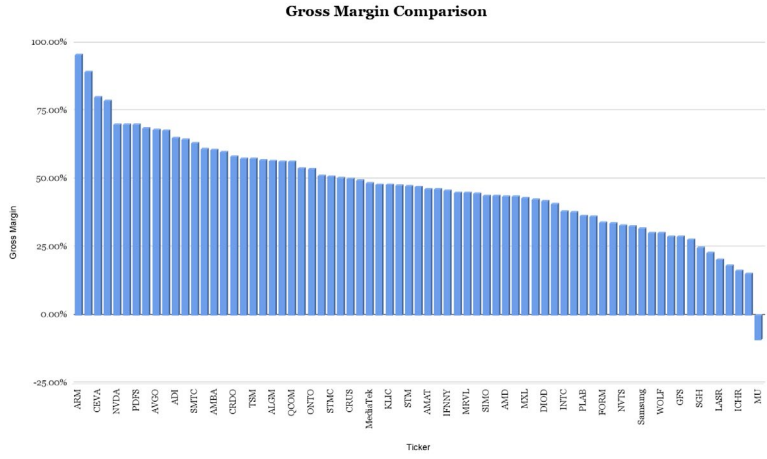
Chapter 6 – Overview

Dall-E 3 Prompt: Photo set in the future at the New York Stock Exchange (NYSE). Instead of human traders, humanoid robots are seen bustling about the trading floor, their LED eyes scanning screens and analyzing data. The atmosphere is electric, with robots making rapid gestures to signify trades, their metal bodies reflecting the screens' glow. The iconic NYSE architecture forms the backdrop, juxtaposed with the futuristic sight of robots dominating the trading scene.

We analyzed almost 50 semiconductor companies, including foundries, IDMs, Fab-Lite companies, and fabless chip makers. Companies within each section are sorted in ascending order based on their market cap at the time of our analysis.

As part of our study, we analyzed the gross margins of each company. Gross margins (the difference between revenue and cost of goods sold, divided by revenue) are a function of many aspects of a company's business, but in our view, they give a good indication of the relative value of the company's products to its customers combined with the difficulty in replicating the company's products. Below is a graph showing a comparison

of the gross margins of the companies included in this book, such as equipment suppliers and EDA (electronic design automation) firms which we did not analyze:



The below table shows the average gross margin by semiconductor category:

Semi Category	AVERAGE of Gross Margin
EDA	79.41%
Equipment Supplier	44.84%
Fab-Lite	57.26%
Fabless	52.81%
Foundry	36.75%
IDM	37.44%
IDM (memory)	8.17%
IP Licensor	87.98%
Grand Total	**47.44%**

The Great Semi Shift Rating Scale

In our analysis of individual companies, we rate each company on a scale of 1 to 10, based on the company's positioning for The Great Semiconductor Shift. A score of 1 suggests "sell this stock now" because it will be completely destroyed by the GSS. Conversely, a rating of 10 means "sell everything and buy this stock, we've found the perfect investment." The GSS rating encompasses our perspectives on the company's fundamentals, balance sheet health, growth potential, and the inherent risks of owning the stock. Here is our summary table showing the stocks included herein, ranked by their GSS score:

Ticker	**Name**	**GSS Rating**
INTC	Intel Corporation	**8.5**
TSM	Taiwan Semiconductor Mfg. Co. Ltd.	**7.5**
STM	STMicroelectronics NV	**7**
SMSG	Samsung Electronics	**6.5**
TXN	Texas Instruments Inc	**6.5**
ON	ON Semiconductor Corp	**6**
DIOD	Diodes Inc	**5.5**
ADI	Analog Devices, Inc.	**5.5**
NXPI	NXP Semiconductors NV	**5.5**
TSEM	Tower Semiconductor Ltd	**5.5**
IFFNY	Infineon Technologies AG	**5**
MCHP	Microchip Technology Inc	**5**
MTSI	MACOM Technology Solutions Holdings Inc	**5**

SKYT	Skywater Technology Inc	**5**
CRDO	Credo Technology Group Holding Ltd	**5**
GFS	Globalfoundries Inc	**5**
MRVL	Marvell Technology Inc	**5**
UMC	United Microelectronics Corp	**5**
VSH	Vishay Intertechnology Inc	**5**
NVDA	NVIDIA Corp	**5**
WOLF	Wolfspeed Inc	**4.5**
MPWR	Monolithic Power Systems Inc	**4**
ALGM	Allegro MicroSystems Inc	**4**
LSCC	Lattice Semiconductor Corp	**4**
MU	Micron Technology Inc	**4**
SMIC	SMIC	**4**
SMTC	Semtech Corp	**4**
AOSL	Alpha and Omega Semiconductor Ltd	**3.5**
MDTK	MediaTek	**3.5**
NVTS	Navitas Semiconductor Corp	**3.5**
POWI	Power Integrations Inc	**3.5**
QRVO	Qorvo Inc	**3.5**
SWKS	Skyworks Solutions Inc	**3.5**
QCOM	Qualcomm Inc	**3.5**
AMD	Advanced Micro Devices, Inc.	**3**
MXL	Maxlinear Inc	**3**
WDC	Western Digital Corp	**3**

AMBA	Ambarella Inc	**2.5**
HIMX	Himax Technologies, Inc.	**2.5**
SIMO	Silicon Motion Technology Corp.	**2.5**
CRUS	Cirrus Logic, Inc.	**2**
INDI	indie Semiconductor Inc	**2**
SGH	SMART Global Holdings Inc.	**2**
STX	Seagate Technology Holdings PLC	**2**
AVGO	Broadcom Inc	**1.5**
SITM	SiTime Corp	**1**

Before delving into our company-level analysis, let's address a few housekeeping items. Our analysis is as of the date shown for each stock and is subject to change as new developments emerge. For each stock, we estimate the company's sales to big tech and their sales subject to the in-house silicon revolution as a percentage of revenue. These estimates are based on information from company filings and our perspective on the GSS. They are not guaranteed. Lastly, 'net cash' refers to the difference between cash plus short-term investments and long-term debt, as per the company's latest reported quarter.

Chapter 7 – Foundries

Dall-E 3 Prompt: Realistic image capturing a moment in a state-of-the-art semiconductor factory. Illuminated by vibrant neon lights, a cyborg with sleek metallic skin and luminescent patterns operates advanced machinery. The scene emphasizes the harmony between the cyborg's design and the high-tech environment.

At the epicenter of the semiconductor industry, foundries serve as the manufacturing hubs responsible for translating intricate chip designs into tangible silicon wafers. These businesses follow a distinct model; they do not design chips but specialize in fabricating them for fabless semiconductor companies, along with numerous IDMs and Fab-Lite companies. The epitome of foundry excellence is Taiwan Semiconductor Manufacturing Company (TSMC), which has managed to entrench itself as the market's juggernaut, holding a near-monopoly on advanced semiconductor nodes.

Overall, foundries have the second lowest gross margins of any segment we analyzed, with the industry averaging nearly 37%. However, TSMC boasts an impressive 57.5% gross margin,

reflective of its dominance of the foundry segment and stranglehold over advanced chip production.

One of the critical parameters that distinguish foundries is the process node technology they employ. Simply put, a process node generally refers to the transistor size and the associated manufacturing method. Over time, these have shrunk dramatically—enabling faster, more energy-efficient chips.

The economics of chip manufacturing also pivot around the size of the silicon wafers used. Common wafer diameters are 6-inch, 8-inch, and 12-inch, with the larger wafers offering better economies of scale by allowing more chips to be fabricated in a single batch. However, the caveat is that larger wafers necessitate more advanced and expensive fabs.

In the next section, we will provide an analytical review of six pivotal pure-play foundry companies, closely examining their strategies, capabilities, and positions in this fast-evolving sector.

Foundry Comparison Table							
Ticker	**Market Cap (bb)**	**TTM Revenue (bb)**	**Gross Margin**	**Fwd. P/E**	**2023/24 Growth Est.**	**Process Nodes**	**GSS Rating**
TSM	$437.00	$74.70	57.57%	17.03	-12.50%	3nm-3000nm	7.5
GFS	$57.60	$7.86	28.99%	27.71	-8.50%	12nm-600nm	5
SMIC	$29.43	$7.27	38.00%	22	-12.90%	14nm-350nm	4
UMC	$17.41	$8.92	45.12%	9.86	-23.00%	14nm-5000nm	5

TSEM	$2.77	$1.68	27.79%	11.11	-14.70%	65nm-800nm	5.5
SKYT	$0.27	$0.25	23.00%	NM	27.10%	90nm-130nm	5

Taiwan Semiconductor Manufacturing Company Ltd. (NYSE: TSM)

Background

Taiwan Semiconductor, commonly known as TSMC, is the world's largest dedicated semiconductor foundry. When the company was founded in 1987, the idea of a dedicated foundry did not exist. At that time, nearly every semiconductor company designed and manufactured its own chips. In the mid-1980s, the Taiwanese government decided that it wanted to develop its semiconductor industry and thus it recruited Morris Chang (founder and long-time CEO) to head up what became TSMC. The foundry model unleashed significant growth in the semiconductor design world by drastically reducing the startup capital required to start a fabless semiconductor company.

TSMC rapidly grew to become the largest foundry in the world by investing heavily in the most advanced process technology in the world. Today, most of the major fabless semiconductor companies and big tech giants, including Apple, NVIDIA, Qualcomm, AMD, Broadcom, and others, rely on TSMC to manufacture their chips. In 2022, TSMC manufactured 12,698 different products for 532 customers.

The total manufacturing capacity of TSMC is 15 million 12-inch equivalent wafers. TSMC operates four 12-inch wafer GIGAFABs, four 8-inch wafer fabs, and one 6-inch wafer fab, all in Taiwan. The company also has one 12-inch wafer GIGAFAB and an 8-inch fab in mainland China, and one 8-inch wafer fab in the USA. Part and parcel with TSMC's fab business is its services business which includes system-level integration design, design technology definition, design tool preparation, wafer processing, advanced packaging and silicon stacking technologies, and testing services.

Business Model

Today, TSMC manufactures 30% of the world's semiconductors (excluding memory chips). Its process nodes range from 3nm to 3mm (the equivalent to 3000nm), although the company specializes in producing the most advanced semiconductors, with 53% of TSMC's revenue in 2022 coming from 7nm nodes and smaller. TSMC's primary end markets include high-performance computing (44%), smartphones (33%), automotive (8%), and IoT (8%).

Around 2015, TSMC took the lead in advanced process technology when it introduced its 16/12nm node, surpassing Intel whose most advanced node at the time was 14nm. TSMC then rolled out its 10nm process node in 2016, an advancement that Intel would not reach until 2019. Today, TSMC and Samsung lead the pack with their 3nm nodes, but both companies are fighting to stay ahead in terms of process technology. Intel ramped its 4nm node in 2023 and is projected to introduce its 20A node (equivalent of 2nm) in early 2024 which would put Intel back in the driver's seat.

TSMC is spending $40 billion to build two new fabs in Phoenix, Arizona, which will help the company diversify its manufacturing base and increase its tech leadership. The first fab will utilize N4 process technology and is expected to begin production in 2025. The second fab is scheduled to begin production of 3nm process technology in 2026. The two Arizona fabs will manufacture over 600,000 wafers per year. However, in July 2023, TSMC announced that it was postponing production from its Arizona fabs until 2025 due to a lack of available skilled workers to man the fab. TSMC is also building a new fab in Kumamoto, Japan with production targeted for 2024.

Our Outlook

While worldwide foundry revenue grew 28% year over year in 2022, it is expected to be down mid-single digits in 2023. The semiconductor industry is still largely working through a big inventory build-up that occurred on the tail end of the COVID pandemic. Several of TSMC's key end markets are facing significant headwinds that we expect could persist for the next year or two. Smartphones, personal computers, and tablets, which currently make up about half of TSMC's revenue, are not expected to see much growth in the near term. However, AI-related chips for data centers (those made by NVDA, MRVL, AVGO, AMD, and INTC) are likely to see extraordinary demand for most of this next decade.

We think a lot of the near-term revenue headwinds for TSMC are probably priced in and the stock presents an attractive setup here. TSMC will be a winner in the Great Semi Shift as it is one of the few businesses investing in advanced fab capabilities. The company's stellar gross margins of nearly 60% are a testament to its near monopoly status in the advanced foundry

market. While we are optimistic about Intel's foundry business, we are still a couple of years from Intel's most advanced nodes reaching full production. And even once Intel's 20A and 18A nodes come online, we expect there will still be significant demand for TSMC's advanced production capabilities. The company has demonstrated exceptional execution and we do not think it is going to slow down any time soon. The demand for advanced semiconductors will only continue to grow as AI reshapes our world, cars become smarter and electrified, and devices become ever more connected to the internet. TradingWithCody.com subscribers have owned TSMC since May 2019 when we bought it for around $39 per share. We want to stick with TSMC as a long-term holding that is perhaps the best-positioned company to benefit from one of the largest secular growth trends we see today.

What Could Go Wrong With The Stock

- The clearest risk with TSMC is its primary location, Taiwan. Taiwan is the epicenter of one of the most serious geopolitical tensions right now as the communist Chinese government is still firmly committed to the belief that Taiwan is not an independent nation.
- As tensions between the US and China ratchet up, the Chinese are growing more infuriated by the chip restrictions placed on them by the US, when those advanced chips are being produced in Taiwan. Thus, TSMC faces an existential threat from the Chinese and any further heating up of US/China relations will likely be a headwind for the stock.
- The current chip glut could last longer than most people think. While TSMC thinks this chip cycle will likely bottom toward the end of this year, there is a possibility

that global economic weakness could drag the inventory correction well into 2024. Semiconductors are and always have been a cyclical business and sometimes these cycles take longer to work through than the industry expects.

Company	**TSMC**
Stock Symbol	NYSE: TSM
Semiconductor Category	Foundry
Stock Price	$84.45 (as of 9/26/23)
Market Capitalization	$437 billion
Headcount	73,090
Key End Markets and Products	High-performance computing, smartphones, automotive, and IoT.
Major Competitors	Samsung, Global Foundries, United Microelectronics, Tower Semiconductor
Total Revenue (ttm)	$74.71 billion
Gross Margin	59.57%
Revenue Breakdown	High-performance computing: 44% Smartphone: 33% Automotive: 8% IoT: 8% DCE: 3% Others: 4%
Notable Customers	Apple, Advanced Micro

	Devices, Inc., Amazon Web Services, Inc., Broadcom Inc., Intel Corporation, MediaTek Inc., NVIDIA Corporation, NXP Semiconductors N.V., Qualcomm Incorporated, Renesas Electronics Corporation, Sony Semiconductor Solutions Corporation, STMicroelectronics N.V. and many more worldwide.
Revenue % From Big Tech	30%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	$18.65 billion
2023 EPS Estimates	$4.95
Forward P/E	17.03
2023 Sales Growth Estimates	-12.5%
The Great Semi Shift Rating	**7.5**

GlobalFoundries Inc. (NASDAQ: GFS)

Background

GlobalFoundries, often abbreviated as GF, was spun off from AMD in 2009 and is one of the larger dedicated foundries in the world. Headquartered in Santa Clara, California, the company focuses on specialized process technologies, including radio-frequency (RF), analog/mixed-signal, and other differentiated technologies. Unlike TSMC, GlobalFoundries strategically pivoted away from the 7nm and smaller nodes in 2018 to concentrate on specialized and legacy semiconductor markets. GlobalFoundries' current process nodes range from 12nm to 0.6mm (600nm equivalent).

The company has four manufacturing sites in the following locations: Dresden, Germany; Singapore; Malta, New York; and Burlington, Vermont. In 2022, these four fabs shipped approximately 2.5 million 300mm equivalent semiconductor wafers. GlobalFoundries is also building a new 300mm fab in Crolles, France, which is targeted to ramp at full capacity by 2026. This new fab will produce up to 620,000 300mm wafers per year at full build-out.

Business Model

GlobalFoundries has moved away from a general-purpose foundry and today is focused on niche semiconductor markets that it feels it serves with less-advanced process nodes. These

chips are found in smartphones, laptops, automobiles, VR systems, video game consoles, and smart speakers, as well as in artificial intelligence and 5G applications.

The company claims to have important intellectual property (IP) that makes it the only company that can produce certain specialized semiconductors such as those for communications and military applications. In 2022, GlobalFoundries reported that approximately 65% of wafer shipment volume was attributable to what it calls "single-sourced business," which includes products that it believes could not be manufactured elsewhere without significant customer redesigns.

With no foundries in China or Taiwan, the company also asserts its geographic base in the US, Europe, and Singapore as a competitive edge. Given the rising political tensions concerning Taiwan, a lot of fabless companies are trying to move production of their chips away from the country to ensure stable supply chains. GlobalFoundries also claims to be one of the most advanced accredited foundry providers to the US Department of Defense.

GlobalFoundries has a fairly concentrated customer base, with its top two customers accounting for 25% of its revenue in 2022. Its primary end markets are smartphones, IoT, automotive, communications infrastructure, data centers, and personal computing.

Our Outlook

We have a neutral to bearish view of GlobalFoundries for the Great Semi Shift. GlobalFoundries' specialty and niche products will likely continue to grow steadily, but we do not think it is positioned to participate in the major growth we

expect to see in AI, data centers, and other high-performance end markets due to the company's lack of advanced process nodes. We also doubt that GF truly is the "sole-source" for the manufacturing of its products as it claims, as we fully expect that anything GF could make, TSMC, Intel, and Samsung could probably make better. The company is also heavily concentrated in the smartphone business, one that we think has likely reached full penetration and will be cyclical from here on out. That said, GlobalFoundries could be a beneficiary of any escalation of US/China tensions as more fabless companies try to move their supply chain away from Taiwan, and the company's automotive segment is growing rapidly.

Furthermore, GlobalFoundries is not investing much to improve its manufacturing capabilities when compared to TSMC and Intel. While GlobalFoundries is building a new fab in France, it recently sold its interest in its second US fab to ON Semiconductor. The fact that GlobalFoundries is divesting production facilities in the US is not what we would like to see in a company that we think has the potential to be a prime beneficiary of the Great Semi Shift. Trading at 27x 2023 earnings estimates, this valuation looks a little rich for a stock that we do not expect to grow much over the next 3-5 years.

What Could Go Wrong With The Stock

- GlobalFoundries is highly exposed to the low and mid-tier smartphone market and could see limited growth over the next few years. Smart mobile devices represented approximately 42% of GF's total revenue in the most recent quarter.
- Over 25% of GlobalFoundries' revenue is concentrated in its top two customers, likely Qualcomm, AMD, or

NXPI. A loss of one of these customers to a rival foundry would significantly harm GF's revenue.

- GlobalFoundries' gross margins (29%) fall below those of TSMC (nearly 60%) and are below the foundry average gross margin of 35%. Any kind of pricing pressure resulting from overstocked inventory would further drive down this relatively low gross margin.

Company	**GlobalFoundries Inc.**
Stock Symbol	**NASDAQ: GFS**
Semiconductor Category	Foundry
Stock Price	$57.64 (as of 10/02/23)
Market Capitalization	$31.87 billion
Headcount	14,000
Key End Markets and Products	Radio-frequency (RF) and analog/mixed signal
Major Competitors	STM, ON, MPWR, MCHP, UMC, NXPI
Total Revenue (ttm)	$7.86 billion
Gross Margin	28.99%
Revenue Breakdown	Smart mobile devices: 42% IoT: 19% Automotive: 13% Communications and Data Center: 12% Personal Computing: 3% Non-wafer: 11%
Notable Customers	AMD, Cirrus Logic,

	Infineon, Marvell, MediaTek, NXP, Qorvo, Qualcomm, Samsung, and Skyworks.
Revenue % From Big Tech	10%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	$579 million
2023 EPS Estimates	$2.08
Forward P/E	27.71
2023 Sales Growth Estimates	-8.50%
2024 Sales Growth Estimates	11.00%
The Great Semi Shift Rating	**5**

Semiconductor Manufacturing International Corporation (HKD: 0981)

Background

Semiconductor Manufacturing International Corporation (SMIC) is China's largest semiconductor foundry company and fourth largest in the world by revenue. SMIC was founded in April 2000 and is headquartered in Shanghai.

Although initially aimed at meeting domestic demand and reducing China's reliance on imported chips, SMIC has expanded its influence globally and is considered a critical player in the semiconductor supply chain. The company has been embroiled in geopolitical tensions, leading to restrictions from the U.S. government over national security concerns, impacting its ability to procure advanced manufacturing equipment. Nonetheless, SMIC continues to be a focal point in China's plans to achieve semiconductor self-sufficiency and is making investments in advanced manufacturing technologies to compete with other leading foundries.

Business Model

SMIC has three 8-inch wafer fabrication facilities (fabs) and four 12-inch fabs in China and is currently building three more 12-inch fabs. The company's process nodes range from 14nm

(possibly 7nm) to 0.35 micron (350nm equivalent), with capabilities including logic, mixed-signal/RF, CMOS, high voltage, SoC, flash, EEPROM, CIS, power management IC and others. The company's primary end markets include smartphones, smart homes, and consumer electronics. Total wafer production in 2022 was 7.5 million 12-inch equivalents. Sales to SMIC's five largest customers amounted to 29.2% of total revenue in 2022.

Recently, SMIC shocked the West when reports emerged that its latest chip, used in Huawei's newest phone, was manufactured using 7nm technology. This raised concerns in Washington that SMIC likely violated US/European sanctions because experts doubt that it could produce any chips using 7nm technology using homegrown technology.

Our Outlook

SMIC is at the forefront of the Chinese Communist Party's attempt to create a mainland advanced semiconductor industry. However, the US and many European nations are banning the export of advanced chip-making equipment to China, which will likely hamper SMIC's ability to lawfully keep up with other advanced chipmakers like TSMC, Samsung, and Intel. For example, the Dutch government has recently imposed restrictions on ASML—the world's leading chip-making equipment supplier—limiting its ability to ship its second most advanced deep ultraviolet (DUV) lithography equipment to China without a license. ASML has never been permitted to ship its most advanced extreme ultraviolet (EUV) lithography to China. Without easy access to advanced lithography equipment, SMIC will struggle to produce the best chips. However, the Chinese are notorious for violating sanctions

and/or stealing IP from American and European companies, which is likely how they were able to build 7nm chips (if true).

On the other hand, if US/China relations were to improve dramatically resulting in the lifting of export bans, SMIC would probably be a good buy as it is trading at a big discount to where it would be if it had access to advanced semiconductor manufacturing equipment. But with the likelihood of the Chinese relinquishing their claim of Taiwan extremely low, we think the US/China chip war will likely drag on for decades. It would take a momentous shift in the policies of both nations for SMIC to suddenly have legal access to advanced chip-making equipment made in the US and Europe. The stock of this Communist-controlled company is not traded in the US and we would not likely be buyers of the stock at any price even if we could purchase it.

What Could Go Wrong With The Stock

- SMIC/China fails to catch up to the US, Europe, and Taiwan in terms of advanced chip-making capabilities.
- SMIC is based in Communist China and is subject to idiosyncratic risks accordingly, up to and including nationalization of SMIC.
- All of SMIC's non-Chinese customers switch to US and European-based foundries to avoid the risk of dependence on China.

Company	**Semiconductor Manufacturing International Corporation**
Stock Symbol	(HKD: 0981)

Semiconductor Category	Foundry
Stock Price	$19.80 (as of 09/27/23)
Market Capitalization	$29.43 billion
Headcount	21,619
Key End Markets and Products	Smartphones, smart home, and consumer electronics
Major Competitors	UMC, TSMC, GFS, other Chinese Foundry pure plays
Total Revenue (ttm)	$7.27 billion
Gross Margin	38.0%
Revenue Breakdown	Smartphone: 27% Smart home: 14% Consumer electronics: 23% Others: 36%
Notable Customers	Huawei, Qualcomm, Broadcom, and Texas Instruments
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	$9.97 billion
2023 EPS Estimates	$0.90
Forward P/E	22
2023 Sales Growth Estimates	-12.90%

2024 Sales Growth Estimates	18.80%
The Great Semi Shift Rating	**4**

United Microelectronics Corporation (NYSE: UMC)

Background

United Microelectronics Corporation, commonly referred to as UMC, is a Taiwanese semiconductor foundry established in 1980. Headquartered in Hsinchu, Taiwan, the company is one of the pioneers in the foundry industry. While not at the forefront of the most cutting-edge semiconductor technologies, UMC has developed a strong reputation for reliability and has a diversified technology portfolio that serves multiple sectors, such as consumer electronics, automotive, and industrial applications.

UMC operates on a global scale with 12 total fabs, 8 of which are located in Taiwan, 2 in China, and one each in Singapore and Japan. UMC's process nodes range from 5 microns (5000nm equivalent) to 14nm. UMC's total production capacity is just over 10 million 8-inch wafer equivalents. Fabless companies contribute 84.1% of UMC's revenue, while IDMs contribute 15.9% of revenue.

Business Model

UMC does not offer the most advanced process nodes but instead provides a broad range of technologies suitable for less performance-sensitive applications, including both traditional

logic and specialty technologies. UMC's specialty portfolio includes embedded High-Voltage (eHV), embedded NonVolatile-Memory (eNVM), radio frequency silicon on insulator (RF SOI), and BCD chips.These products are used for data processing, connectivity, communications, scanning, and sensing in phones, automobiles, computers, etc.

In 2022, UMC's top ten customers accounted for 52.4% of its operating revenues. The company is expanding its manufacturing capabilities with a new fab in Singapore that is expected to provide a monthly capacity of 30,000 wafers. This new fab will utilize 22/28nm processes.

Despite the very broad range of process nodes available at UMC, the vast majority of UMC's revenue (about 67.5%) comes from sales of wafers made using 28nm to 90nm nodes. UMC's most advanced technology, its 14nm node, only contributed 0.1% of sales in 2022. The remainder of UMC's revenue (32.4%) came from legacy nodes (.11 micron to 0.50 micron).

Our Outlook

UMC trades at a steep discount to rival TSMC because the company is focused on much older process nodes and legacy technologies. Despite producing relatively lower-tech semiconductors, UMC has been able to improve its gross margins from 22.1% to 45.1% over the last three years. UMC accomplished this by raising average selling price (ASPs) by over 21%. Meanwhile, the company also cut operating costs, falling from 13.2% to 9.6% of revenue in the most recent fiscal year. This resulted in the company's operating margin rising from 11.5% in 2020 to 32.4% in 2022. We give the company

good marks for management's operational excellence and a nice improvement in profitability over the last three years.

However, we are not very excited about this stock because the current chip glut has had a significant impact on revenue and profitability, with gross margins dropping back down to about 35% in the most recent quarter. Fab utilization rates went down from 100% last year to only 70% in the most recent quarter. Like with GlobalFoundries, we do not model much secular growth for UMC given its lack of advanced process nodes. Throw in the fact that the company's fabs are mostly in Taiwan and China, and there are plenty of reasons not to own this foundry. But with the stock trading at about 10x 2023 earnings estimates and 23% of the market cap in net cash, the stock is already trading at a significant discount to its peers in the foundry category and may not be a bad buy here.

What Could Go Wrong With The Stock

- UMC is Taiwan-based with significant assets located in China and subject to geopolitical risks accordingly.
- The company's lack of advanced process technology will probably limit its growth for the foreseeable future.
- UMC will likely continue to face increased competition from IDMs and other foundries which are investing heavily in expansion.

Company	**United Microelectronics Corporation**
Stock Symbol	**NYSE: UMC**
Semiconductor Category	Foundry
Stock Price	$7.00 (as of 10/02/23)

Market Capitalization	$17.412 billion
Headcount	20,680
Key End Markets and Products	Communications (smartphones), PCs, servers, IoT, automotive, and industrial
Major Competitors	TSMC, SMIC, GFS, Samsung, INTC, and Toshiba.
Total Revenue (ttm)	$8.92 billion
Gross Margin	45.12%
Revenue Breakdown	Communication: 45.2% Consumer: 26.2% Computer: 14.6% Others: 14%
Notable Customers	Texas Instruments and Intel Mobile, plus leading fabless design companies, such as MediaTek, Realtek, Qualcomm and Novatek.
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	$3,940
2023 EPS Estimates	$0.71
Forward P/E	9.86
2023 Sales Growth Estimates	-23.00%

2024 Sales Growth Estimates	14.3%
The Great Semi Shift Rating	**5**

Tower Semiconductor Ltd. (NASDAQ: TSEM)

Background

Tower Semiconductor Ltd., formerly known as TowerJazz, is an Israel-based global specialty foundry focused on manufacturing analog integrated circuits. Founded in 1993, the company has carved a niche in delivering a broad range of customizable process technologies, including silicon-germanium (SiGe), bipolar complementary metal-oxide-semiconductor (BiCMOS), silicon on insulator (SOI), and CMOS image sensors, among others. These enable high-speed, low-noise and low-power products for consumer, infrastructure, and automotive applications.

Tower Semiconductor owns two manufacturing facilities in Israel, two in the U.S., two in Japan through a joint venture, and is sharing a manufacturing facility in Italy with STMicroelectronics. Tower's process nodes range from 65nm to 0.80 micron (800nm).

Intel agreed to purchase Tower in February 2022 for $5.4 billion, or $53/share, but the agreement was terminated in August of 2023 after Chinese regulators refused to approve the deal.

Business Model

Over the years, Tower Semiconductor has strategically positioned itself as a versatile foundry that serves the consumer electronics, automotive, industrial, and medical sectors. Tower's focus has often been on specialized and differentiated products, rather than competing directly with the advanced-node giants (TSMC, Samsung, Intel, etc.), and the pure-play low-tech foundries like UMC, SMIC, and GFS. The CMOS chips it makes for image sensors are used in cameras, x-rays, machine vision products, and infrared imaging solutions. The MEMS chips it manufactures, on the other hand, are used for speech recognition in microphones for earbuds. These are just a couple of examples of Tower's unique technology portfolio. Competition for many of Tower's products is from small foundries and IDMs in Asia that you have probably never heard of (DongBu, for example). Tower is also an approved foundry for US DoD applications. Other unique product applications include satellite chips, GPS, gyroscopes, precision medical sensors, and AR/VR to name a few.

Our Outlook

Tower Semiconductor stands out as a unique and interesting foundry company. Unlike TSMC, Samsung, and Intel, the company is not investing in advanced process nodes. And unlike UMC, SMIC, and GFS, the company does not focus on producing a wide range of commoditized, low-tech ICs. Instead, Tower has played to its strengths and invested in producing products that other major companies are not producing. We also like Tower's exposure to the Space, AR/VR, and Wearables Revolutions.

This stock has been absolutely crushed this year, especially since the Intel merger fell through, and is also under pressure as the bloody Israel-Hamas War rages on. Tower Semiconductor is currently trading at 11x 2023 earnings estimates and we estimate it will have over $1 billion in net cash once it books the $353 million merger breakup fee from Intel. That gives the stock an EV/Profits ratio of 6.4, which is on the very low end of the universe of semiconductor stocks analyzed herein. TSEM could also be an acquisition target for a company like GlobalFoundries or STMicroelectronics that is not subject to receiving Chinese approval for an acquisition.

What Could Go Wrong With The Stock

- Tower Semiconductor realizes no growth and/or sees a decline in demand for its niche offerings if the end markets for these chips deteriorate further.
- The company is based in Israel and the stock will likely remain under pressure for as long as the current Israel-Hamas war lasts.
- Tower Semiconductor's gross margins are below the sector average for foundries and need to improve for the stock to get traction.

Company	**Tower Semiconductor Ltd.**
Stock Symbol	NASDAQ: TSEM
Semiconductor Category	Foundry
Stock Price	$24.55 (as of 09/29/23)
Market Capitalization	$2.77 billion

Headcount	5,500
Key End Markets and Products	Automotive, consumer, medical, industrial and aerospace and defense
Major Competitors	GF, Vanguard Semiconductor, DongBU, X-Fab, and Hua Hong Semiconductor
Total Revenue (ttm)	$1.68 billion
Gross Margin	27.79%
Revenue Breakdown	RF Infrastructure: 13% Power IC: 16% Imaging: 15% Automotive: 12% Other: 44%
Notable Customers	Intel, Broadcom, Panasonic, Teledyne, Samsung, Skyworks Solutions, Semtech and Vishay – Siliconix.
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	~$1 billion
2023 EPS Estimates	$2.21
Forward P/E	11.11
2023 Sales Growth Estimates	-14.7%

2024 Sales Growth Estimates	6.6%
The Great Semi Shift Rating	**5.5**

Skywater Technology, Inc. (NASDAQ: SKYT)

Background

SkyWater Technology is a small US-based foundry which was formed in 2017 after it was spun out of a subsidiary of Cypress Semiconductor (the German chip giant Infineon acquired Cypress in 2019). SkyWater focuses on a diverse category of products including mixed-signal CMOS, ROICs, rad-hard ICs, power management, MEMS, superconducting ICs, photonics, carbon nanotubes, and interposers. The company's process nodes range from 90nm to 130nm. SkyWater came public in April 2021 at a price of $14/share.

Business Model

SkyWater's end markets include aerospace & defense, automotive, biomedical, cloud computing, consumer, industrial, and IoT. Its fabs are located in Bloomington, Minnesota, and Kissimmee, Florida. The company claims to specialize in co-creating advanced solutions with its customers, meaning it helps them design and package their chips which is not necessarily unique in the foundry business. That said, SkyWater generates a much higher percentage of its revenue from services rather than pure wafer production which is a testament to the value of its design services.

SkyWater has significant exposure to US government spending and aerospace end markets. Its US fab is one of only 16 fabs in the world to receive DMEA Category 1A accreditation from the DoD, which makes it eligible to produce chips for sensitive military applications. This also goes well with the company's space business, which for example just received a $99 million dollar contract extension from the Defense Department to develop radiation-hardened (rad-hard) electronics using its 90nm process node. Rad-hard semiconductors are designed to handle high-radiation and extreme temperature environments like space.

Our Outlook

SkyWater has grown rapidly since spinning out of Cyprus and has continued to grow even during the significant downturn in chip demand that started in the third quarter of last year. Analysts expect SkyWater to continue to grow in the high double-digits for the next two years. The company has nice exposure to some secularly growing end markets like space and quantum computing and has improved its gross margins dramatically over the last year, rising from 4.4% in 2022 to 23.9% in the most recent quarter. The stock is down 58% from its 2021 IPO price and is down 83% from its all-time high set in 2021. SKYT is trading at close to 1x sales and is the only publicly traded 100% US-based foundry, so it may not be a bad buy at these levels.

What Could Go Wrong With The Stock

- SkyWater is very small compared to its competitors and may simply be too small to ever truly become a serious player in the foundry industry.

- This company faces serious competition from much larger and more established foundries and IDMs alike, and we see a difficult path for this company to really scale to become a major player in the semiconductor industry.
- With interest rates on the rise, access to capital is especially difficult for small companies like SkyWater and thus it may find it difficult to get the money to expand its foundries for the next few years or so.
- SkyWater still depends on Infineon (the owner of its former parent Cypress) for a substantial percentage (28%) of its revenue, and generates 24% of its revenue from another undisclosed customer.

Company	**SkyWater Technology, Inc.**
Stock Symbol	**NASDAQ: SKYT**
Semiconductor Category	Foundry
Stock Price	$5.82 (as of 09/27/23)
Market Capitalization	$0.27 billion
Headcount	706
Key End Markets and Products	Aerospace & defense, automotive, biomedical, cloud & computing, consumer, industrial and IoT
Major Competitors	Vanguard International Semiconductor, TSEM, ON, GFS, and XFAB Silicon Foundries.
Total Revenue (ttm)	$0.253 billion

Gross Margin	23%
Revenue Breakdown	Advanced Technology Services: 76% Wafer Services: 24%
Notable Customers	Infineon, D-Wave, L3Harris, and Leonardo DRS.
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	($18.6 million)
2023 EPS Estimates	($0.45)
Forward P/E	NM
2023 Sales Growth Estimates	27.1%
2024 Sales Growth Estimates	18.8%
The Great Semi Shift Rating	**5**

Chapter 8 – Integrated Device Manufacturers (IDMS) And Fab-Lite Companies

Dall-E 3 Prompt: Photo of the interior of a Tesla robotaxi, fully equipped for self-driving. In the backseat, a female lawyer is meticulously reviewing her documents and laptop, preparing for an upcoming meeting. The car's advanced features are evident as it autonomously navigates the road.

In this section of the book, we turn our attention to Integrated Device Manufacturers (IDMs) and Fab-Lite companies. While IDMs design and manufacture their own chips, akin to a vertically integrated model, Fab-Lite entities straddle a middle ground, maintaining some fabrication abilities but increasingly outsourcing to third-party foundries. A cursory glance at the

market reveals Samsung and Intel as the stalwarts in the IDM realm, with both companies wielding extensive manufacturing capabilities. Besides them, memory makers like Micron (MU), Western Digital (WDC), and Seagate Technology (STX) also operate as full-fledged IDMs.

Over the last two decades, many erstwhile IDMs have transitioned to a Fab-Lite model or entirely fabless operations, spurred by the imperative to enhance margins and reduce capital expenditures (capex). This strategic migration reflects a broader industry trend, prompted by the escalating costs and complexities associated with chip manufacturing. As the industry has evolved, the contours defining IDMs have also blurred; today's IDMs are a heterogeneous set, dabbling in various sub-sectors from logic and analog/mixed-signal chips to memory ICs.

Financially, the Fab-Lite companies are generally more profitable, with an average gross margin of about 57% compared to about 37% for that of the IDMs ex-memory. The memory companies are still working through a glut of inventory, and their gross margins of just about 8% for the last twelve months reflect the commoditized nature of the industry. This disparity in margins is an economic manifestation of the differing business models and risk profiles among these three groups.

The companies analyzed in this section, therefore, offer a spectrum of investment opportunities, each impacted differently by market dynamics, technological advancements, and the Great Semiconductor Shift. Their strategic choices around manufacturing, specialization, and partnerships not only shape their individual destinies but also collectively influence the broader semiconductor ecosystem. In the subsequent

chapters, we will dissect these twenty IDMs and Fab-Lite companies, providing you with a granular understanding of their business models, strategies, and growth prospects in the context of the ongoing seismic shifts in the semiconductor industry.

IDM/Fab-Lite Comparison Table							
Ticker	**Market Cap (bb)**	**TTM Revenue (bb)**	**Gross Margin**	**Fwd. P/E**	**2023/24 Growth Est.**	**2024/25 Growth Est.**	**GSS Rating**
Samsung	$335.00	$200.53	31.96%	51.4	-13.20%	14.10%	6.5
INTC	$149.81	$54.00	38.27%	57.7	-16.80%	11.80%	8.5
TXN	$143.78	$18.82	68.76%	21.5	-10.10%	7.20%	6.5
ADI	$84.85	$12.84	65.23%	16.9	2.40%	-9.90%	5.5
MU	$75.65	$15.54	-9.11%	NM	34.10%	45.60%	4
NXPI	$50.50	$13.81	56.99%	14.2	0.40%	5.10%	5.5
IFNNY	$45.30	$17.30	45.70%	12.5	10.90%	5.90%	5
MCHP	$42.10	$8.44	67.85%	12.7	3.30%	0.50%	5
STM	$39.28	$16.13	47.34%	10.2	7.60%	4.10%	7
ON	$37.54	$8.35	47.78%	16.7	0.70%	6.80%	6
SWKS	$15.65	$4.96	46.32%	11.7	-13.00%	4.80%	3.5
WDC	$14.95	$12.32	15.30%	NM	-1.80%	33.90%	3
STX	$13.80	$7.38	18.30%	100.6	-9.20%	26.10%	2
QRVO	$9.30	$3.19	36.14%	18.9	0.90%	14.00%	3.5
MTSI	$5.90	$0.68	60.00%	30.6	-4.00%	3.40%	5
WOLF	$4.15	$0.92	30.26%	NM	5.20%	50.00%	4.5

DIOD	$3.70	$2.00	42.00%	14.5	-11.30%	2.30%	5.5
VSH	$3.40	$3.54	30.31%	9.3	-0.40%	0.90%	5
SGH	$1.20	$1.80	25.00%	9.2	-9.10%	3.70%	2
AOSL	$0.81	$0.80	32.60%	24.8	2.00%	8.80%	3.5

Samsung Electronics Co., Ltd. (KSE: 005930)

Background

Samsung Electronics is a part of the greater South Korean Samsung conglomerate, known as a "chaebol" in Korean. While the company sells everything from phones to TVs, its semiconductor division includes a dedicated foundry that focuses on producing DRAM, NAND flash memory, and logic processors for both in-house use and third parties.

Samsung serves a wide array of industries, including computing, telecommunications, automotive, and IoT. Beginning in May 2017, the company expanded its foundry services, aiming to cater to fabless semiconductor designers, thereby becoming a critical part of the global semiconductor supply chain. Samsung controls a commanding share of the global DRAM market with 43% market share.

Business Model

Samsung and Intel are the only companies in the world that can rival TSMC for advanced chipmaking capabilities. Samsung's process nodes range from 180nm to 3nm, and the company is the only chipmaker to offer 3nm transistors made using "gate-all-around," (GAA) technology currently. GAA transistor technology is an advanced semiconductor design where the gate

material surrounds the channel region from all sides, enabling more precise control of the current flow. This architecture reduces leakage, enhances performance, and improves energy efficiency compared to the traditional FinFET transistors. Intel and TSMC both plan to offer products made with GAA but those chips will not hit the market until 2024 and 2025, respectively.

In 2022, Samsung's major foundry customers included Apple and Qualcomm (primarily for its memory chips), and the largest buyers of Samsung's devices (including its Android-based handsets) were Best Buy, Deutsche Telekom, and Verizon. Collectively these customers accounted for approximately 16% of Samsung's total sales. The company continues to focus on building the most advanced semiconductor manufacturing processes and is already in the development of second-generation 3nm products. Samsung also began mass production of second- and third-generation 4nm products in the first half of 2023. The company's fabs are located in South Korea and the United States (Austin, TX), and it has two new fabs under construction, one in Pyeongtaek, South Korea and the other in Taylor, Texas.

Our Outlook

With demonstrated leadership in advanced process technology, a focus on vertical integration, and a massive distribution network that spans the globe, there is a lot to like about Samsung. We expect the three-way race for the most advanced semiconductors between Samsung, Intel, and TSMC to continue for the foreseeable future. However, because Samsung is such a massive and diversified conglomerate and trades only in South Korea, it is not at the top of our list of stocks we want to own.

What Could Go Wrong With The Stock

- Samsung has a lot of exposure to cyclical end markets with its consumer electronics business and we expect it will likely grow and/or decline more or less in tandem with the world economy.
- With Intel's 20A technology coming online in 2024, both it and TSMC will be ahead of Samsung in terms of process nodes.
- Samsung's memory business continues to struggle as the entire memory industry is commoditized and is facing a prolonged supply glut that is projected to continue well into 2024.
- The company is based in South Korea and could face geopolitical headwinds given the actions of its raucous neighbor to the north.

Company	**Samsung Electronics Co Ltd.**
Stock Symbol	**KRE: 005930.KS**
Semiconductor Category	IDM
Stock Price	68,400 KRW (as of 09/27/23)
Market Capitalization	$335 billion
Headcount	270,000
Key End Markets and Products	Consumer electronics, smartphones,
Major Competitors	TSMC, Intel, Micron, UMC, Apple, WDC, STX

Total Revenue (ttm)	$200.53 billion
Gross Margin	31.96%
Revenue Breakdown	Consumer Hardware: 67% Memory, Logic, and Foundry: 25% Display Panels: 11% Automotive: 7%
Notable Customers	Apple, Best Buy, Deutsche Telekom, Qualcomm, and Verizon
Revenue % From Big Tech	5%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	$55 billion
2023 EPS Estimates	$1,330.59
Forward P/E	51.4
2023 Sales Growth Estimates	-13.2%
2024 Sales Growth Estimates	14.1%
The Great Semi Shift Rating	**6.5**

Intel Corporation (NASDAQ: INTC)

Background

Founded in 1968 by Gordon Moore and Robert Noyce, Intel is often credited with laying the groundwork for the personal computer revolution through its x86 series of microprocessors, which have been a mainstay in PCs since their inception. Its current CEO, Pat Gelsinger, helped design the company's x86 architecture, which is a family of instruction sets used in almost all CPUs since its creation in the 1980s. Today, the company has a diversified product portfolio that includes products for data centers, IoT devices, cloud computing, artificial intelligence, and autonomous driving technologies.

After decades of process technology leadership, Intel faced challenges in recent years, particularly with delays in its 10nm and 7nm process nodes, giving competitors' products manufactured by TSMC and Samsung an opportunity to surpass Intel in some key market segments (i.e. data centers). Additionally, there has been major softness in the PC market following the pandemic, as a lot of demand was pulled forward when businesses and workers bought new PCs to enable work from home.

Intel has a very diversified product mix which falls into six operating segments: Client Computing Group (CCG), Datacenter and AI Group (DCAI), Network and Edge Group

(NEX), Accelerated Computing Systems and Graphics Group (AXG), Intel Foundry Services (IFS), and Mobileye (MBLY). Intel has five fabs in the US and Europe and four assembly and test facilities.

Business Model

In March 2021, long-time Intel executive Pat Gelsinger returned to the company as CEO and laid out a new vision for the company moving forward. His strategy, coined "IDM [integrated device manufacturer] 2.0," marks a major change in Intel's historical business model. As part of the strategy, Gelsinger made clear that Intel would continue to focus on manufacturing leadership and, for the first time, open up its fabs to manufacture chips for third parties. Additionally, Gelsinger promised to return Intel to process-technology leadership and claimed that the company would clear "five nodes in four years," moving from 10nm in 2021 to 18A (18 angstrom or 1.8nm) by 2025.

As part of its IDM 2.0 strategy, Intel has made major investments in its fab capacity. Since laying out this new operating framework, the company has announced over $116 billion in investments for new and upgraded facilities as follows:

- $30 billion for new fabs in Arizona
- $20 billion for new fabs in Ohio
- $33 billion for new fabs in Germany
- $25 billion for new fabs in Israel (announced by Israeli government, not confirmed by Intel yet)
- $4.6 billion for a new assembly and test facility in Poland

- $3.5 billion to equip its New Mexico operations for the manufacturing of advanced semiconductor packaging technologies

Critically, Intel's foundry division will produce chips that run on ARM architecture. Historically, Intel has only produced chips for itself using its x86 architecture, but almost all chips other than Intel and AMD CPUs run on ARM because it is much more power efficient. Obviously, Intel had to make ARM-based chips if there was to be any hope at all for its foundry services.

In addition to expanding its physical infrastructure, Intel continues to make major strides in chip design and packaging. The company introduced a new transistor design in 2021, known as "RibbonFET" that utilizes a gate-all-around architecture which is much more powerful and efficient than current transistor designs. Intel also introduced "Tiles" as it raced to catch up to AMD's powerful "chiplet" design, which made individual chips (known as dies) much smaller, more efficient, and cheaper to manufacture. Further, Intel unveiled a radical new wafer design called Powervia that will move the power supply for the chip to the bottom side of the wafer, making it faster and more efficient.

Our Outlook

Despite a very challenging environment for Intel's core CPU business, the company is executing on its strategic growth plans laid out in 2021. With respect to the five-nodes-in-four-years plan, the first node, Intel 7 (7nm) was in full-scale production for most of the second half of 2022. Intel 4 (4nm) began high-volume production in September of 2023 at Intel's Ireland fab. This was the first use of EUV technology in Europe. Lastly, Intel 3, 20A, and, 18A are on track and all have products "taped

out," meaning the chips have reached the final point in the design process before being sent to manufacturing. Additionally, Intel's gate-all-around (GAA) technology, dubbed "RibbonFet," will be incorporated in the 20A and 18A nodes, placing Intel even further ahead of TSMC, which does not expect to manufacture chips with GAA until 2025 or 2026. Powervia will be used in chips beginning in the first half of 2024. TSMC does not expect to have chips with backside power in production until 2026.

That said, Intel still faces a challenging competitive environment. Most recently, Reuters reported that NVIDIA is working on an ARM-based CPU that would run Microsoft's Windows operating system. ARM's architecture is much more power efficient than x86 architecture, and for that reason, Microsoft in 2016 tapped Qualcomm to develop an ARM-based processor that would support Windows PCs. However, while the possibility of competition is significant, we think that it will take quite some time before Qualcomm, NVIDIA, or any other company besides AMD can seriously compete with Intel in the PC CPU market. At best, competitor chips won't hit the market until 2025, and it will take more time for those chips to be integrated into hardware if agreed to do so by the OEMs like Dell, Lenovo, HP, etc. It will take longer still for software developers to build applications to run on ARM-based PCs.

We are optimistic about Intel's prospects from here. With the ongoing advances in process technology and the massive investments in fab capacity, the company is extremely well positioned to benefit from the Great Semi Shift. We expect high demand for Intel's foundry service because it will have the only advanced process nodes located in the US and Europe for the next 2-3 years. In addition to building its own chips, Intel foundries will also produce ARM- and RISC-V-based chips for

fabless companies like Amazon, Google, Tesla, Qualcomm, MediaTek, etc. The existence of a non-Asian advanced chip manufacturer will be a game-changer for the entire Western world by significantly reducing a major risk to the chip supply chain. Further, Intel's constant rollout of exciting new technology, from RibbonFet to Tiles to Powervia should propel the company to higher market share across its various business lines. We are long Intel.

What Could Go Wrong With The Stock

- Intel CEO Pat Gelsinger's vision for IDM 2.0 fails to pan out.
- The foundry business never gets off the ground and the company's announced investments of nearly $120 billion in new and upgraded fabs (about 80% of the company's current market cap) bankrupt the company.
- Intel fails to regain leadership in process technology.
- AMD begins retaking market share in the CPU business.

Company	**Intel Corporation**
Stock Symbol	**NASDAQ: INTC**
Semiconductor Category	IDM
Stock Price	$35.76 (as of 10/04/23)
Market Capitalization	$149.81 billion
Headcount	131,900
Key End Markets and Products	Personal computing, data center, tablets, gaming, edge computing, automotive

Major Competitors	TSMC, Samsung, AMD, NVIDIA, QCOM, MRVL, MU
Total Revenue (ttm)	$54 billion
Gross Margin	38.27%
Revenue Breakdown	Client Computing Group: 52.7% Data Center and AI: 31.0% Network and Edge: 10.9% Mobileye: 3.5% Intel Foundry Services: 1.8%
Notable Customers	Dell, Lenovo, HP, Google, and Meta
Revenue % From Big Tech	25%
Revenue % Subject To The GSS	10%
Net Cash (Debt)	($22.1 billion)
2023 EPS Estimates	$0.62
Forward P/E	57.7
2023 Sales Growth Estimates	-16.8%
2024 Sales Growth Estimates	11.8%
The Great Semi Shift Rating	**8.5**

Texas Instruments Inc. (NASDAQ: TXN)

Background

Texas Instruments, often abbreviated as TI, is a multinational semiconductor company headquartered in Dallas, Texas. Founded in 1930 as a geophysical services firm, it later delved into defense electronics during the Second World War. By the mid-20th century, TI ventured into the semiconductor business and made pioneering contributions, including the invention of the integrated circuit in 1958 by Jack Kilby. This breakthrough paved the way for modern electronic devices.

Today, TI is the leading manufacturer of analog semiconductors, which are fundamental components in a vast array of consumer electronic devices, industrial equipment, and automotive applications. TI explains that analog semiconductors "*change real-world signals, such as sound, temperature, pressure or images, by conditioning them, amplifying them and often converting them to a stream of digital data that can be processed by other semiconductors, such as embedded processors. Analog semiconductors are also used to manage power in all electronic equipment by converting, distributing, storing, discharging, isolating and measuring electrical energy, whether the equipment is plugged into a wall or using a battery.*"

TI is also a leading manufacturer of embedded products, which are essentially the digital “brains” of many types of electronic equipment. These low-cost microcontrollers are used in everything from electric toothbrushes to motor controllers. In 2022, sales of embedded processing products generated about 16% of TI’s revenue.

Business Model

TI sells into six end markets: industrial, automotive, personal electronics, communications equipment, enterprise systems, and others. The company expects the most growth in its industrial and automotive markets due primarily to the reshoring of the supply chain and the electrification of vehicles. In 2022, ICinsights.com estimated that TI controlled roughly 20% of the global market for analog semiconductors.

The company’s manufacturing process nodes are targeted towards 45nm to 130nm technologies, which are optimized for analog and embedded processing products. TI has three existing 300mm fabs (two in Texas and one in Utah) and one under construction in Sherman, Texas. TI has one of the largest portfolios of any IDM consisting of roughly 80,000 unique products, which include everything from smart thermostats and door locks to sensors for robots and autonomous vehicles. In 2022, the company reported having over 100,000 customers, the largest of which included companies like Cisco, Apple, Dell, HP, IBM, Lexmark, and Motorola. However, none of these end customers constituted more than 10% of TI’s revenue last year.

Our Outlook

TI is well positioned to see above-average growth for the foreseeable future as the "electrification of everything" trend continues to gain steam. TI should also benefit from the Reshoring and EV Revolutions. The company has a well-diversified portfolio of products that it sells to wide-ranging end markets. This probably insulates TI from a downturn in any given market but also limits its upside.

Given TI's clear leadership in the analog semiconductor space, we like the company but the stock is a little expensive for our taste. Trading at 21.5x 2023 earnings estimates and with single-digit growth on the horizon, there are more attractive semiconductor stocks with exposure to these same Revolutions.

What Could Go Wrong With The Stock

- A downturn in the economy hurts TI which is more subject to cyclical pressures than many other semiconductors companies.
- Competition for analog semiconductors heats up and hurts TI's relatively high gross margins.
- Higher interest rates slow down the Reshoring Revolution as manufacturers pull back on their US expansion plans in the near term.
- Valuation contraction.

Company	**Texas Instruments Incorporated**
Stock Symbol	**NASDAQ: TXN**
Semiconductor Category	Fab-Lite

Stock Price	$158.40 (as of 10/04/23)
Market Capitalization	$143.78 billion
Headcount	33,000
Key End Markets and Products	Automation, medical, aerospace, appliances, motor drives, lighting, infotainment centers, ADAS, TVs, gaming, data storage, PCs, networking infrastructure
Major Competitors	ADI, Skyworks, NXP, Microchip, STM, onsemi, Infineon
Total Revenue (ttm)	$18.82 billion
Gross Margin	68.76%
Revenue Breakdown	Industrial: 40% Automotive: 25% Personal electronics: 20% Communications equipment: 7% Enterprise systems: 6% Other: 2%
Notable Customers	Cisco, Apple, Dell, HP, IBM, Lexmark, and Motorola
Revenue % From Big Tech	10%
Revenue % Subject To The GSS	5%
Net Cash (Debt)	($1.4 billion)

2023 EPS Estimates	$7.35
Forward P/E	21.5
2023 Sales Growth Estimates	-10.1%
2024 Sales Growth Estimates	7.2%
The Great Semi Shift Rating	**6.5**

Analog Devices, Inc. (NASDAQ: ADI)

AHEAD OF WHAT'S POSSIBLE™

Background

Established in 1965 and headquartered in Wilmington, Massachusetts, Analog Devices specializes in signal processing technology. Over the years, ADI has been instrumental in developing a wide range of innovations in analog, mixed-signal, and digital signal processing (DSP) integrated circuits. The company's products play crucial roles in converting real-world phenomena into digital data, finding applications in various sectors such as communications, healthcare, automotive, and industrial systems.

Business Model

ADI is very similar to Texas Instruments (TI) and is one of its primary competitors. Like TI, ADI has a massive portfolio of analog products, with more than 75,000 SKUs (Stock Keeping Units). These products power everything from industrial robots to hearing aids. While ADI has its own fabs in Massachusetts, Washington, Oregon, and Ireland, the company still relies heavily on third-party fabs to make its products. In 2022, over half of ADI's chips were made by foundries like TSMC. With approximately 13% market share, ADI is the second largest analog device manufacturer after TI.

Our Outlook

Analog Devices is probably a mid- to single-digit grower for the next decade or so. Similar to TI, ADI is subject to cyclical pressures in the economy and does not have much in the way of secular growth drivers. If we had to choose between the two, we would probably choose TI due to its commanding market share, better gross margins, and slightly higher revenue growth. However, both companies are very similar and will likely follow similar trajectories going forward.

What Could Go Wrong With The Stock

- Analog Devices likely struggles if the world economy enters a recession.
- Higher interest rates put a damper on industrial spending and temporarily pause the US Reshoring Revolution.
- Innovative technologies are brought to market that disrupt the traditional analog business, reducing the outsized gross margins currently earned by both TI and ADI.

Company	**Analog Devices, Inc.**
Stock Symbol	**NASDAQ: ADI**
Semiconductor Category	Fab-Lite
Stock Price	$170.45 (as of 10/05/23)
Market Capitalization	$84.85 billion
Headcount	25,000
Key End Markets and	Aerospace & defense,

Products	consumer, healthcare, automotive, data center, industrial, communications, and energy
Major Competitors	TI, Skyworks, NXP, Microchip, STM, onsemi, Infineon
Total Revenue (ttm)	$12.84 billion
Gross Margin	65.23%
Revenue Breakdown	Industrial: 51% Automotive: 21% Communications: 16% Consumer: 13%
Notable Customers	Not disclosed
Revenue % From Big Tech	10%
Revenue % Subject To The GSS	5%
Net Cash (Debt)	($5.29 billion)
2023 EPS Estimates	$10.09
Forward P/E	16.9
2023 Sales Growth Estimates	2.4%
2024 Sales Growth Estimates	-9.9%
The Great Semi Shift Rating	**5.5**

Micron Technology, Inc. (NASDAQ: MU)

Background

Founded in 1978 and headquartered in Boise, Idaho, Micron Technology is a global producer of computer memory and computer data storage solutions. The company specializes in DRAM (Dynamic Random Access Memory), NAND (NOT AND) flash, and NOR (NOT OR) flash memory. NAND flash memory is designed for high-capacity data storage and is commonly used in devices like SSDs, while NOR flash memory offers faster read speeds and is typically used for firmware storage and direct code execution.

In case you are not familiar with how different types of memory chips work, DRAM provides quick access memory that computers use for immediate tasks, but it forgets everything once powered off. NAND Flash is the long-term memory storage found in devices like smartphones and SSDs (solid state drives) like those USB flash drives you are familiar with. SSDs retain information even when the device is turned off. NOR Flash offers dependable storage often used for critical device instructions, ensuring devices boot up or operate correctly.

Business Model

Micron operates in a highly commoditized market. The memory market is commoditized because the specifications for memory chips are standardized across the industry, and there is very little differentiation in the quality of the products between manufacturers. Thus, companies like Micron and Samsung focus on volume-driven cost efficiency, and are subject to cyclical demand patterns. As of Q3 2022, it was estimated that Micron controlled about 27% of the DRAM market, in third place after Samsung and SK Hynix.

The company's eleven fabs are located in Idaho, Virginia, Japan, Malaysia, Singapore, Taiwan, and China. Micron is focused on bringing more capacity back to the US and in 2022, the company announced its intent to invest $100 billion over the next 20 years in a megafab in upstate New York. The company is also building a new $15 billion fab near its headquarters in Idaho.

Our Outlook

Micron’s business is subject to the booms and busts of the memory sector, with gross margins varying between 45% and -33% over the last two years. While the company has a decent share of the DRAM market, it faces a lot of competition and has to fight to keep costs down in order to remain competitive. Because the memory business is basically a game of scale and cost, we think Micron and the other American memory makers might struggle to compete in the long run with low-cost producers based in Asia. For example, Micron counts several state-owned Chinese companies as competitors. Micron currently has significant manufacturing facilities in Asia, but it is trying to re-domesticate its supply chain and we are afraid

that Micron's US and European fabs may not be cost-competitive in the long run. China is historically great at manufacturing commodities, and we feel it could take a big chunk of the memory market given the CCP's focus on bringing more chip-making to the mainland.

Additionally, Micron's stock is trading at a big premium to its peers in the memory business and to its historical mean. The memory sector is currently in the depths of a supply glut that is expected to last well into 2024. Yet, Micron's stock is barely off its all-time highs. We are short Micron.

What Could Go Wrong With The Stock

- The oversupply of memory chips lasts longer than Micron's management currently expects.
- Micron's attempt to re-domesticate its supply chain may backfire as its US-produced products may not be competitive in a commoditized market dominated by Asian producers.
- Unlike advanced semiconductors that are critical to national interests, memory chips are widely available and there is no special reason that they need to be manufactured in the US.

Company	**Micron Technology, Inc.**
Stock Symbol	**NASDAQ: MU**
Semiconductor Category	IDM (memory)
Stock Price	$69.02 (as of 10/05/23)
Market Capitalization	$75.65 billion

Headcount	48,000
Key End Markets and Products	PCs, cloud, networking, smartphones, industrial, automotive, and consumer
Major Competitors	Intel, Kioxia, Samsung, SK hynix, WDC, Chinese state-owned entities
Total Revenue (ttm)	$15.54 billion
Gross Margin	-9.11%
Revenue Breakdown	Compute and Networking: 30% Mobile: 30% Embedded: 21.5% Storage: 18.5%
Notable Customers	Apple, Dell, IBM, Lenovo, Microsoft, Samsung, HP, Intel, Kingston
Revenue % From Big Tech	15%
Revenue % Subject To The GSS	10%
Net Cash (Debt)	($4.01 billion)
2024 EPS Estimates	-$1.58
Forward P/E	NM
2024 Sales Growth Estimates	34.1%
2025 Sales Growth Estimates	45.6%

The Great Semi Shift Rating	4

NXP Semiconductors N.V. (NASDAQ: NXPI)

Background

NXP Semiconductors was formed in 2006 after being spun out of Philips' semiconductor division and is headquartered in Eindhoven, Netherlands. NXP specializes in high-performance mixed-signal electronics and is recognized for its solutions in automotive, industrial & IoT, mobile, and communication infrastructure sectors.

Business Model

NXP has shifted to a “fab lite” model, which means they utilize third-party foundries for a significant portion of their wafer production. The company’s fabs are focused on specialty process technology ranging from 90nm to 4 microns (4000nm equivalent) nodes. The company has six fabs, one in Singapore (joint venture with TSMC), one in the Netherlands, and four in the US. In August 2023, NXP announced a joint venture with TSMC, Bosch, and Infineon to build a €10 billion 300mm fab in Dresden, Germany utilizing TSMC’s 28/22nm and 16/12nm nodes. NXP will own a 10% interest in the new Dresden fab.

NXP’s end markets include automotive, industrial, IoT, mobile, and communication infrastructure. Among the company’s key growth drivers are radar systems and electrification systems for

vehicles, smart home and industrial automation systems, and mobile access solutions. NXP also has a strong focus on gallium nitride (GaN) chips, which offer better power efficiency compared to traditional silicon-based semiconductors.

Our Outlook

NXP has a lot of exposure to the auto and industrial markets and has long been a major supplier to the traditional automakers. NXP sold chips to the auto companies before the rise of electrification and autonomy and still does a lot of business with companies like Ford, GM, and Stellantis, who we fear will struggle to make the transition to EV. Additionally, we do not think the company's "fab-lite" business model is ideal for the Great Semiconductor Shift. We see more value shifting towards the pure foundry model or the *fully integrated* device manufacturers like Intel and Samsung. That said, the company has a good manufacturing base in the US and could benefit as demand shifts away from Asian-based foundries.

What Could Go Wrong With The Stock

- Traditional automakers struggle with their electrification efforts and this results in little growth materializing for NXP in that end market.
- NXP's "fab-lite" model could turn out to be the worst of both worlds, meaning it does not have the capacity to build advanced chips and its customers decide to move silicon design in-house.
- Without advanced process nodes, NXP could fall behind its competition in the key automotive, industrial, and smartphone end markets.

Company	**NXP Semiconductors N.V.**
Stock Symbol	**NASDAQ: NXPI**
Semiconductor Category	Fab-lite
Stock Price	$196.05 (as of 10/05/23)
Market Capitalization	$50.5 billion
Headcount	34,500
Key End Markets and Products	Auto (ADAS, eCockpit, Powertrain), Industrial & IoT (smart home, edge nodes, automation), Mobile (smartphones and wearables), and Communications (wireless base stations, networking, and RFID).
Major Competitors	ADI, Infineon, Intel, Marvell, Mediatek, MCHP, NVIDIA, QCOM, Renesas, STM, and TI
Total Revenue (ttm)	$13.81 billion
Gross Margin	56.99%
Revenue Breakdown	Automotive: 52.1% Industrial & IoT: 20.5% Mobile: 12.2% Communication Infrastructure & Other: 15.2%
Notable Customers	Apple, Aptiv, Bosch, Continental, Denso, Harman

	Auto, LGE, Samsung, Visteon, and Vitesco
Revenue % From Big Tech	12%
Revenue % Subject To The GSS	5%
Net Cash (Debt)	($7.3 billion)
2023 EPS Estimates	$13.84
Forward P/E	14.2
2023 Sales Growth Estimates	0.4%
2024 Sales Growth Estimates	5.1%
The Great Semi Shift Rating	**5.5**

Infineon Technologies AG (OTC: IFFNY)

Background

Infineon Technologies AG is a Germany-based semiconductor manufacturer with a diverse product portfolio that spans various sectors, from automotive to security solutions. Established as a spin-off from Siemens AG in the late 1990s, Infineon has carved its niche in power semiconductors and chip solutions for smart card and security applications.

Business Model

In 2022, Infineon ranked 12th in the global semiconductor market share and first in Europe. The company's offerings encompass microcontrollers, RF power transistors, and sensor ICs, among others. Given its significant role in the automotive electronics domain, Infineon's components find their way into an array of vehicle systems, from safety and powertrain systems to in-car entertainment. Additionally, the company's solutions cater to industrial power control, power management, and multimarket sectors. With its commitment to innovation, Infineon plays an integral role in shaping energy-efficient, secure, and high-performance electronic solutions.

Our Outlook

Infineon's core business centers on power semiconductors, and the company reportedly commands the largest share of the automotive and industrial power markets. The company grew revenue by 24% in 2022 on the backs of vehicle electrification and reshoring. Infineon is targeting long-term revenue growth of 10% and is placing a heavy focus on the development of SiC and GaN semiconductors.

Infineon has 20 front-end and back-end manufacturing sites around the world. Its four operating fabs are located in Germany, Malaysia, and Austin, Texas. The company is currently working on a new factory to support SiC (Silicon Carbide) and GaN (Gallium Nitride) products in Malaysia with production expected to begin in Q3 '24. Infineon is also building an additional 300-mm in Dresden. Based on our research, Infineon's most advanced process node is 28nm.

In our view, Infineon is well positioned to continue to see steady growth as megatrends like vehicle electrification and industrial automation continue to gain steam. The company is a leader in many of its respective end markets and has done a good job of staving off competition from dozens of smaller competitors. We also think Infineon has the potential to take a lot of the GaN and SiC markets once its new fab is online as the company has a rich history of producing high-quality power semiconductors for the auto and industrial markets. The stock is listed in Germany and does not have an ADR as it only trades in the US in the OTC markets, otherwise, this would be a stock we would seriously consider owning.

What Could Go Wrong With The Stock

- Infineon falls behind up-and-comers in the power semiconductor market like onsemi, MPWR, and Wolfspeed.
- Infineon's lack of advanced process nodes places it further behind the competition.
- The company is based in Europe and there are certain geopolitical risks with the ongoing Russia-Ukraine War.
- Infineon's over-dependence on the auto market hurts the company in the long run as traditional automakers fail to make the transition to electric.
- Infineon's over-diversified portfolio of products limits its long-term growth potential.

Company	**Infineon Technologies AG**
Stock Symbol	**OTC: IFNNY**
Semiconductor Category	IDM
Stock Price	$34.79 (as of 10/10/2023)
Market Capitalization	$45.3 billion
Headcount	56,194
Key End Markets and Products	Automotive, industrial, renewable energy, data centers and IoT
Major Competitors	ADI, NXP, Intel, onsemi, MPWR, and Wolfspeed.
Total Revenue (ttm)	$17.3 billion

Gross Margin	45.7%
Revenue Breakdown	Automotive: 45% Industrial Power Control: 13% Power & Sensor Systems: 29% Connected Secure Systems: 13%
Notable Customers	Bosch, Cisco, Dell, HP, IBM, Motorola, and Siemens.
Revenue % From Big Tech	10%
Revenue % Subject To The In-House Silicon Revolution	10%
Net Cash (Debt)	($1.7 billion)
2023 EPS Estimates	$2.79
Forward P/E	12.5
2023 Sales Growth Estimates	10.9%
2024 Sales Growth Estimates	5.9%
The Great Semi Shift Rating	**5**

Microchip Technology Incorporated (NASDAQ: MCHP)

Background

Established in 1987 and headquartered in Chandler, Arizona, Microchip Technology is a prominent provider of microcontroller, analog, FPGA (field-programmable gate array), connectivity, and power management semiconductors. Microchip has completed some significant acquisitions in the last 8 years or so, buying Atmel in 2016 for $3.56 billion and Microsemi in 2018 for $10.15 billion. The company's products serve diverse sectors ranging from automotive to consumer electronics and industrial applications.

Business Model

Microchip casts its diverse portfolio of products as a “Total System Solution (TSS)” for its customers, meaning Microchip can provide all or most of the silicon for most customer applications. Its mixed-signal microcontrollers are essentially self-contained computers on a chip, which consist of a CPU, memory, storage, analog components, and I/O capabilities.

While Microchip historically manufactured all of its own products, because of its recent acquisitions, 63% of its revenue

now comes from products manufactured at third-party foundries. Microchip's three fabs are all located in the US (Oregon, Colorado, and Arizona), and the company is investing $880 million to expand SiC production at its Colorado fab. Unlike most other IDMs not named Samsung and Intel, Microchip is working to transition its fabs to more advanced process technologies in order to stay competitive. Microchip is also unique in that it is one of the few IDMs to offer foundry services to outside chipmakers, although the foundry division does not make up a substantial portion of Microchip's revenue just yet (<15%).

Our Outlook

Trading at 12.7x 2023 earnings estimates, Microchip is attractively valued and has some growth potential with its US-based foundry business and the expansion of its SiC capacity. Additionally, the company is probably the only IDM or foundry that is willing to invest in advanced process technologies besides the big three (Samsung, Intel, and TSMC). The company has very nice gross margins and a diversified product portfolio which probably reduces its overall risk to any one of its end markets.

What Could Go Wrong With The Stock

- Microchip is hurt by a broader pullback in the economy because it produces primarily low-tech semiconductors that are used across cyclical industries like appliances, autos, and industrials.
- Microchip's investments in its foundry business and SiC could be too little, too late if other players like TSMC, Intel, Samsung, Wolfspeed, or onsemi bring their foundries online quicker than Microchip.

- The company's dependence on third-party foundries subjects it to supply-chain risks and limits its control of the production process.

Company	**Microchip Technology Incorporated**
Stock Symbol	**NASDAQ: MCHP**
Semiconductor Category	Fab-Lite
Stock Price	$77.35 (as of 10/05/23)
Market Capitalization	$42.1 billion
Headcount	22,600
Key End Markets and Products	Automotive, aerospace and defense, communications, consumer appliances, data centers and computing, and industrial.
Major Competitors	TI, ADI, Intel, Skyworks, Micron, Broadcom, Infineon, and Marvell
Total Revenue (ttm)	$8.44 billion
Gross Margin	67.85%
Revenue Breakdown	Mixed-signal Microcontrollers: 56.3% Analog: 28.2% Other: 15.5%
Notable Customers	Not disclosed (125,000 customers)

Revenue % From Big Tech	10%
Revenue % Subject To The GSS	5%
Net Cash (Debt)	($4.36 billion)
2023 EPS Estimates	$6.09
Forward P/E	12.7
2023 Sales Growth Estimates	3.3%
2024 Sales Growth Estimates	0.5%
The Great Semi Shift Rating	**5**

STMicroelectronics N.V. (NYSE: STM)

Background

Founded in 1987 and headquartered in Geneva, Switzerland, STMicroelectronics is the product of a merger between SGS Microelettronica of Italy and Thomson Semiconductors of France. The company specializes in a wide range of semiconductor solutions, encompassing microcontrollers, analog ICs, MEMS (Micro-Electro-Mechanical Systems), and power devices. STMicroelectronics' product portfolio caters to a diverse set of end markets, including automotive, industrial, personal electronics, and communication infrastructure.

Business Model

STMicro is one the most diversified semiconductor companies with a massive assortment of products it sells to over 200,000 customers. Its key end markets include automotive, industrial, personal electronics and communications equipment, computers, and peripherals. The company makes many ASICs and semi-custom devices using its proprietary manufacturing technology. STM is also a leader in next-generation substrates like SiC and GaN for high-efficiency systems.

STMicro operates 14 manufacturing sites spread across Europe, Asia, and the US. The company's fabs have a total maximum capacity of approximately 140,000 wafer starts per week on an 8-inch equivalent basis. While STMicro builds most of its own chips, the company subcontracts about 25% of its annual silicon production to dedicated foundries like TSMC.

With respect to expansion, STMicro is spending $4 billion in 2023 to expand its 12-inch wafer fabs and SiC capacity. The company is currently ramping its newest 300mm fab in Italy and recently entered a joint venture with GlobalFoundries to build a new 300mm fab in Crolles, France. STMicro's goal is to double its 300mm wafer production by 2025.

Our Outlook

As one of the only semiconductors to count both SpaceX and Tesla (two of our largest positions which we intend to own forever) as customers, and with a heavy focus on SiC and GaN, STMicro stands out as one of the better-positioned semiconductor companies in this book. STMicro is probably a winner in the Great Semi Shift with its significant manufacturing base and specialty in developing ASICs. STMicro already has established relationships with big tech companies like Apple and Tesla that will likely continue to move silicon design in-house, and they may look to STMicro to build their less advanced chips.

We also like STMicro's portfolio of next-generation SiC and GaN products. With respect to operations, STMicro is one of the only semiconductor stocks that were able to grow revenues (13% y/y in Q2 '23) since the chip slowdown began in the second half of 2022. With the stock trading at just over 10x

forward earnings and with lots of potential growth in SiC, space, etc., we are long STMicro.

What Could Go Wrong With The Stock

- STMicro has an over-diversified product portfolio which limits its growth potential.
- Big tech companies like Apple and Tesla could choose to have another foundry (Intel, TSMC, etc.) manufacture their chips.
- STMicro fails to expand its fab capacity and offer foundry services quickly enough to meet demand and it ends up missing out on much of the increased demand for US/European-made chips.

Company	**STMicroelectronics N.V.**
Stock Symbol	**NYSE: STM**
Semiconductor Category	IDM
Stock Price	$43.42 (as of 10/05/23)
Market Capitalization	$39.28 billion
Headcount	51,370
Key End Markets and Products	Automotive, communications equipment, functions, industrial, IoT, and consumer
Major Competitors	Broadcom, Fujitsu, TI, and Infineon
Total Revenue (ttm)	$16.13 billion
Gross Margin	47.34%

Revenue Breakdown	Automotive and Discrete: 44% Analog, MEMS and Sensors: 23% Microcontrollers and Digital: 33%
Notable Customers	Apple, Bosch, Continental, HP, Huawei, Mobileye, Samsung, SpaceX, Tesla, and Vitesco.
Revenue % From Big Tech	30%
Revenue % Subject To The GSS	10%
Net Cash (Debt)	$2.09 billion
2023 EPS Estimates	$4.34
Forward P/E	10.2
2023 Sales Growth Estimates	7.6%
2024 Sales Growth Estimates	4.1%
The Great Semi Shift Rating	**7**

ON Semiconductor Corporation (NASDAQ: ON)

Background

Originating from a 1999 spin-off of Motorola's components group and headquartered in Phoenix, Arizona, ON Semiconductor (stylized in lowercase as “onsemi”) has gradually shifted its focus to energy-efficient solutions. Its product lineup is geared towards power management and sensor technologies, reflecting the emerging trends in electric vehicles, connectivity, and automation. onsemi is also a leading manufacturer of silicon carbide (SiC) semiconductors. The company also makes rad-hard ASICs for the space and aerospace markets.

Business Model

The company has moved away from lower gross margin products and refocused on strategic end markets like automotive and industrial. In 2022, onsemi purchased GlobalFoundries’ stake in its East Fishkill fab in New York, which gave onsemi the only 300mm power discrete and image sensor fab in the US. The company also divested non-strategic fabs in Maine, Idaho, and Japan.

onsemi is one of the few companies that has been able to successfully scale its SiC offerings. While other companies like Wolfspeed have struggled to ramp up SiC production due to its inherently difficult manufacturing techniques, onsemi was able

to increase SiC revenue 4x y/y in the most recent quarter. The company already has a $1 billion run rate for SiC and has signed over $11 billion in long-term supply agreements for its SiC products. Importantly, onsemi's SiC division is already profitable, yielding high-teen operating margins in Q2 2023.

Our Outlook

onsemi's operational excellence coupled with its strategic positioning in some of the most important end markets and SiC dominance make us buyers of this stock. We like onsemi's strategic investments in vertical integration and specifically are impressed by its ability to rapidly scale SiC manufacturing with positive operating margins. Among other things, SiC chips are key to extending the range and increasing the power of EVs and also allowing for faster and more efficient charging of EVs. We think that the demand for SiC chips will grow much faster than that for traditional power semiconductors due to the inherently better performance of SiC.

What Could Go Wrong With The Stock

- onsemi has a lot of exposure to non-Tesla EV companies like Hyundai, GM, and Nio. These companies will likely struggle to scale their EV offerings and may never be able to sell EVs profitably.
- Tesla has stated that its next-generation vehicle will be built using 75% less silicon carbide than its current lineup. Tesla and other EV companies might figure out how to extend the range and battery life of their vehicles without using onsemi's SiC.
- Higher interest rates cause a slowdown in industrial spending which is one of onsemi's key end markets.

Company	**ON Semiconductor Corporation**
Stock Symbol	**NASDAQ: ON**
Semiconductor Category	IDM
Stock Price	$86.98 (as of 10/05/23)
Market Capitalization	$37.54 BILLION
Headcount	31,000
Key End Markets and Products	Automotive, industrial, 5G, cloud power, medical, aerospace & defense
Major Competitors	Infineon, STM, NXP, Wolfspeed, TI, and Nexperia, Sony, Samsung, and Omnivision.
Total Revenue (ttm)	$8.35 billion
Gross Margin	47.78%
Revenue Breakdown	Power Solutions: 50.5% Advanced Solutions: 34.1% Intelligent Sensing: 15.3%
Notable Customers	Delphi, Hyundai, Honeywell, Siemens, Tyco, Apple, LG, Samsung, and Microsoft
Revenue % From Big Tech	15%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	$58 million

2023 EPS Estimates	$5.23
Forward P/E	16.71
2023 Sales Growth Estimates	0.7%
2024 Sales Growth Estimates	6.8%
The Great Semi Shift Rating	**6**

Skyworks Solutions, Inc. (NASDAQ: SWKS)

Background

Founded in 2002 and headquartered in Irvine, California, Skyworks Solutions specializes in radio frequency (RF) and analog semiconductors. Its products play a crucial role in facilitating wireless connectivity in a variety of devices, from smartphones to industrial equipment. Over the years, Skyworks has established itself as a key player in the wireless infrastructure sector, with its components becoming integral to the functionality of 4G and 5G networks.

Business Model

Skyworks arguably offers the broadest portfolio of chips for wireless connectivity from the transceiver to the antenna. Apple is its largest customer, making up more than 10% of Skyworks' revenue. Skyworks' chips are critical for The 5G Revolution. In terms of manufacturing, the company has two fabs in the US, two in Japan, and one each in Mexico and Singapore.

Our Outlook

Skyworks is well positioned to benefit from the continued growth of The 5G Revolution and the demand for broader and faster connectivity around the world. However, much of the growth in this Revolution has already materialized and we

expect Skyworks to grow in the mid to high single digits from here. With the stock trading at 11.7x forward earnings, it is not a bad buy but not at the top of our list either.

What Could Go Wrong With The Stock

- Skyworks faces intense competition for many of its products and it generates a significant portion of its revenue from the biggest tech company in the world, Apple.
- Although Skyworks' proprietary technology will likely keep it in the iPhone in the near term, Apple could try to cut Skyworks' products in the future like it has (unsuccessfully) attempted to do with Qualcomm.
- Skyworks' manufacturing base is geared toward its specialty products and it is not clear that the company's fabs could be easily converted to make ASICs if needed.

Company	**Skyworks Solutions, Inc.**
Stock Symbol	**NASDAQ: SWKS**
Semiconductor Category	IDM
Stock Price	$98.18 (as of 10/06/23)
Market Capitalization	$15.65 billion
Headcount	11,150
Key End Markets and Products	Smartphones, 5G, and communications
Major Competitors	ADI, Broadcom, Cirrus Logic, Murata Manufacturing, NXP, Qorvo, QCOM, and TI

Total Revenue (ttm)	$4.96 billion
Gross Margin	46.32%
Revenue Breakdown	Not provided
Notable Customers	Apple, Bose, Cisco, Ericsson, Garmin, GE, Google, Honeywell, Lenovo, Microsoft, Samsung, Sony, and Northrop Grumman
Revenue % From Big Tech	20%
Revenue % Subject To The GSS	20%
Net Cash (Debt)	($752 million)
2023 EPS Estimates	$8.39
Forward P/E	11.7
2023 Sales Growth Estimates	-13.0%
2024 Sales Growth Estimates	4.8%
The Great Semi Shift Rating	**3.5**

Western Digital Corporation (NASDAQ: WDC)

Background

Established in 1970 and headquartered in San Jose, California, Western Digital is a global data storage company known for its hard disk drives (HDDs) and solid-state drives (SSDs). Over the decades, Western Digital has expanded its portfolio to encompass a range of storage solutions, catering to both consumers and enterprises. With its acquisitions, notably that of SanDisk in 2016, the company further solidified its presence in the flash storage market.

Business Model

Western Digital's storage products serve a broad range of customers, from students to gamers to data centers. The company considers itself the only company in the world with large-scale capabilities to develop and manufacture both Flash and HDD products. However, it faces stiff competition from firms in the US like Micron and Seagate, in addition to many foreign companies that make commoditized storage products. Western Digital's manufacturing facilities are largely in Asia but the company does have a large fab in California.

Our Outlook

As with the other memory makers, Western Digital does not get high marks from us due to the commoditized nature of its products. Worse yet for Western Digital is that over half of its revenue comes from hard disk drives (HDDs), which are all but obsolete outside of the enterprise storage market. The company is also carrying a significant amount of debt (over $7 billion) and recently had to raise more cash via $900 million convertible notes from a group led by Apollo. Given the company's struggling financials and poor product mix, we are short Western Digital.

What Could Go Wrong With The Stock

- The memory/storage chip glut drags on longer than expected, keeping prices for chips and Western Digital's margins too low for too long.
- The company could be at risk of bankruptcy if it is unable to generate cash flow to service its debt.
- Even if Western Digital does not go bankrupt, shareholders will face dilution if the company keeps issuing convertible debt to vultures like Apollo.

Company	**Western Digital Corporation**
Stock Symbol	**NASDAQ: WDC**
Semiconductor Category	IDM (memory)
Stock Price	$46.45 (as of 10/06/23)
Market Capitalization	$14.95 billion

Headcount	53,000
Key End Markets and Products	PCs, gaming, cloud, enterprises
Major Competitors	Kioxia, Micron, Samsung, SK hynix, Yangtze, STX, and Toshiba
Total Revenue (ttm)	$12.32 billion
Gross Margin	15.3%
Revenue Breakdown	Cloud: 43% Client: 35% Consumer: 22%
Notable Customers	Arrow Electronics and Apple
Revenue % From Big Tech	15%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	($3.8 billion)
2023 EPS Estimates	-$4.06
Forward P/E	NM
2023 Sales Growth Estimates	-1.8%
2024 Sales Growth Estimates	33.9%
The Great Semi Shift Rating	**3**

Seagate Technology Holdings PLC (NASDAQ: STX)

Background

Founded in 1978 and headquartered in Dublin, Ireland, Seagate Technology is a leading data storage company, historically known for its hard disk drives (HDDs). Seagate has evolved to meet the changing demands of the data storage industry, expanding its product portfolio to include solid-state drives (SSDs) and storage solutions tailored for enterprises, personal computers, and external storage markets.

Business Model

Of the three major storage makers, Seagate is the one most focused on HDDs. In the second quarter of 2023, over 86% of Seagate's revenue still came from the sale of HDDs. Although HDDS are basically no longer used in most consumer electronics, they are still the cheapest form of storage on a cost/terabyte basis and thus are utilized by cloud companies who are storing ever more data. Seagate is primarily focused on selling into what it calls the "Mass Capacity Storage Market," which essentially includes cloud and edge providers. The company still sells into "legacy" markets which include things like discount PCs and Xboxes.

Our Outlook

We are concerned that Seagate could get left behind as the major cloud companies, which are the last real buyers of HDDs, ultimately move to SSDs. SSDs are a fundamentally better technology and the only prohibiting factor is cost, which has come substantially. Analysts expect SSDs could reach cost parity with HDDs on a $/TB basis as early as 2026. Seagate's executives firmly believe that they can keep driving down the cost of HDDs to stay competitive, but that does not sound good for Seagate's long-term profitability. With a good amount of debt on the balance sheet (about $6 billion), and given our concerns about the long-term fundamentals of the business, we are short Seagate.

What Could Go Wrong With The Stock

- SSD prices reach cost parity with HDDs and the major cloud vendors reduce purchases of HDDs dramatically.
- Seagate is unable to generate sufficient cash flow to service debt payments and/or long-term margins are reduced to the point that the business is uneconomic.
- Low-cost Asian competitors take market share from Seagate and further place pressure on Seagate's gross margins.

Company	**Seagate Technology Holdings plc**
Stock Symbol	**NASDAQ: STX**
Semiconductor Category	IDM (memory)
Stock Price	$66.37 (as of 10/06/23)

Market Capitalization	$13.8 billion
Headcount	33,400
Key End Markets and Products	Cloud, PCs, gaming, misc. consumer products
Major Competitors	Micron, Samsung, SK hynix, Kioxia, Toshiba, and Western Digital
Total Revenue (ttm)	$7.38 billion
Gross Margin	18.3%
Revenue Breakdown	Mass capacity: 66% Legacy: 21% Other: 13%
Notable Customers	HP, Dell, EMC, IBM, and Acer
Revenue % From Big Tech	75%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	($4.6 billion)
2024 EPS Estimates	$0.66
Forward P/E	100.6
2024 Sales Growth Estimates	-9.2%
2025 Sales Growth Estimates	26.1%
The Great Semi Shift Rating	**2**

Qorvo, Inc. (NASDAQ: QRVO)

Background

Founded in 2015 from the merger of RF Micro Devices and TriQuint Semiconductor, Qorvo is headquartered in Greensboro, North Carolina. The company specializes in radio frequency (RF) solutions that are integral to wireless communications, particularly in mobile devices. Qorvo's product portfolio spans a wide range, from RF filters and amplifiers to integrated modules that support advanced connectivity like 5G. Beyond the mobile sector, Qorvo's solutions also find applications in the infrastructure, defense, and aerospace industries. Qorvo has three fabs which are all located in the US (North Carolina, Oregon, and Texas). These fabs produce Qorvo's BAW (bulk acoustic wave), GaAs (gallium arsenide), GaN (gallium nitride), SAW (surface acoustic wave), and temperature-compensated SAW wafers. The company's silicon-based chips are manufactured by dedicated foundries.

Business Model

Qorvo's largest end market is its mobile business, which constituted 66% of its revenue in fiscal 2023. Its two largest customers, Apple and Samsung, respectively generated 37% and 12% of Qorvo's revenue. Apple and Samsung primarily

purchase Qorvo's RF (radio frequency) solutions for their smartphones. These RF products include amplifiers, control products, discrete transistors, filters, duplexers, frequency converters, switches, and connectivity chips.

All three of Qorvo's fabs are located in the US, but the company's backend facilities (assembly, packaging, and testing) are located in China, Costa Rica, and Germany. Qorvo is unique in that it offers third-party foundry services for GaN and SiC semiconductors, with process nodes ranging from 0.15 to 0.50 micron.

Our Outlook

As Qorvo is highly dependent on smartphone sales, it's no surprise that its revenue was down 23% in fiscal 2023, commensurate with the slowdown in unit shipments. The slowdown in production also impacted the company's gross margin, dropping to 36.3% from 49.2%, due in part to factory underutilization resulting from the lack of demand.

Qorvo has too much exposure to the smartphone market and too much dependence on Apple and Samsung for our taste. Both of its major customers have the incentive and capability to design Qorvo's products in-house. While we think the GaN and SiC foundry business could be interesting, it will take a lot of growth in that area to offset the likely decline we expect to see in Qorvo's smartphone business.

What Could Go Wrong With The Stock

- Apple and Samsung could decide to replace Qorvo's products with chips designed in-house.

- Even if the phone makers do not move to in-house silicon design, we are not expecting a lot of growth in the smartphone market going forward.
- Qorvo could struggle to generate meaningful revenue from its newer business segments like GaN and SiC.

Company	**Qorvo, Inc.**
Stock Symbol	**NASDAQ: QRVO**
Semiconductor Category	IDM
Stock Price	$94.83 (as of 10/06/23)
Market Capitalization	$9.3 billion
Headcount	8,500
Key End Markets and Products	Automotive, defense and aerospace, cellular infrastructure, and broadband
Major Competitors	ADI, Infineon, NXPI, onsemi, STM, TI, Wolf, Broadcom, Qualcomm, and Skyworks.
Total Revenue (ttm)	$3.19 billion
Gross Margin	36.14%
Revenue Breakdown	High Performance Analog: 20% Connectivity and Sensors: 13% Advanced Cellular: 66% Other: 1%
Notable Customers	Apple and Samsung

Revenue % From Big Tech	50%
Revenue % Subject To The GSS	35%
Net Cash (Debt)	($1.3 billion)
2024 EPS Estimates	$5.01
Forward P/E	18.9
2024 Sales Growth Estimates	0.9%
2024 Sales Growth Estimates	14.0%
The Great Semi Shift Rating	**3.5**

MACOM Technology Solutions Holdings, Inc. (NASDAQ: MTSI)

Background

Headquartered in Lowell, Massachusetts, MACOM Technology Solutions designs and manufactures a broad portfolio of analog RF (radio frequency), microwave, millimeter wave, and photonic semiconductor products. The company was founded in 1950 as Microwave Associates and saw growth throughout much of the later half of the 20th century commensurate with the growth in the telecom industry. MACOM came public in 2012 at a price of $19/share.

Business Model

MACOM's over 3,000 products are used in various applications, including data center connectivity, telecommunications networks, defense, and industrial sectors. These products are for unique applications like satellites, radar, smart munitions, medical systems, and measurement applications. MACOM also produces optical interconnects for data centers and a lot of backend equipment for telecoms.

The company operates a fab-lite business model with two company-owned wafer fabs in Massachusetts and Michigan. MACOM handles a lot of aerospace and defense work and its

foundries are accredited by the US DoD for manufacturing of sensitive semiconductors for the military. MACOM has a diverse customer base and in 2022, its top 25 customers accounted for an aggregate of only 47% of total revenue.

MACOM offers foundry services for traditional silicon semiconductors and many specialty products like gallium arsenide (GaAs), gallium nitride (GaN), and indium phosphide (InP) semiconductors. The company also recently announced an agreement to buy Wolfspeed's legacy RF business for $125 million. This business generates about $150mm in revenue annually. The sale includes Wolfspeed's 4-inch GaN fab in North Carolina.

Our Outlook

MACOM is a unique fab-lite company in that it specializes in a lot of end markets that are not the focus of many other semiconductor companies. We like MACOM's exposure to the space and aerospace markets, as well as its foundry model focused on the design and manufacture of specialty semiconductors made from GaAs, GAN, etc.

We expect MACOM will steadily grow in the mid- to high single digits but analysts are only predicting about 3.4% revenue growth next year after a slight revenue drop in 2023. There is probably room to the upside for these estimates which could boost the stock, although it is already trading at about 30x forward earnings which keeps us from buying the stock today.

What Could Go Wrong With The Stock

- Telecom spending growth is muted for the next few years as major carriers cut back capex due to elevated interest rates.
- MACOM loses market share to newer rivals like Credo or Wolfspeed.
- The fab-lite model loses its luster as IDMs retake market share with more advanced process technology and greater control over the manufacturing process.

Company	**MACOM Technology Solutions Holdings, Inc.**
Stock Symbol	**NASDAQ: MTSI**
Semiconductor Category	Fab-lite
Stock Price	$82.71 (as of 10/10/2023)
Market Capitalization	$5.9 billion
Headcount	1,200
Key End Markets and Products	Industrial & defense, data center, and telecom
Major Competitors	ADI, Broadcom, Credo, Marvell, MaxLinear, Microchip, NXP, Qorvo, Semtch, Skyworks, and Wolfspeed.
Total Revenue (ttm)	$676 million
Gross Margin	60%
Revenue Breakdown	Telecom: 36%

	Industrial & Defense: 44% Data Center: 20%
Notable Customers	Not material
Revenue % From Big Tech	15%
Revenue % Subject To The In-House Silicon Revolution	10%
Net Cash (Debt)	$71 million
2023 EPS Estimates	$2.7
Forward P/E	30.6
2023 Sales Growth Estimates	-4.0%
2024 Sales Growth Estimates	3.4%
The Great Semi Shift Rating	**5**

Wolfspeed, Inc. (NYSE: WOLF)

Background

Formerly known as Cree, Inc., Wolfspeed is focused on silicon carbide (SiC) and gallium nitride (GaN) power semiconductors. These advanced materials are known for their ability to handle high frequencies and high power levels while maintaining efficiency, making them integral to modern electronics and wireless communication technologies. Wolfspeed also produces RF devices but entered an agreement in August 2023 to sell the RF segment, including its 4-inch GaN fab, to MACOM for $125 million.

Business Model

Wolfspeed produces both raw SiC wafers (which it can sell to other semiconductor manufacturers) and SiC power chips which it sells to OEMs. The company built a one-of-a-kind $1.2 billion 200mm SiC fab in Marcy, New York that it is currently attempting to ramp up. Wolfspeed's power semiconductors are primarily used in EVs and as of June 25, 2023, the company had $2.9 billion in backlog and $8.3 billion of "design-ins," which are customer commitments to purchase Wolfspeed's products.

Our Outlook

As the only pure-play SiC manufacturer, Wolfspeed is an interesting investment opportunity but the company has repeatedly run into problems trying to ramp up its new fab in New York. Management has repeatedly pushed back the ramp schedule and now the factory is not expected to be in full production until the end of 2024 or early 2025. The most recent delay comes after two prior delays in the ramp, causing analysts to question whether Wolfspeed will be able to successfully ramp the factory at all. Silicon carbide is an extremely difficult material to work with, and many have questioned whether it can be scaled to a sufficient level to handle modern needs for power semiconductors.

Management's inability to ramp the new fab in New York and its repeated kicking of the can down the road earns Wolfspeed bad marks from us. Silicon carbide is a revolutionary material and will likely continue to grow significantly, but we think Wolfspeed is falling behind competitors like onsemi and STMicro who have already successfully ramped up production of their SiC products. Both onsemi and STMicro have more manufacturing experience than Wolfspeed and we think that likely explains the disparity in the ramp of SiC production.

What Could Go Wrong With The Stock

- Many of Wolfspeed's customers who have designed products that utilize SiC may switch to onsemi or STM due to Wolfspeed's inability to produce SiC chips on schedule.
- Wolfspeed is not profitable and has borrowed heavily to build out its new fab.

- Wolfspeed may run out of cash or be forced to borrow at unfavorable terms (or do a secondary offering) if it cannot get production ramped soon.

Company	**Wolfspeed, Inc.**
Stock Symbol	**NYSE: WOLF**
Semiconductor Category	IDM
Stock Price	$33.15 (as of 10/06/2023)
Market Capitalization	$4.15 billion
Headcount	4,802
Key End Markets and Products	Automotive and Industrial
Major Competitors	Infineon, onsemi, Rohm, and STMicro
Total Revenue (ttm)	$0.92 billion
Gross Margin	30.26%
Revenue Breakdown	Power products: 44% Materials products: 38% RF products: 18%
Notable Customers	Mercedes-Benz, GM, and Lucid
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	0%
Net Cash (Debt)	($1.23 billion)

2024 EPS Estimates	-$2.69
Forward P/E	NM
2024 Sales Growth Estimates	5.2%
2025 Sales Growth Estimates	50.0%
The Great Semi Shift Rating	**4.5**

Diodes Incorporated (NASDAQ: DIOD)

Background

Diodes Incorporated is a semiconductor company that designs, manufactures, and supplies a broad range of standard and application-specific products. Its portfolio encompasses discrete, logic, analog, and mixed-signal semiconductor components. Founded in 1959, Diodes initially focused on rectifier products (a special type of diode that converts alternating current (AC) into direct current (DC)), but over the years, it expanded its offering to include amplifiers, LED drivers, transistors, and voltage regulators, among others. Serving the consumer electronics, communications, computing, industrial, and automotive sectors, Diodes aims to address a wide array of electronic design challenges with its components. Diode is headquartered in Plano, Texas, and has been publicly traded since 1966.

Business Model

Diode has had 31 consecutive years of profitability and its current goal is to reach $2.5 billion in revenue and $1 billion in gross profit by 2025. The company has been expanding with strategic acquisitions including:

- the 2022 acquisition of onsemi's 200mm South Portland, Maine fab for analog products;

- the 2020 acquisition of Lite-On Semiconductor which extended capabilities in the automotive and industrial end markets;
- the 2019 acquisition of TI's 200mm fab in Greenock, Scotland.

Our Outlook

Diode has a long history of profitable growth and has a very diversified customer base. The company is investing in growing its domestic fab capacity and should be well-positioned for the Great Semiconductor Shift. However, like many of the other diversified, low-tech manufacturers, Diode is probably limited to growing in the high single digits. That said, Diode is trading at about 15x forward earnings which is pretty reasonable compared to many of its peers.

What Could Go Wrong With The Stock

- Downturn in the global economy.
- Over-diversification limits the company's growth.
- Diode loses market share to larger competitors.

Company	**Diodes Incorporated**
Stock Symbol	**NASDAQ: DIOD**
Semiconductor Category	IDM
Stock Price	$80.06 (as of 10/10/2023)
Market Capitalization	$3.7 billion
Headcount	8,877
Key End Markets and Products	Industrial (lighting, power supplies, HVAC, smart meters), Automotive (ADAS, infotainment, power train), Computing (PCs, cloud, printers), Communications (5g, smartphones, routers, fiber optics), and Consumer (set-top boxes, TVs, game consoles, and smartwatches).
Major Competitors	Infineon, Epson, Kyocera, NXP, onsemi, TI, and Vishay
Total Revenue (ttm)	$2 billion
Gross Margin	42%
Revenue Breakdown	Industrial: 27% Automotive: 15% Computing: 24% Communications: 15% Consumer: 19%
Notable Customers	Not disclosed
Revenue % From Big Tech	15%
Revenue % Subject To The	5%

In-House Silicon Revolution	
Net Cash (Debt)	$276 million
2023 EPS Estimates	$5.52
Forward P/E	14.5
2023 Sales Growth Estimates	-11.3%
2024 Sales Growth Estimates	2.3%
The Great Semi Shift Rating	**5.5**

Vishay Intertechnology, Inc. (NYSE: VSH)

Background

Established in 1962 by Dr. Felix Zandman, Vishay Intertechnology is a global manufacturer of discrete semiconductors and passive electronic components. With its headquarters in Malvern, Pennsylvania, Vishay's products include diodes, resistors, capacitors, inductors, and other basic electronic components. These components are foundational to a broad range of electronic devices and systems across the industrial, computing, automotive, consumer, telecommunications, military, and aerospace sectors. Vishay claims that its products can populate greater than 80% of the components on a circuit board in many applications.

Business Model

Vishay has an extremely broad product portfolio, including everything from LEDs to power modules for EVs. Many of Vishay's products are commoditized, with the company estimating that commodity products made up 35%-40% of revenues in 2022.

The company is expanding its capacity by investing $1.2 billion over the next three years, including building a new 12-inch fab in Heilbronn, Germany. Vishay's facilities are scattered across

Europe, the US, and Asia, and the company also relies on third-party foundries for much of its production.

Our Outlook

Vishay sells low-tech, commoditized products to a broad range of end markets. This is one of the more cyclical IDMs and we do not see a lot of growth for this company in the near term. While we are encouraged by the company's significant investment to grow its fab capacity, the new fab will still produce the same commoditized products that make up much of Vishay's revenue. The stock is cheap and the company has a healthy balance sheet, but the lack of major growth potential keeps us out of this stock for now.

What Could Go Wrong With The Stock

- Vishay could fail to see any new growth despite its significant investments in new fabs.
- Vishay's products could become further commoditized thereby lowering gross margins and profitability.
- A downturn in the global economy hurts Vishay's rather cyclical business.

Company	**Vishay Intertechnology, Inc.**
Stock Symbol	**NYSE: VSH**
Semiconductor Category	IDM
Stock Price	$24.21 (as of 10/06/2023)
Market Capitalization	$3.4 billion
Headcount	23,900
Key End Markets and Products	Industrial, computing, automotive, consumer, telecommunications, military, and aerospace
Major Competitors	Infineon, onsemi, STMicro, Rohm, Broadcom, Toshiba, Panasonic, and Hyocera.
Total Revenue (ttm)	$3.54 billion
Gross Margin	30.31%
Revenue Breakdown	MOSFETs: 24% Diodes: 21% Optoelectronic Components: 7.5% Resistors: 24% Inductors: 9% Capacitors: 14%
Notable Customers	Not disclosed
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	0%

Net Cash (Debt)	$357 million
2023 EPS Estimates	$2.59
Forward P/E	9.3
2023 Sales Growth Estimates	-0.4%
2024 Sales Growth Estimates	0.9%
The Great Semi Shift Rating	**5**

Smart Global Holdings, Inc. (NASDAQ: SGH)

Background

Smart Global Holdings, Inc. operates as a parent company with multiple subsidiaries focusing on specific areas within the electronics and semiconductor sectors. Established in 1988, the company originally started as a memory module producer, with products catering to PCs and servers. Memory modules are essentially the circuit boards to which memory ICs are attached to. Over the years, SGH has expanded its reach through organic growth and strategic acquisitions. The company now has a diverse portfolio that includes specialty memory solutions, LED lighting products, and computing and storage solutions.

Business Model

SGH is a semiconductor rollup company with a core low-margin memory business. SGH's recent acquisitions include:

- the 2022 acquisition of Stratus Technologies for $225 million. Stratus produces fault-tolerant servers and software.
- the 2021 acquisition of Cree LED for $300 million.
- the 2019 acquisition of Artesyn Embedded Computing for $80 million.

- the 2018 acquisition of Penguin Computing for $85 million. Penguin designs high-performance computing solutions.

SGH does not own wafer fabs but it does have several backend manufacturing facilities. One of its primary manufacturing facilities is located in Brazil, which the company in July of 2023 announced it intended to sell to a Chinese company for $166 million.

Our Outlook

We do not like SGH's aggressive pursuit of acquisitions and the company's high debt load. Further, the company's core memory module business is most likely in secular decline as SGH struggles to keep up with much bigger players in this arena like HP, Dell, and Samsung. We expect SGH will struggle to maintain its historic cadence of acquisitions at today's higher levels of interest rates. We are long puts on SGH.

What Could Go Wrong With The Stock

- SGH is unable to grow through acquisitions at today's higher interest rates.
- The memory market continues to deteriorate and SGH loses what little market share it has to larger players.
- SGH's low margins deteriorate due to intense competition from low-cost Chinese competitors.

Company	**SMART Global Holdings, Inc.**
Stock Symbol	**NASDAQ: SGH**

Semiconductor Category	Fab-Lite
Stock Price	$24.33 (as of 10/11/2023)
Market Capitalization	$1.2 billion
Headcount	3,600
Key End Markets and Products	PCs, data center, and consumer products
Major Competitors	Dell, HP, Samsung, and Chinese competitors
Total Revenue (ttm)	$1.8 billion
Gross Margin	25%
Revenue Breakdown	Memory Solutions: 54% Intelligent Platform: 24% LED Solutions: 22%
Notable Customers	Not disclosed
Revenue % From Big Tech	10%
Revenue % Subject To The In-House Silicon Revolution	10%
Net Cash (Debt)	($455 million)
2023 EPS Estimates	$2.66
Forward P/E	9.2
2023 Sales Growth Estimates	-9.1%
2024 Sales Growth Estimates	3.7%
The Great Semi Shift Rating	**2**

Alpha And Omega Semiconductor Limited (NASDAQ: AOSL)

Background

Founded in 2000 and headquartered in Sunnyvale, California and incorporated in Bermuda, Alpha and Omega Semiconductor (AOS) specializes in the design, development, and supply of a broad range of power ICs and discrete semiconductors. AOS's portfolio of products are used in phone chargers, TVs, power tools, PCs, set-top boxes, and other portable electronic devices.

Business Model

AOS is primarily focused on developing power semiconductors for the PC market. In 2023, the company's revenue from its PC segment accounted for 35.2% of its total revenue. Because of the slowdown in PC sales, AOS has been trying to diversify its product lineup away from the PC market. The company is currently trying to expand in the home appliance and gaming markets. AOS currently operates one 8-inch fab in Hillsboro, Oregon, and one in China via a joint venture, but still depends on third-party foundries for about 10% of its wafer production.

Our Outlook

AOS's over-concentration to the PC market and lack of proprietary technology makes us very cautious about the stock. The company has explained that the majority of its product sales are to contract manufacturers like Foxconn, who are now designing and selling their own power semiconductors for many of AOS's applications. We think these types of power and discrete semiconductors are easily replicable and do not think that AOS has much moat to protect its core PC business. While we appreciate the company's attempt to diversify, it faces stiff competition in the high-tech power semiconductor market from established players like Monolithic Power, onsemi, TI, and others. We are long puts on AOSL.

What Could Go Wrong With The Stock

- Contract manufacturers like Foxconn could design their own power and discrete semiconductors and cut out AOS.
- AOS could fail to successfully diversify into new end markets as it faces stiff competition from established players like onsemi and MPWR in those areas.
- Continued weakness in the global PC market drags down AOS's sales for longer than expected.

Company	**Alpha and Omega Semiconductor Limited**
Stock Symbol	**NASDAQ: AOSL**
Semiconductor Category	IDM

Stock Price	$29.08 (as of 10/09/23)
Market Capitalization	$806 million
Headcount	2,468
Key End Markets and Products	PCs, consumer electronics, phone chargers, etc.
Major Competitors	Infineon, onsemi, STMicro, Toshiba, Diodes, TI, Monolithic Power, and Vishay
Total Revenue (ttm)	$800 million
Gross Margin	32.6%
Revenue Breakdown	Computing: 35% Consumer: 26% Communication: 15% Power Supply & Industrial: 22% Other: 2%
Notable Customers	Dell, HP, Samsung, Stanley Black & Decker, Compal, Foxconn, Quanta Computer, Wistron, and Delta Electronics.
Revenue % From Big Tech	0%
Revenue % Subject To The GSS	50%
Net Cash (Debt)	$133 million
2024 EPS Estimates	$1.17
Forward P/E	24.8

2024 Sales Growth Estimates	2%
2025 Sales Growth Estimates	8.8%
The Great Semi Shift Rating	**3.5**

Chapter 9 – Fabless Chip Makers

Dall-E 3 Prompt: Photo capturing several humanoid robots in a construction site. Dressed in hardhats and yellow vests, they work in unison to dig ditches for a waterline. The background shows piles of soil and construction equipment, emphasizing the scale of the project.

The universe of fabless semiconductor companies is as diverse as it is dynamic, encompassing a vast range of products that power our modern world. At the forefront of this category is NVIDIA, a company that has witnessed an astronomical increase in market capitalization, buoyed by surging demand for its server chips fundamental to the burgeoning Artificial Intelligence (AI) Revolution. However, the scope of products designed by fabless firms is not restricted to cutting-edge

semiconductor solutions alone; it also includes an assortment of relatively low-tech analog and mixed-signal devices that find applications in everyday consumer products.

Interestingly, the fabless landscape also features companies like AMD, which once operated as Integrated Device Manufacturers (IDMs) but strategically divested their foundry operations in a quest for improved financial metrics and a sharper focus on core competencies. This transformation underlines the adaptability and diverse strategies that characterize the fabless sector. Fabless companies generally boast higher average gross margins—around 53%—than their foundry or IDM counterparts, but actually have lower average gross margins than the Fab-Lite companies of about 57%. Their low capex model allows them to focus on design innovation, thereby driving advancements in various technological arenas.

The fabless semiconductor landscape, while rich in innovation and opportunity, also harbors a degree of vulnerability that cannot be overlooked, especially in the context of the Great Semiconductor Shift (GSS). Companies like Broadcom, Qualcomm, and NVIDIA are particularly susceptible, owing to their high revenue concentration from major technology firms like Google, Microsoft, Apple, and Amazon. These tech giants are increasingly venturing into in-house chip design to gain greater control over their hardware ecosystems, putting pressure on the fabless companies that have historically supplied them.

Consequently, most of these fabless companies have been assigned lower GSS ratings in our analysis, indicating elevated risk profiles. Given this landscape, we are actively shorting several names within this sector. It’s imperative for investors to carefully scrutinize the dependencies and risks associated with

these fabless companies, particularly as tech conglomerates continue to invest in custom silicon solutions.

The subsequent chapters will delve into the intricate dynamics of these 20 major fabless semiconductor companies. As we explore their varying business models, strategies, and product portfolios, consider how these factors interact with the risks posed by the Great Semiconductor Shift and how they impact potential investment decisions.

Fabless Comparison Table							
Ticker	**Market Cap (bb)**	**TTM Revenue (bb)**	**Gross Margin**	**Fwd. P/E**	**Sales from Big Tech**	**Sales subject to The GSS**	**GSS Rating**
NVDA	$1,100.00	$32.70	65.00%	41.4	80.00 %	50.00%	5
AVGO	$333.64	$35.45	68.28%	20.5	40.00 %	30.00%	1.5
AMD	$170.80	$21.80	44.00%	38.3	40.00 %	40.00%	3
QCOM	$111.65	$35.50	56.31%	-13.4	50.00 %	50.00%	3.5
MRVL	$46.80	$5.60	45.00%	35.2	25.00 %	25.00%	5
MediaTek	$40.92	$13.76	48.40%	19.4	15.00 %	15.00%	3.5
MPWR	$22.70	$1.85	58.00%	40.5	20.00 %	5.00%	4
LSCC	$11.00	$0.73	70.00%	38.3	25.00 %	10.00%	4
ALGM	$5.90	$1.03	57.00%	20.6	0.00%	10.00%	4
POWI	$4.50	$0.52	54.00%	47.7	15.00 %	0.00%	3.5

CRUS	$3.90	$1.80	50.20%	13.4	83.00 %	83.00%	2
SITM	$2.60	$0.20	58.00%	737.5	30.00 %	30.00%	1
CRDO	$2.50	$0.17	58.00%	410	75.00 %	75.00%	5
AMBA	$2.20	$0.29	61.00%	NM	0.00%	10.00%	2.5
SIMO	$1.90	$0.72	44.00%	28.7	0.00%	50.00%	2.5
MXL	$1.80	$1.00	43.00%	18.1	40.00 %	40.00%	3
SMTC	$1.50	$0.82	51.00%	NM	15.00 %	15.00%	4
NVTS	$1.10	$0.05	33.00%	NM	30.00 %	30.00%	3.5
HIMX	$1.00	$0.96	29.00%	23.4	30.00 %	5.00%	2.5
INDI	$0.84	$0.16	44.00%	NM	0.00%	15.00%	2

NVIDIA Corporation (NASDAQ: NVDA)

Background

With a market cap of $1.1 trillion, NVIDIA is currently the most valuable semiconductor company on the planet. This is because NVIDIA is the leading maker of the graphics processor units (GPUs) that are powering the ongoing AI Revolution.

NVIDIA was founded in 1993 by Jensen Huang (current CEO), Curtis Priem, and Chris Malachowsky. The company is headquartered in Santa Clara, California. NVIDIA's GPUs have long been used in gaming and professional visualization, but demand recently exploded with the widespread use of generative AI applications like OpenAI's ChatGPT.

At its core, both CPUs and GPUs are both chips that process data. However, the ways in which they process data are markedly different. CPUs are great for tasks that require sequential processing or decision-making. This is analogous to a general manager of a factory, who works on a few tasks at a time and makes high-level decisions. On the other hand, GPUs are great at handling tasks that can be broken down into small parts and handled simultaneously. Returning to our factory analogy, GPUs are akin to teams of specialized workers that can quickly produce a lot of widgets because they do the same task over and over. CPUs contain anywhere from 2 to 64 cores,

while GPUs contain thousands of cores. For these reasons, GPUs are optimal for image processing and machine learning, which require large simultaneous processing of large amounts of data.

In addition to designing semiconductors, NVIDIA creates proprietary software that allows developers to build applications that utilize the power of GPUs. The NVIDIA software platform known as CUDA (Compute Unified Device Architecture) makes it easy for developers to write programs for GPUs in traditional programming languages like C/C++. NVIDIA creates algorithms that are packaged into "libraries" optimized for specific use cases like graphics, scientific computing, data science, and AI. Currently, about four million developers are working with CUDA, up from only two million two and a half years ago.

Business Model

NVIDIA has created an ecosystem of hardware and software all around the concept of "accelerated computing." One of the central premises of accelerated computing is that the exponential scaling of CPU-based general-purpose computing is coming to an end. Jenson Huang has famously stated that "Moore's Law is dead," implying that the era of ever cheaper and ever more powerful chips is behind us. Thus, rather than counting on incrementally better and cheaper chips to achieve better performance, NVIDIA GPUs offer more efficient compute power by changing the way computing is done, from vertical to parallel. For example, NVIDIA recently launched a new library for computational lithography, a process used to design chips, that it claims can handle the workloads with 500 H100 systems compared to 40,000 CPUs.

Our Outlook

We have owned NVIDIA since we first wrote about it for TradingWithCody.com subscribers in 2016 when the stock was at $8 per share. At that time, Cody wrote that *"with the potential for 20-30% growth in the VR and Smart Car Revolution, I think the stock could double or triple from these current levels over the next five years."*

There is no doubt that NVIDIA remains at the cutting edge of the AI Revolution and will likely continue to see immense growth in the near term. And while we think NVIDIA's hardware + software ecosystem gives it a substantial moat, we see three primary risks to owning the stock at these levels:

1. NVIDIA is a prime target of the In-House Silicon Revolution. The major cloud companies, Tesla, and others are all focused on developing their own AI chips. NVIDIA even recognizes this risk and lists many of its major customers like Google, Amazon, Baidu, and Tesla as competitors as well.
2. While NVIDIA clearly has the lead in accelerated computing, AMD and Intel are both racing to improve their own GPUs to compete with NVIDIA's products. NVIDIA's gross margins skyrocketed in the last two quarters (up to 70% from 43.5% last year) and these kinds of margins attract competition. Due to NVIDIA's dependence on TSMC, we are particularly concerned that Intel could develop a competitive GPU using its more advanced process nodes which should come online in the next year.
3. NVIDIA's valuation is stretched. The stock is currently trading at 33x 2023 sales and 41x 2024 earnings

estimates. This valuation far exceeds that of any other major semiconductor stock we have analyzed.

Despite these risks, we still hold NVIDIA for its potential to be the continued leader of the AI Revolution. Moreover, NVIDIA is also enabling the entire AI Revolution at this point and we expect it will take at least two years before we see any major competition for NVIDIA's most advanced chips. Considering NVIDIA's dominant position in the GPU market paired with its comprehensive software solutions that are helping businesses develop all kinds of new generative AI applications, NVIDIA is a stock that we want to continue to hold for the long term.

What Could Go Wrong With The Stock

- NVIDIA's customers are developing their own AI chips and these could replace NVIDIA chips in future AI systems.
- Competitors like AMD or Intel are trying to develop GPUs that are on par with those of NVIDIA and thus could start to chip away at NVIDIA's margins.
- The AI Revolution loses steam because of the inability of companies and startups to monetize generative AI.
- NVIDIA's high multiple contracts.

Company	**NVIDIA Corporation**
Stock Symbol	**NASDAQ: NVDA**
Semiconductor Category	Fabless
Stock Price	$444.67 (as of 10/09/2023)
Market Capitalization	$1.1 trillion

Headcount	26,196
Key End Markets and Products	Data center, gaming, autonomous driving, and visualization
Major Competitors	AMD, Broadcom, Intel, Alibaba, Google, Amazon, Baidu, and Tesla.
Total Revenue (ttm)	$32.7 billion
Gross Margin	65%
Revenue Breakdown	Data Center: 76% Gaming: 18% Professional Visualization: 3% Automotive and Other: 3%
Notable Customers	Amazon, Microsoft, Google, Meta, Tesla, and Dell.
Revenue % From Big Tech	80%
Revenue % Subject To The GSS	50%
Net Cash (Debt)	$6.5 billion
2024 EPS Estimates	$10.78
Forward P/E	41.4
2024 Sales Growth Estimates	102.8%
2024 Sales Growth Estimates	49.5%
Great Semi Shift Rating	**5**

Broadcom Inc. (NASDAQ: AVGO)

Background

Broadcom falls in the unique category of "giant fabless semiconductor conglomerate rollup black box companies." Well, maybe that's not a very broad category, but it certainly describes this company. Since its founding in 1991, Broadcom and its predecessor, Avago Technologies, have completed numerous, what could best be described as non-strategic mergers. For example, one of the recent targets of Broadcom's affection was Computer Associates, a company that created software for running mainframe computers (a sector that has been shrinking for 20 years), which Broadcom bought for $18.9 billion in July 2018. This acquisition came as a surprise to most because it was only four months earlier that President Trump blocked Broadcom's proposed $130 billion acquisition of Qualcomm (QCOM). Desperate? More recently, Broadcom is attempting to buy VMware (VMW) for $61 billion. VMware is a cloud computing and virtualization technology company, not a chipmaker.

Business Model

Today, Broadcom's self-described "diverse portfolio" of products and services includes a variety of chips used in networking, data centers, automobiles, communications, and industrial applications. The products include "*data center switches and routers, set-top/CMTS, cable modems, and PON/DSL, Ethernet NICs, filters and amplifiers, ASIC, wireless*

connectivity solutions, embedded processors, HDD/SSD controllers, enterprise SAS/SATA/Fibre Channel connectivity, optical isolation/motion encoders/LEDs, and fiber optic solutions." Wow, that's a lot. This is in addition to their expansive software offerings which include the slow-growing mainframe computer software.

Despite such an expansive suite of products and services, we know very little about the individual performance of Broadcom's business segments. This is because Broadcom's two reportable segments include "Semiconductor Solutions" and "Infrastructure Software." This is in stark contrast to almost every other semiconductor stock that typically breaks down its business segments by end market, providing would-be investors color on the relative size, growth, and profits between various business lines. This is especially helpful for investors in obscure conglomerates/rollups like Broadcom.

What we do know about Broadcom is that the company believes the aggregate sales to its top 5 end customers (big tech) accounted for 35% of its net revenue in 2022. The company also "believes" that its aggregate sales to Apple alone accounted for approximately 20% of its net revenue for the last two years.

Our Outlook

We see a tough road ahead for the world's fourth most valuable semiconductor company, Broadcom. The company's growth plan is centered on aggressively completing acquisitions and ratcheting up prices to maintain extraordinary gross margins. We think that Broadcom has grown to the point that it has become unsustainable for it to continue its debt-fueled M&A activity at the same size and pace as it has over the last 30 years.

Moreover, the company remains overly concentrated on big tech companies like Apple and Google that have the capability and incentive to design their own chips. It was recently reported that Google is considering moving away from Broadcom's custom-designed AI chips for Google's data centers, although both companies later denied this. We estimate that upwards of 30% of Broadcom's revenue is subject to elimination as big tech companies continue to move to in-house silicon over the next decade. Lastly, we don't like the black boxes that are Broadcom's financial statements. While the company owns some valuable IP that will keep it kicking for years to come, we see little opportunity for growth from these levels and anticipate that the path of least resistance for Broadcom's revenues, profits, and market cap are lower. We are short AVGO stock.

That said, Broadcom is a behemoth and may be able to continue its roll-up strategy for longer than we expect. As mentioned, it is the fourth most valuable semiconductor company in the world and generated over $35 billion in revenue last year. The stock has been one of the best performers in the Philadelphia Semiconductor Index (SOX) over the last decade, up over 24x while the SOX was up just over 6x. While we are not saying that past performance is indicative of future results, calling a top in Broadcom today is not something we take lightly. Given its massive market capitalization, Broadcom could use its stock as currency to continue rolling up competitors and expanding its market share. In the near term, the VMware acquisition will also likely juice Broadcom's earnings once it closes.

What Could Go Wrong With The Stock

- Broadcom's biggest customers design more of their chips in-house and eliminate Broadcom's chips from future applications, especially in important end markets

like data centers that the company is currently claiming will drive significant future growth.

- The company's rollup strategy proves to be unsustainable given Broadcom's current size and policymakers' recent acts to block Broadcom's largest-ever attempted acquisition of Qualcomm.
- Broadcom's financials turn out to be overstated or inaccurate.
- Broadcom is unable to generate sufficient cash flow to service its high debt load.

Company	**Broadcom Inc.**
Stock Symbol	**NASDAQ: AVGO**
Semiconductor Category	Fabless
Stock Price	$808.36 (as of 09/21/23)
Market Capitalization	$333.64 billion
Key End Markets and Products	Broadband (STB and Broadband Access) Networking (Data Center, Service Providers, Enterprise and Embedded Networking) Wireless (Mobile Device Connectivity, RF, Wifi, GPS, inductive charging ASICs) Storage (Servers and Storage systems, HDD and SSD (SAS and RAID controllers, PCIe switches) Industrial (factory automation, renewable energy, auto (optocouplers, fiber optics,

	motion control, LED, ethernet)
Major Competitors	ADI, AMD, Cisco, Wolfspeed, Marvell, MediaTek, NVIDIA, Microchip, NXP, onsemi, Qorvo, Qualcomm, STM, Intel, TI, Synaptics, Atlassian, BMC, Cisco, CrowdStrike, CyberArk, IBM, Microsoft, New Relic, Oracle, Salesforce, ServiceNow, Splunk, and Zscaler.
Total Revenue (ttm)	$35.454 billion
Gross Margin	68.28%
Revenue Breakdown	Semiconductor solutions: 78% Infrastructure software: 22%
Notable Customers	Apple, Google, Microsoft, Amazon, Dell, Honeywell, HP, Motorola, IBM, Asus, Lenovo, etc.
Revenue % From Big Tech	40%
Revenue % Subject To The GSS	30%
Net Cash (Debt)	($26.17 billion)
2023 EPS Estimates	$39.37
Forward P/E	20.53

2023 Sales Growth Estimates	7.8%
2024 Sales Growth Estimates	8.1%
The Great Semi Shift Rating	**1.5**

Advanced Micro Devices, Inc. (NASDAQ: AMD)

Background

AMD was founded in 1969 and is headquartered in Santa Clara, California after eight employees led by Jerry Sanders left Fairchild Semiconductor to start their own company. Historically, AMD was Intel's main competitor in the CPU market, especially in the desktop and server segments. In the graphics arena, AMD, through its acquisition of ATI Technologies in 2006, competes primarily with NVIDIA.

Despite founder Jerry Sanders famously saying that “Real men have fabs,” AMD spun out its fabs in 2009 creating GlobalFoundries. Since then, the company has been entirely fabless and relies primarily on TSMC to produce its most advanced processors.

AMD struggled to keep up with Intel for many years and was on the brink of bankruptcy before the current CEO, Dr. Lisa Su, took over in 2014. Su pushed AMD to diversify away from the PC market and was also able to lead the company to technology leadership by utilizing TSMC and its advanced process nodes. Su made the decision to have AMD focus on high-performance computing because she believed it was more in line with AMD’s core competencies, and chose not to focus on less-advanced processors in the IoT and mobile markets, even though those markets were growing rapidly.

Su's bets paid off. AMD's share of the CPU market has risen to about 35% from a low of 17.5% in 2016. Su also led AMD back into the data center market in 2017, and the company now controls about 20% of the data center CPU market. Under Su's leadership, AMD's stock has risen about 4100%.

AMD recently completed the largest chip acquisition in history with its $49 billion purchase of Xilinx, a company that primarily supplied FPGAs (field programmable gate arrays). This further put AMD in competition with Intel which also has a sizable FPGA segment. However, in October 2023, Intel announced its intent to spin off its FPGA group in the next two to three years.

Business Model

AMD has five strategic pillars that it expects will drive its future growth: "compute technology leadership, expanding data center leadership, enabling pervasive artificial intelligence(AI), providing software platforms and developer enablement, and designing custom silicon and solutions." AMD spends heavily on research and development and has a good track record under Su's leadership of developing innovative technology. The company is currently playing catch up with NVIDIA in the GPU market and currently does not have a chip that can compete with NVIDIA's A100 and H100s in terms of performance, nor does AMD have a software platform like NVIDIA's CUDA to help design applications using AMD's chips. Additionally, sites like Tom's Hardware have reported that Intel's latest chips produced using its 7nm node achieve better performance than AMD's latest Ryzen CPUs.

Our Outlook

AMD has a good grip on the gaming market (which is its largest revenue driver) as it currently supplies the CPUs for Microsoft's Xbox and Sony's Playstation, but is seemingly falling behind Intel's CPUs and NVIDIA's GPUs. Additionally, AMD supplies the chips for Tesla's (one of our favorite longs) infotainment system, and AMD's products were used in some of SpaceX's (another one of our favorites) spacecraft. However, the company has been struggling, and in the most recent quarter, every operating segment other than gaming saw significant declines year over year. Notably, AMD's PC business was down 54% Y/Y, and the data center business was down 11% Y/Y. We think AMD may struggle to catch up to Intel and NVIDIA in the near term and the stock is priced to perfection. Trading at 38x 2023 estimates, we are currently long puts on AMD.

What Could Go Wrong With The Stock

- AMD fails to keep up with Intel and NVIDIA and loses market share.
- Microsoft and Sony take silicon design in-house (or switch to a competitor) for the Xbox and Playstation, respectively.
- AMD's stock is priced to perfection and the valuation could return to historical levels.

Company	**Advanced Micro Devices, Inc.**
Stock Symbol	**NASDAQ: AMD**
Semiconductor Category	Fabless
Stock Price	$105.60 (as of 10/09/2023)
Market Capitalization	$170.8 billion
Headcount	25,000
Key End Markets and Products	Data center, gaming, PCs, automotive.
Major Competitors	Intel, NVIDIA, Lattice Semi, Microchip, Broadcom, Marvell, ADI, TI, and NXP.
Total Revenue (ttm)	$21.8 billion
Gross Margin	44%
Revenue Breakdown	Data Center: 26% Client: 26% Gaming: 29% Embedded: 19%
Notable Customers	Sony, Microsoft, Meta, Tesla, SpaceX, Amazon, Google, Oracle, Tencent, and Subaru.
Revenue % From Big Tech	40%
Revenue % Subject To The In-House Silicon Revolution	40%
Net Cash (Debt)	$4.2 billion

2023 EPS Estimates	$2.76
Forward P/E	38.3
2023 Sales Growth Estimates	-3.3%
2024 Sales Growth Estimates	20.4%
Great Semi Shift Rating	**3**

Qualcomm Incorporated (NASDAQ: QCOM)

Background

Established in 1985 and based in San Diego, California, Qualcomm specializes in wireless technology. It played a foundational role in the development and proliferation of CDMA (Code Division Multiple Access) and subsequent 3G, 4G, and 5G technologies. Qualcomm's core products encompass a broad spectrum, with a strong emphasis on chipsets for mobile devices, notably the Snapdragon series of processors. Beyond chip design, Qualcomm is also known for its extensive patent portfolio in wireless communications, enabling it to earn substantial licensing revenues.

Business Model

Qualcomm essentially developed, patented, and then standardized much of the technology that is used in modern cellular communication. Today, almost any company that makes devices or equipment that use 3G, 4G, or 5G must pay Qualcomm royalties to license its technologies. In addition to its core 3G, 4G, and 5G technologies, Qualcomm owns a huge suite of patents that include essential technologies in Wi-Fi, memory interfaces, wireless power, GPS, broadcast and streaming protocols, and Bluetooth. Licensing revenue currently accounts for about 16% of Qualcomm’s sales.

In addition to licensing its IP, Qualcomm designs and distributes chips based on its proprietary technology. Qualcoomm's "Snapdragon" lineup of chips includes modems and other RF products (which connect phones to cellular networks) and SoCs (essentially all-in-one processors). The Snapdragon processors currently power a huge chunk of Android phones in addition to a number of other non-Apple devices like Meta's Quest VR/AR headset, Google's Chromebook, and Samsung's Tablets. In 2022, Qualcomm commanded 31% market share in SoCs for handsets, second only to Taiwan-based MediaTek.

Apple currently uses Qualcomm's 5G modem but the two companies have had an extremely tumultuous relationship. Apple and Qualcomm have sued other multiple times regarding patent infringement, patent fees, etc. According to Edward Snyder, a managing director of Charter Equity Research and a wireless industry expert, Apple "hate[s] Qualcomm's living guts."

In 2019, Apple acquired Intel's modem division and is in the process of developing its own modems in hopes that it can one day eliminate Qualcomm's chips from the iPhone. While Apple originally expected to have its own modems ready by 2024, Apple's chips reportedly had poor performance and Apple was recently forced to extend its contract with Qualcomm through 2026.

Our Outlook

Qualcomm's connectivity technology is certainly Revolutionary and the company's products are obviously not easily replicable as shown by Apple's failure to build its own modems on schedule. That said, Apple is investing billions of

dollars to develop its 5G modem and it is probably only a matter of time before they are able to eliminate Qualcomm from the iPhone. Currently, Qualcomm is dependent on Apple and Samsung for 42% of its revenue, and both companies have the incentive and likely the capability to design Qualcomm's chips out of their products. And even if Apple and Samsung don't eliminate Qualcomm entirely, we do not see much secular growth for smartphones going forward. While we appreciate Qualcomm's attempts to diversify away from smartphones and focus on the industrial, IoT, and automotive end markets, those revenue streams pale in comparison to the smartphone business, and we expect it will be quite some time before those become meaningful drivers of Qualcomm's bottom line.

What Could Go Wrong With The Stock

- Apple and/or Samsung develop their own chips that allow them to eliminate Qualcomm's products.
- Qualcomm is unable to successfully supplement its likely declining smartphone business with revenue from new end markets like automotive.
- Growth in the smartphone market stagnates and/or Qualcomm loses market share to its biggest rival, MediaTek.

Company	**Qualcomm Incorporated**
Stock Symbol	**NASDAQ: QCOM**
Semiconductor Category	Fabless
Stock Price	$111. 65 (as of 10/09/23)
Market Capitalization	$124.6 billion

Headcount	51,000
Key End Markets and Products	Mobile, industrial, IoT, and automotive.
Major Competitors	Apple, Broadcom, MediaTek, NVIDIA, NXP, Qorvo, Samsung, Skyworks, TI
Total Revenue (ttm)	$35.85
Gross Margin	56.31%
Revenue Breakdown	Handsetts: 66% RFFE: 11% Automotive: 4% IoT: 19%
Notable Customers	Apple, Samsung, Meta, Asus, and Lenovo.
Revenue % From Big Tech	50%
Revenue % Subject To The In-House Silicon Revolution	50%
Net Cash (Debt)	($5.9 billion)
2023 EPS Estimates	$8.31
Forward P/E	13.4
2023 Sales Growth Estimates	-19.2%
2024 Sales Growth Estimates	5.2%
The Great Semi Shift Rating	**3**

Marvell Technology, Inc. (NASDAQ: MRVL)

Background

Founded in 1995, Marvell Technology Group is a semiconductor company specializing in data infrastructure solutions. The company's product suite encompasses Ethernet switches, PHYs, and controllers for high-speed data transmission; storage solutions like SSD and HDD controllers for data storage and retrieval; custom ASICs tailored to specific applications; wireless solutions for Wi-Fi and Bluetooth connectivity; Arm-based processors for various devices; and embedded security features to ensure data protection. Serving diverse sectors from data centers to automotive systems, Marvell addresses the evolving demands of a data-centric global landscape.

Business Model

Marvell is a leader in networking and data center chips and also has a significant ASIC business that makes custom chips for large companies. Specifically, several major cloud customers are using Marvell’s technology to design custom accelerators to handle generative AI workloads. Marvell is utilizing its vast

experience and IP to help cloud companies design ASICs utilizing 5nm and 3nm process nodes.

Our Outlook

Marvell saw significant growth in its automotive business (up 32% y/y) and is also taking market share with 5G carriers. The company's traditional on-premises enterprise segment declined as more and more companies moved data to the cloud. Marvell probably has some of the best networking products for the AI Revolution including its electro-optics platform, which facilitates the movement of data between compute clusters at the data center.

There is a lot to like about Marvell. The company is well-positioned for The AI and Driverless Revolutions and is already developing ASICs for cloud companies looking to get away from NVIDIA's expensive H100s and A100s. However, the stock is not cheap (trading at 35x 2023 earnings estimates) and Marvell faces a lot of competition for networking equipment from companies like Broadcom, NXP, and Microchip.

What Could Go Wrong With The Stock

- Marvell stops gaining market share and/or its growth slows down in key end markets like data center and automotive.
- Marvell struggles if its technology falls behind other players like Broadcom or NXP.
- Large cloud customers design Marvell's products out of their data centers, replacing them with in-house silicon.
- Marvell is disrupted by smaller competitors like Credo.

Company	**Marvell Technology, Inc.**
Stock Symbol	**NASDAQ: MRVL**
Semiconductor Category	Fabless
Stock Price	$54.27 (as of 10/09/23)
Market Capitalization	$46.8 billion
Headcount	7,448
Key End Markets and Products	Data center (ethernet switching, network-attached storage, servers, interconnects), Enterprise networking (routers, switches, WAPs, firewalls, workstations) Carrier infrastructure (broadband access systems, switches, optical transport systems, routers, wireless RAN systems), Consumer (gateways, routers, gaming consoles, home data storage, WAPs, PCs, printers) and Automotive (ADAS, AV, networking, switches, video surveillance).
Major Competitors	AMD, Astera Labs, Broadcom, Cisco, Credo, Intel, MediaTek, Microchip, Montage, NVIDIA, NXP, Qualcomm, and Realtek.
Total Revenue (ttm)	$5.6 billion
Gross Margin	45%

Revenue Breakdown	Data center: 41% Enterprise networking: 23% Carrier infrastructure: 18% Consumer: 12% Automotive/industrial: 6%
Notable Customers	Not publicly disclosed, but likely includes Google, Amazon, Microsoft, etc.
Revenue % From Big Tech	25%
Revenue % Subject To The In-House Silicon Revolution	25%
Net Cash (Debt)	($2.7 billion)
2024 EPS Estimates	$1.54
Forward P/E	35.2
2024 Sales Growth Estimates	-6.6%
2025 Sales Growth Estimates	18.0%
The Great Semi Shift Rating	**5**

MediaTek Inc. (TWSE: 2454.TW)

Background

Founded in 1997 and based in Taiwan, MediaTek Inc. is the fifth largest global fabless semiconductor company in terms of revenue. MediaTek initially focused on optical storage chipsets and home entertainment solutions but has since diversified into various semiconductor technologies, including chips for smartphones, HDTV, DVD players, and wireless communications.

MediaTek is known for its System-on-Chip (SoC) solutions in the mobile and home entertainment markets. It rose to prominence as a major supplier of cost-effective, yet powerful chips for smartphones, particularly in emerging markets. The company has also been a significant player in the development of 5G technologies and has broadened its portfolio to include AI-computing, IoT devices, and automotive solutions. The company states that its devices power 2 billion devices per year.

Business Model

MediaTek is the largest SoC designer for handsets, commanding 34% of the market in 2022, followed by Qualcomm (31%), Apple (16%), Unisoc (10%), Samsung (7%), and Huawei (2%). These processors are used in Android-based phones made by Samsung, ASUS, and others. MediaTek

processors are also used in Chromebooks made by Acer, ASUS, HP, and Lenovo. TSMC and UMC produce almost all of MediaTek's chips.

Our Outlook

MediaTek is a good company and has been able to take the top spot in SoCs for mobile devices despite fierce competition from Qualcomm. Analysts are expecting a big pullback in sales in 2023 due to the global slowdown in smartphone shipments. We do not see a lot of secular growth in the smartphone market going forward, but MediaTek appears to be doing a better job of diversifying into other end markets compared to rival Qualcomm. MediaTek is already in many Chromebooks and it has introduced a lot of products for the IoT. Additionally, MediaTek is actively helping its customers design ASICs using its technology, which might help the company mitigate some of the effects of the GSS. The company pays a 9% dividend but the stock is only traded on the Taiwanese exchange, otherwise, this might be one we would consider owning if the stock were to get crushed further.

What Could Go Wrong With The Stock

- MediaTek loses market share to Qualcomm or other SoC competitors.
- The global slowdown in handset demand lasts longer than expected, weighing on MediaTek's sales.
- Samsung or Google design their own SoCs that replace MediaTek's chips in their products.

Company	**MediaTek Inc.**
Stock Symbol	**TWSE: 2454.TW**
Semiconductor Category	Fabless
Stock Price	$825.00 TWD (as of 10/17/2023)
Market Capitalization	$40.92 billion
Headcount	21,956
Key End Markets and Products	Smartphones, smart home, networking, IoT, Chromebooks, and ASICs
Major Competitors	Qualcomm, Broadcom, SMTC, NXP, Marvell, Power Integrations, and MaxLinear
Total Revenue (ttm)	$13.76 billion
Gross Margin	48.4%
Revenue Breakdown	Not disclosed
Notable Customers	Samsung, Google, Acer, ASUS, HP, Lenovo, and Motorola
Revenue % From Big Tech	15%
Revenue % Subject To The In-House Silicon Revolution	15%
Net Cash (Debt)	$5.7 billion
2023 EPS Estimates	$42.42 TWD
Forward P/E	19.4

2024 Sales Growth Estimates	-23.8%
2025 Sales Growth Estimates	18.3%
The Great Semi Shift Rating	**3.5**

Monolithic Power Systems, Inc. (NASDAQ: MPWR)

Background

Monolithic Power Systems makes high-performance analog semiconductors. Michael Hsing founded the company in 1997 with the belief that an entire power system could be integrated onto a single chip. The company's diverse product portfolio spans power management products used across various markets such as industrial, automotive, communications, and consumer electronics.

Business Model

The company considers its three core strengths to be "deep system-level knowledge, strong semiconductor expertise, and innovative proprietary technologies in the areas of semiconductor processes, system integration, and packaging." Monolithic's key products are DC to DC semiconductors, which convert and control voltages within a broad range of electronic systems, from computer monitors to medical devices.

Monolithic claims that its products are differentiated because they are highly integrated, smaller in size, more energy-efficient, and more accurate with respect to performance specifications. The company is focusing on developing next-

generation technologies like silicon carbide (SiC) for data centers and battery management solutions.

Our Outlook

Monolithic is a leader in power semiconductors and seems to have an edge in high-growth end markets like data centers and automotive. However, the company faces intense competition from other analog device makers like ADI and TI who own some of their own fabs and probably have more competitive advantages than Monolithic. Lastly, the company is trading a big premium (40.5 forward p/e) to its analog-semiconductor peers, although it is growing about twice as fast.

What Could Go Wrong With The Stock

- Nearly all (86%) of Monolithic's sales come from OEMs in Asia, and Monolithic could be hurt by further geopolitical tensions around Taiwan.
- The company faces stiff competition and could fail to keep up with fab-lite competitors like ADI and TI.
- Monolithic loses market share to Fab-Lite companies like TI or ADI who have better control of the design and production of their products.

Company	**Monolithic Power Systems, Inc.**
Stock Symbol	**NASDAQ: MPWR**
Semiconductor Category	Fabless
Stock Price	$476.02 (as of 10/09/2023)
Market Capitalization	$22.7 billion

Headcount	3,247
Key End Markets and Products	Cloud computing, enterprise, automotive, industrial, communications, and consumer
Major Competitors	Analog Devices, Infineon Technologies, NXP Semiconductors, ON Semiconductor, Power Integrations, Renesas Electronics, ROHM Semiconductor, Semtech and Texas Instruments.
Total Revenue (ttm)	$1.85 billion
Gross Margin	58%
Revenue Breakdown	Storage & Computing: 25.3% Enterprise Data: 14% Automotive: 16.7% Industrial: 12.2% Communications: 14% Consumer: 17.8%
Notable Customers	Not disclosed
Revenue % From Big Tech	20%
Revenue % Subject To The In-House Silicon Revolution	5%
Net Cash (Debt)	$940 million
2023 EPS Estimates	$11.76
Forward P/E	40.5

2023 Sales Growth Estimates	1.5%
2024 Sales Growth Estimates	14.9%
The Great Semi Shift Rating	**4**

Lattice Semiconductor Corporation (NASDAQ: LSCC)

Background

Established in 1983 and headquartered in Portland, Oregon, Lattice Semiconductor is focused on smart connectivity solutions. The company designs and develops various programmable logic devices, including field-programmable gate arrays (FPGAs) and complex programmable logic devices (CPLDs). These products are integral for tasks like hardware acceleration, signal processing, and interfacing. Lattice's solutions are widely adopted across sectors such as industrial, automotive, consumer, communications, and computing.

Business Model

While Intel and AMD dominate the high-end, high-performance FPGA markets, Lattice is focused on offering low-power FPGAs with smaller form factors. Lattice's FPGAs are ideal for edge devices, IoT applications, and other scenarios where power and size are constrained. Lattice's FPGAs consume power at very low rates and are I/O rich, meaning they have more connections with system ASICs.

Our Outlook

Lattice has shown some exceptional growth during a very difficult time for most semiconductor companies. Revenue

grew almost 18% Y/Y in the most recent quarter after the company grew a whopping 28% in 2022. Lattice's gross margins are also far above average for a fabless semiconductor, coming in at about 70% compared to 52% for its peers. A sizable portion of the company's revenue growth is coming from the industrial and automotive end markets, revenues from which were up 55% Y/Y in Q2 2023.

Despite Lattice's recent success, the company has been around for a long time and only recently surpassed its dot com bubble high of ~$40/share. For most of the last 20 years, the stock traded in a range between $2 and $7/share. The recent growth in AI-related cloud spending, the electrification of vehicles, and The Reshoring Revolution essentially brought Lattice back from the dead. With the stock trading at 15x sales and nearly 40x forward earnings, it is a little too rich for us.

What Could Go Wrong With The Stock

- Lattice faces competition from very big players for FPGAs like Intel, AMD, and Microchip Technologies.
- Microchip specifically has introduced low-power FPGAs that should give Lattice a run for its money.
- Lattice's high gross margins could come under attack as larger competitors enter the market.

Company	**Lattice Semiconductor Corporation**
Stock Symbol	**NASDAQ: LSCC**
Semiconductor Category	Fabless
Stock Price	$79.67 (as of 10/09/2023)
Market Capitalization	$11 billion
Headcount	949
Key End Markets and Products	Communications, computing, industrial, and automotive.
Major Competitors	Microchip, Intel, and AMD
Total Revenue (ttm)	$730 million
Gross Margin	70%
Revenue Breakdown	Communications & Computing: 42% Industrial & Automotive: 48% Consumer: 7% Licensing & Services: 3%
Notable Customers	ABB, Amazon, Boeing, Dell, Google, Meta, Rockwell Automation, Schneider Electric, and Sony
Revenue % From Big Tech	25%
Revenue % Subject To The In-House Silicon Revolution	10%
Net Cash (Debt)	$49 million

2023 EPS Estimates	$2.08
Forward P/E	38.3
2023 Sales Growth Estimates	15.4%
2024 Sales Growth Estimates	13.1%
The Great Semi Shift Rating	**4**

Allegro Microsystems, Inc. (NASDAQ: ALGM)

Background

Allegro MicroSystems, Inc. focuses on the design, manufacture, and sale of analog power ICs, microcontrollers, and Hall-effect sensor integrated circuits. These products are key components in the rapidly growing automotive and industrial markets, addressing pressing needs for power conservation and precision measurement. Allegro's solutions primarily target applications like electric and hybrid vehicles, industrial automation, and robotics. Their portfolio encompasses motor drivers, voltage regulators, and magnetic sensors, among other products. Allegro's sensors allow systems to precisely measure motion, speed, position, and current. Allegro divested its manufacturing facilities in 2020 and 2021.

Business Model

Allegro is a major supplier of magnetic sensor IC solutions to the auto industry and also has a significant presence in the power ICs and photonics markets. Allegro's chips are used in electric powertrains and advanced driver assistance systems (ADAS), aka, semi-self-driving cars. The company sells to all of the traditional automakers. Currently, the company is strategically focused on multiple growth areas such as e-mobility, clean energy, and automation. Yet, at its core, Allegro operates with an "Automotive First" mindset, evidenced by the

fact that close to 70% of its 2022 revenue originated from the automotive sector.

In a move to further bolster its offerings, the company acquired Heydey Integrated Circuits in 2023, which specializes in designing fully integrated, isolated gate drivers tailored for GaN and SiC material applications. An isolated gate driver serves as an interface between a microcontroller and power transistors, like MOSFETs or IGBTs. It's designed to control the transistor by switching it on and off but does so in a way that electrically isolates the control circuit from the power circuit. This isolation is crucial for protecting sensitive components from voltage spikes and electrical noise generated in high-power applications.

Our Outlook

We think Allegro could see a slowdown in its revenue growth as most of the legacy automakers struggle to successfully roll out their EV offerings. Based on our research, Allegro does not sell to Tesla or Rivian, and thus its success will be highly dependent on the ultimate success of traditional automakers like Ford, GM, and Stellantis. Given our doubts about the legacy automakers' ability to make the transition, we are staying away from Allegro for now.

What Could Go Wrong With The Stock

- Traditional automakers struggle to make the transition to electric vehicles and Allegro's growth slows down accordingly.
- Larger analog semiconductor companies like TI, ADI, and Monolithic power could beat Allegro as the largest

suppliers of power semiconductors and sensors for the auto industry.

- A slowdown in industrial spending limits Allegro's growth prospects.

Company	**Allegro MicroSystems, Inc.**
Stock Symbol	**NASDAQ: ALGM**
Semiconductor Category	Fabless
Stock Price	$30.42 (as of 10/09/23)
Market Capitalization	$5.9 billion
Headcount	4,687
Key End Markets and Products	Automotive and industrial
Major Competitors	ADI, Infineon, Melexis, Monolithic Power Systems, TDK Micronas, and TI
Total Revenue (ttm)	$1.03 billion
Gross Margin	57%
Revenue Breakdown	Automotive: 68% Industrial: 20% Other: 12%
Notable Customers	Ford, GM, Stellantis, Toyota, Hyundai, and other major OEMs.
Revenue % From Big Tech	0%
Revenue % Subject To The In-House Silicon Revolution	10%

Net Cash (Debt)	$328 million
2024 EPS Estimates	$1.48
Forward P/E	20.6
2024 Sales Growth Estimates	12.7%
2025 Sales Growth Estimates	7.8%
The Great Semi Shift Rating	**4**

Power Integrations, Inc. (NASDAQ: POWI)

Background

Power Integrations specializes in power conversion semiconductors. Established in 1988, the company's focus has always been on high-voltage process and device technologies including gallium-nitride (GaN). Primarily, Power Integrations' chips are used in power converters that convert electricity from a high-voltage source to the type of power required for a specified downstream use. These ICs are employed in a myriad of devices and products, ranging from home appliances and consumer electronics to industrial systems. Power Integrations came public in 1997 at a split-adjusted price of $2/share.

Business Model

Power Integrations casts itself as the only publicly traded pure play on high-voltage power semiconductors. Like many power semiconductor makers, Power Integrations saw a massive run-up in sales as the electrification of vehicles, industrial buildup, and renewable energy waves all hit at the same time. The company is counting on continued growth in high-power applications like industrial motors, solar- and wind-power systems, EVs, and high-voltage DC transmission systems.

Our Outlook

We expect Power Integrations will continue to see secular growth as many of its key end markets should grow for the foreseeable future. However, the company has lots of competition from larger firms including those that manufacture their own products like STMicro. The stock is up big from its historical trading range and we think any prolonged weakness in sales could send this stock much lower.

What Could Go Wrong With The Stock

- Legacy automakers struggle to make the transition to EVs.
- Broader economic weakness.
- Power Integrations falls behind IDMs.

Company	**Power Integrations, Inc.**
Stock Symbol	**NASDAQ: POWI**
Semiconductor Category	Fabless
Stock Price	$78.18 (as of 10/10/2023)
Market Capitalization	$4.5 billion
Headcount	831
Key End Markets and Products	Communications (phone chargers, adapters for routers, modems), Computer (PCs, servers, adapters for tablets), Consumer (appliances, HVAC, TVs, consoles), and Industrial (LEDs, meters, motor controllers,

	locomotives).
Major Competitors	STMicro, Infineon, NXP, Diodes, MediaTek, Broadcom, onsemi, and Fuji Electric.
Total Revenue (ttm)	$515 million
Gross Margin	54%
Revenue Breakdown	Communications: 21% Computer: 10% Consumer: 33% Industrial: 36%
Notable Customers	Avnet and Honestar Technologies (distributors)
Revenue % From Big Tech	15%
Revenue % Subject To The In-House Silicon Revolution	0%
Net Cash (Debt)	$346 million
2023 EPS Estimates	$1.64
Forward P/E	47.7
2023 Sales Growth Estimates	-23.4%
2024 Sales Growth Estimates	19.9%
The Great Semi Shift Rating	**3.5**

Cirrus Logic, Inc. (NASDAQ: CRUS)

Background

Cirrus Logic is known for its expertise in mixed-signal audio and voice semiconductors. The company designs products that enhance the audio experience in various consumer devices, including smartphones, tablets, smart home applications, and more. Its product portfolio encompasses both analog and digital signal processing technologies and includes a range of audio converters, audio DSPs (digital signal processors), and amplifiers. Additionally, Cirrus Logic has ventured into solutions for voice processing, haptic drivers, camera controllers, and battery and power ICs. Founded in 1984, Cirrus Logic has become a prominent player in the audio IC market, collaborating with many leading technology manufacturers to integrate its solutions into a wide array of consumer electronics.

Business Model

As might be expected, Cirrus has outsized exposure to the major smartphone makers. In this case, that exposure is to one customer: Apple. For the last three years, Apple represented between 79% and 83% of Cirrus' revenue. While Apple has not expressed an intent to eliminate Cirrus chips from its phones (unlike it has done with Qualcomm), it is clearly a concern for Cirrus and investors. In April 2023, Cirrus shares dropped about 13% one day after an analyst predicted that Apple would be

keeping an existing button on the iPhone and not switching to a button presumed to be supplied by Cirrus.

Cirrus has obviously been focused on diversifying away from Apple and has recently had some success with Android phone makers. Additionally, Cirrus' non-audio products like its camera controllers, charging devices, and haptic devices have seen significant growth over the last few quarters, however much of these new chips are still going into Apple products.

Our Outlook

We think Cirrus is struggling to find its footing as it attempts to move away from its traditional iPhone audio business. The company had forecasted stronger growth in its HPMS business but was forced to cut its guidance when Apple chose not to switch the design of the haptic button that apparently Cirrus was planning on selling to Apple. The company has good management and a sound balance sheet, but there is just no getting around the 79%-83% gorilla that is Apple. If Cirrus is able to continue getting design wins with Android makers, PC companies, etc. the company could return to growth, but with the looming possibility that Apple could take the design of its audio products in-house, we think the risk/reward setup for Cirrus is not great here.

What Could Go Wrong With The Stock

- Cirrus is unable to diversify away from Apple, thus limiting its growth for the foreseeable future.
- Apple takes the design of Cirrus' products in-house.
- Even if all else remains the same, growth in the smartphone business is limited for the next few years, thereby limiting Cirrus' growth concurrently.

Company	**Cirrus Logic, Inc.**
Stock Symbol	**NASDAQ: CRUS**
Semiconductor Category	Fabless
Stock Price	$70.42 (as of 10/09/23)
Market Capitalization	$3.9 billion
Headcount	1,719
Key End Markets and Products	Smartphones, headsets, wearables, PCs, tablets, smart home, and speakers
Major Competitors	AKM Semiconductor, ADI, Goodix, Infineon, MPWR, Realtek, Skyworks, STM, Synaptics, TI, and multiple Chinese entities.
Total Revenue (ttm)	$1.8 billion
Gross Margin	50.2%
Revenue Breakdown	Audio: 62% High-Performance Mixed-Signal: 38%
Notable Customers	Apple
Revenue % From Big Tech	83%
Revenue % Subject To The In-House Silicon Revolution	83%
Net Cash (Debt)	$263 million
2024 EPS Estimates	$5.26

Forward P/E	13.4
2023 Sales Growth Estimates	-11.3%
2024 Sales Growth Estimates	9.9%
The Great Semi Shift Rating	**2**

SiTime Corporation (NASDAQ: SITM)

Background

SiTime Corporation is engaged in the design and production of MEMS (Micro-Electro-Mechanical Systems) timing semiconductors. These products are used to ensure synchronization and precision in a wide array of electronic devices, from mobile phones and cloud infrastructure to industrial systems and aerospace applications. Their solutions aim to outperform traditional quartz-based devices in resilience, accuracy, and flexibility. SiTime was spun out of MegaChips Corporation, a Japanese fabless chip maker in 2019, and MegaChips still owns approximately 23% of SiTime.

Business Model

SiTime's timing chips are designed into over 300 applications across end markets including communications, automotive, industrial, aerospace, mobile, IoT, and consumer. The company's largest customer is Apple, which constituted 20% of the company's revenue in 2022, down from 40% in 2020. SiTime's total revenue was down 28% Y/Y in the most recent quarter, allegedly due to the fact that its customers were still working through excess inventory.

Our Outlook

We are very leery of SiTime given the CEO's, Rajesh Vashist, background. From 1999 to 2006, he was the Chairman & CEO of Ikanos Communications (NASDAQ: IKAN), a communication semiconductor company. That company was sued for securities fraud and the following allegations are taken from court filings in that case. In January 2006, Ikanos learned that there were major quality issues with its chips, which turned out to result in a 25-30% overall failure rate. These chips were sold to Ikanos' two largest customers which constituted 72% of the company's revenue from the year before. At the time, Ikanos was already losing money and despite learning of this major deficiency in its products, Ikanos decided to do a secondary offering in March 2006 that raised $120 million for the company. CEO Vashist and the other executives personally sold $7.3 million in stock at the same time. In June 2006, Ikanos reached an agreement to replace all of the chips sold to its two largest customers at its own expense and the stock price collapsed.

Vashist eventually resigned from Ikanos and was later sued along with much of the management team for securities fraud. The Second Circuit Court of Appeals held that the shareholders of the company had a valid basis for their claim of securities fraud against Ikanos, Vashist, and most of the remaining management team.

On the SiTime website, Vashist's bio claims that he led Ikanos from a pre-revenue startup to a major company with 90% market share and a market value of $600 million. What his bio fails to mention is that he stepped down following the discovery

of the chip failure at Ikanos only after he and the rest of the management team sold millions of their own stock to shareholders who knew nothing of the failure of the company's chips. The stock fell over 50% after the news was revealed in late 2006 and never recovered. Ikanos was eventually sold to Qualcomm in 2015 for $47 million, a 92% drop from the $600 million valuation quoted in Vashist's current bio. In 2016, Qualcomm closed the Ikanos operations.

Given the CEO's history of alleged securities fraud and the massive drop in revenue in the last few quarters, we are long puts on SiTime. The stock is also very expensive, trading at 13x sales and 93x 2024 earnings estimates. SiTime's management is predicting a massive jump (25% sequential increase) in revenue from Apple next quarter and analysts are apparently taking the company's word for it. Further, SiTime is not the exclusive maker of MEMS timing solutions, as it faces competition from established companies like Microchip Technologies.

What Could Go Wrong With The Stock

- Sales to Apple may not increase as quickly as SiTime's management anticipates.
- The company's valuation could return to Earth.
- Management has a history of securities fraud allegations.
- The CEO's last public company resulted in a 92% loss for shareholders who bought at the peak.

Company	**SiTime Corporation**
Stock Symbol	***NASDAQ: SITM***

Semiconductor Category	Fabless
Stock Price	$117.95 (as of 10/10/23)
Market Capitalization	$2.6 billion
Headcount	377
Key End Markets and Products	Communications, automotive, industrial, aerospace, mobile, IoT, and consumer
Major Competitors	Abracon, Kyocera, Microchip, Seiko Epson, Skyworks, TI, and TXC Corp.
Total Revenue (ttm)	$200 million
Gross Margin	58%
Revenue Breakdown	Mobile, IoT, and Consumer: 38% Industrial, Automotive, and Aerospace: 44% Communications and Enterprise: 18%.
Notable Customers	Apple
Revenue % From Big Tech	20-40%
Revenue % Subject To The In-House Silicon Revolution	20-40%
Net Cash (Debt)	$568 million
2023 EPS Estimates	$0.16
Forward P/E	737.5

2023 Sales Growth Estimates	-48.6%
2024 Sales Growth Estimates	35.9%
The Great Semi Shift Rating	**1**

Credo Technology Group Holding Ltd
(NASDAQ: CRDO)

Background

Credo Technology Group Holding Ltd was founded in 2008 and specializes in the development of high-performance, low-power serial connectivity semiconductors. These products are used in networking infrastructure like data centers and enterprise networks. Credo's offerings encompass a range of advanced serializer-deserializer (SerDes) technology and advanced signal processing, enabling more efficient data transmission across high-speed networks. Advanced SerDes technology is basically a set of techniques used to convert parallel data into serial data and vice versa, facilitating high-speed data transmission over long distances while minimizing the number of data paths and thus reducing cost and complexity. Credo came public in January 2022 at a price of $10/share.

Business Model

Credo casts itself as a disruptor in the data infrastructure market. The company’s products reportedly achieve similar performance to leading existing products but at a lower cost, because Credo manufactures its products on legacy process nodes that are cheaper and more readily available. Credo’s products utilize traditional ethernet technology while its more expensive competitors (i.e. Marvell) use proprietary

interconnect technology. Credo also works with large customers like Microsoft that license its technology to develop their own ASICs. As might be expected, Credo's largest end customers are hyperscalers and other cloud providers, as well as wireless carriers like Verizon and AT&T.

The founders of the company are almost all former senior Marvell executives and engineers and the company's products primarily compete with those of Marvell. Credo reports that its products often consume as much as 50% less power than the optical-based solutions offered by competitors like Marvell. Credo is growing rapidly, with its sales more than 73% Y/Y in Fiscal 2023. This has been driven by the massive increase in cloud computing, and specifically the recent increases in cloud spending related to generative AI.

Our Outlook

Credo is one of the best pure plays to bet on the continued growth of the Cloud and AI Revolutions. The company is still in its early growth stages, but the fact that the company has been able to grow sales with the major public CSPs in the face of competition from Marvell and Broadcom is a testament to the Revolutionary nature of Credo's products. We think the possibility of using simpler, cheaper, and more power-efficient networking devices is a no-brainer for the CSPs.

In February of 2023, the company announced that one of its major cloud customers (most likely Microsoft) was significantly cutting its spending, and Credo's stock was cut in half in one trading session. The stock has since largely recovered, but that one-day move in the stock reflects the risk that comes along with having such a high customer concentration.

While we are bullish on the company, Credo's stock is expensive. The company is currently trading at over 14x sales and is barely profitable. With 60% plus growth expected next year, we think the company valuation can be justified. The company has plenty of cash on the balance sheet and by all accounts has a superior management team with the experience to take Credo to the finish line.

What Could Go Wrong With The Stock

- Credo's growth slows down due to a pullback in spending from the major CSPs.
- Marvell and Broadcom develop new products that compete with those of Credo in terms of cost, simplicity, and power efficiency.
- The major cloud companies develop their own products that replace Credo's.
- Credo's valuation contracts.

Company	**Credo Technology Group Holding Ltd**
Stock Symbol	**NASDAQ: CRDO**
Semiconductor Category	Fabless
Stock Price	$16.4 (as of 10/10/2023)
Market Capitalization	$2.5 billion
Headcount	438
Key End Markets and Products	Hyperscalers, cloud infrastructure providers, and wireless networks

Major Competitors	Marvell and Broadcom
Total Revenue (ttm)	$173 million
Gross Margin	58%
Revenue Breakdown	Product sales: 77% IP licensing: 16% Engineering Services: 7%
Notable Customers	Amazon, Google, and Microsoft
Revenue % From Big Tech	75%
Revenue % Subject To The In-House Silicon Revolution	75%
Net Cash (Debt)	$226 million
2024 EPS Estimates	$0.04
Forward P/E	410
2023 Sales Growth Estimates	3.1%
2024 Sales Growth Estimates	61.9%
The Great Semi Shift Rating	**5**

Ambarella, Inc. (NASDAQ: AMBA)

Background

Ambarella is a semiconductor design company known for its high-definition video compression, image processing, and computer vision processors. Originally making a name for itself with solutions catered to the video compression space, Ambarella has since broadened its focus to various applications within the artificial intelligence (AI) domain. The company's products can be found in a wide array of devices, including security cameras, dash cams, body cams, robots, drones, and automotive cameras.

Business Model

Ambarella is attempting to pivot to becoming an AI company, although historically its products have had very little to do with generative AI. There is no doubt that autonomy depends on machines, cars, and robots being able to see and interact with the real world, but that trend has been ongoing and it was only with the recent AI hype cycle that Ambarella suddenly reclassified many of its existing products as “AI products.”

Our Outlook

We are concerned that Ambarella is trying too hard to become an AI company. The company saw a precipitous drop in sales

in the last few quarters (down about 25% in the most recent quarter), which is surprising given the company claims that demand for its "AI products" is growing rapidly. Moreover, the company came public in 2012 and has struggled to maintain profitability. Even though the COVID demand surge, when Ambarella's revenue surged 50%, the company managed to lose $26 million, or $0.72/share. The company has not turned in profit in the last four years.

What Could Go Wrong With The Stock

- Ambarella's attempted pivot to AI turns out to be nothing but hype.
- The company fails to achieve profitability.
- Ambarella's products become commoditized and erode the company's relatively high gross margins.
- 82% of Ambarella's comes from OEMs in Asia and is subject to geopolitical risk.

Company	**Ambarella, Inc.**
Stock Symbol	**NASDAQ: AMBA**
Semiconductor Category	Fabless
Stock Price	$55.45 (as of 10/10/2023)
Market Capitalization	$2.2 billion
Headcount	937
Key End Markets and Products	Automotive, security, consumer, IoT, and industrial.
Major Competitors	Huawei, Novatek, NVIDIA, OmniVision, Qualcomm,

	Mobileye, NXP, Qualcomm, and TI.
Total Revenue (ttm)	$291 million
Gross Margin	61%
Revenue Breakdown	Video processors: 40% AI inference SoCs: 60%
Notable Customers	Wintech Microelectronics, Chicony Electronics, GoPro, and Hakuto.
Revenue % From Big Tech	0%
Revenue % Subject To The In-House Silicon Revolution	10%
Net Cash (Debt)	$214 million
2024 EPS Estimates	-$1.09
Forward P/E	NM
2023 Sales Growth Estimates	-32.6%
2024 Sales Growth Estimates	16.0%
The Great Semi Shift Rating	**2.5**

Silicon Motion Technology Corporation (NASDAQ: SIMO)

Background

Silicon Motion Technology Corporation is a Taiwanese-American company that develops NAND flash controllers for solid-state storage devices. The company designs and markets SSD (solid-state drive) controllers, eMMC (embedded multimedia card), and UFS (Universal Flash Storage) controllers, which are essential for managing NAND flash memory in various electronic devices. These components find applications in devices like smartphones, tablets, PCs, and industrial and commercial products. Additionally, Silicon Motion provides SSD providers with SIMO's controllers and firmware for use in PCs and data centers.

Business Model

Silicon Motion's controllers are integrated with SSDs manufactured by major memory companies like Micron, Samsung, and Western Digital. Memory controllers are critical to the functionality of memory devices and handle things like processing, encryption, power-loss protection, and temperature monitoring. Most of Silicon Motion's sales are to NAND manufacturers, and in 2022 sales to Micron and SK Hynix constituted 45% of the company's net revenue.

MaxLinear (NASDAQ: MXL) attempted to acquire Silicon Motion for $4 billion, or $114.34 per share, but MaxLinear suddenly refused to proceed with the transaction in July of this year. MaxLinear cited “deteriorating business conditions” at Silicon Motion which caused a ton of volatility for both stocks. Silicon Motion has announced that it is suing MaxLinear for its failure to proceed with the acquisition.

Our Outlook

We are staying away from Silicon Motion for two reasons. First, we expect prolonged weakness in the memory market and think Silicon Motion faces a lot of competition for what is a relatively low-tech product. Its largest customers are both sophisticated memory chip makers with significant manufacturing capabilities, and it seems possible that those customers could design their own controllers for their memory products. Second, MaxLinear’s last-minute refusal to proceed with the acquisition of Silicon Motion does not bode well for the stock for obvious reasons.

What Could Go Wrong With The Stock

- Silicon Motion’s could lose its suit against MaxLinear for damages based on the latter's refusal to acquire the former.
- Prolonged weakness in the memory market keeps a damper on Silicon Motion’s sales for an extended period.
- Micron and SK Hynix could move to designing their controllers in-house.

Company	**Silicon Motion Technology**

	Corporation
Stock Symbol	**NASDAQ: SIMO**
Semiconductor Category	Fabless
Stock Price	$56.53 (as of 10/10/2023)
Market Capitalization	$1.9 billion
Headcount	1,643
Key End Markets and Products	PCs, data centers,
Major Competitors	Marvell, Phison, and Chinese merchant controller suppliers.
Total Revenue (ttm)	$716 million
Gross Margin	44%
Revenue Breakdown	SSD controllers: 50% eMMC and UFS controllers: 40% SSD solutions: 10%
Notable Customers	Micron and SK Hynix
Revenue % From Big Tech	0%
Revenue % Subject To The In-House Silicon Revolution	50%
Net Cash (Debt)	$250 million
2023 EPS Estimates	$1.97
Forward P/E	28.7

2023 Sales Growth Estimates	-35.4%
2024 Sales Growth Estimates	22.2%
The Great Semi Shift Rating	**2.5**

MaxLinear, Inc. (NASDAQ: MXL)

Background

MaxLinear focuses on providing radio-frequency (RF), analog, digital, and mixed-signal integrated circuits (ICs). Established in 2003, the company's products are designed primarily for broadband communications applications, spanning a variety of markets including cable and satellite broadband, video surveillance, and connected homes. MaxLinear's solutions aim to capture and process digital and analog broadband signals to be distributed in high-speed networks, data centers, and digital TVs.

Business Model

MaxLinear purports to be a leading provider of SoCs for broadband infrastructure. The company's focus is on building high-performance, low-cost semiconductors to gain share in its key end markets. Its two largest customers are Microsoft and Amazon, which collectively accounted for 31% of MaxLinear's revenue in 2022.

Our Outlook

We think MaxLinear is a small fish in a big pond. The company sells products that compete with giants like Broadcom, Qualcomm, Marvell, TI, and Microchip to some of the most

sophisticated buyers of chips in the world, Microsoft and Google. While the company has obviously had some success in this market, in the long run, this high level of competition and the possibility that Microsoft and Google could design their own broadband chips will likely keep a lid on the stock price. In the near term, MaxLinear's stock will be bogged down by the litigation with Silicon Motion which accused it of wrongfully breaching the agreement to purchase Silicon Motion.

What Could Go Wrong With The Stock

- Silicon Motion wins its lawsuit against MaxLinear claiming that it had no right to terminate the acquisition.
- Microsoft and Google design their own broadband chips.
- MaxLinear loses market share to giants like Broadcom, Marvell, or Microchip.

Company	**MaxLinear, Inc.**
Stock Symbol	**NASDAQ: MXL**
Semiconductor Category	Fabless
Stock Price	$22.53 (as of 10/11/2023)
Market Capitalization	$1.8 billion
Headcount	1,844
Key End Markets and Products	Data centers, 5G, and consumer
Major Competitors	Broadcom, Qualcomm, Realtek, Nokia, Skyworks, Xilinx, Altera, Credo,

	MediaTek, Marvell, MACOM, TI, ADI, and Microchip
Total Revenue (ttm)	$1 billion
Gross Margin	43%
Revenue Breakdown	Broadband: 44% Connectivity: 27% Infrastructure: 12% Industrial: 17%
Notable Customers	Amazon and Google
Revenue % From Big Tech	40%
Revenue % Subject To The In-House Silicon Revolution	40%
Net Cash (Debt)	$92 million
2023 EPS Estimates	$1.24
Forward P/E	18.1
2023 Sales Growth Estimates	5.7%
2024 Sales Growth Estimates	3.0%
The Great Semi Shift Rating	**3**

Semtech Corporation (NASDAQ: SMTC)

Background

Semtech Corporation is a supplier of analog and mixed-signal semiconductors. Founded in 1960, Semtech's product portfolio is diverse, encompassing solutions for industrial, communications, high-end consumer, and enterprise computing markets. Some of its key offerings include protection devices, power management products, and wireless RF technology. One of Semtech's well-recognized contributions to the tech industry is the LoRa technology, a long-range, low-power wireless platform used extensively in Internet of Things (IoT) networks worldwide.

Business Model

Semtech developed its own form of wireless communication known as LoRa. LoRa is great for the IoT because it enables long-range data communications (up to six miles) with very little power. It offers much lower bandwidth than cellular, Wi-Fi, or Bluetooth, but for many IoT applications, not much bandwidth is needed. Network operators like Alibaba Cloud, American Tower, and SK Telecom operate LoRaWAN networks. Additionally, innovative network deployments have emerged for companies like Helium, which is a blockchain/cryptocurrency-based LoRa network. Semtech recently acquired Sierra Wireless, a Canadian company, in a $1.3 billion all-cash transaction.

Our Outlook

Semtech's LoRa technology is interesting and we like the fact that it has become a sort of standard for wireless connection for many IoT devices. The ability to transmit data across a range of up to six miles with relatively low power is key for many sensors and other IoT devices. However, the company is barely profitable and only growing in the low single digits. Moreover, the company's recent all-cash acquisition left it saddled with $1.2 billion in net debt, which is nearly equivalent to the market cap of the company. For those reasons, we are staying out of Semtech.

What Could Go Wrong With The Stock

- Semtech struggles to achieve profitability.
- Better wireless technologies surpass Semtech's proprietary LoRa network.
- Semtech is unable to service its large debt load.

Company	**Semtech Corporation**
Stock Symbol	**NASDAQ: SMTC**
Semiconductor Category	Fabless
Stock Price	$23.39 (as of 10/11/2023)
Market Capitalization	$1.5 billion
Headcount	2,248
Key End Markets and Products	Infrastructure, consumer, industrial, and IoT

Major Competitors	ADI, STMicro, Infineon, onsemi, and MediaTek
Total Revenue (ttm)	$820 million
Gross Margin	51%
Revenue Breakdown	Infrastructure: 38% High-End Consumer: 21% Industrial: 41%
Notable Customers	Google, Cisco, HP, Samsung, LG, Sharp, Helium, Honeywell, Panasonic, Raytheon, Rockwell Automation, and Sony
Revenue % From Big Tech	15%
Revenue % Subject To The In-House Silicon Revolution	15%
Net Cash (Debt)	($1.2 billion)
2023 EPS Estimates	-$0.03
Forward P/E	NM
2023 Sales Growth Estimates	17.8%
2024 Sales Growth Estimates	8.9%
The Great Semi Shift Rating	**4**

Navitas Semiconductor Corporation (NASDAQ: NVTS)

Background

Navitas Semiconductor is at the forefront of the power electronics sector with its focus on developing GaN (Gallium Nitride) and SiC (Silicon Carbide) power ICs. Both GaN and Sic technology offer significant advantages such as higher energy efficiency, smaller form factors, and reduced costs. Established in 2014, Navitas introduced its proprietary AllGaN™ platform, which combined GaN power and analog circuits onto a single chip. Navitas estimates that GaN-based power systems can provide 20x faster switching, up to 3x higher power density, 3x faster charging, up to 40% energy savings, and are 3x smaller and lighter compared to traditional silicon systems.

Business Model

As the electronic industry seeks greener, more compact, and cost-effective solutions, Navitas aims to harness the benefits of GaN and SiC technology to meet these evolving needs. Products that can use GaN and SiC to improve power efficiency include TVs, home appliances, EV charging infrastructure, solar/microgrid installations, and data centers.

Navitas claims to be the first company to enter commercial production of monolithically-integrated high-voltage GaN

semiconductors. Most of its competitors reportedly offer only discrete (i.e., non-integrated) GaN solutions, which still require traditional silicon for drive, control, and protection functions. Since its inception, Navitas' exclusive partner for manufacturing its GaN-based products has been TSMC. Navitas' SiC products will be manufactured by X-Fab in Lubbock, Texas.

Our Outlook

Navitas is growing rapidly. Analysts expect revenue to more than double in 2023 and grow another 90% in 2024, which puts Navitas at or near the top of the list for fastest-growing semiconductor companies in our universe. However, this rapid sales growth is coming off of a very small base, as the company only had $54 million in revenue in the last 12 months. The company is also spending a lot on R&D and will not be profitable for the next two to three years.

GaN and SiC certainly appear to be Revolutionary technologies, and Navitas may have a first-mover advantage, but we are concerned that more sophisticated competitors like Infineon, TI, onsemi, and STMicro may be the ultimate winners of the GaN and SiC Revolutions. Navitas is still in its very early stages and the risk/reward setup here is simply not ideal. Additionally, one of the primary challenges with GaN and SiC is scaling manufacturing, and we think that as a fabless semi, Navitas is not well positioned to actually solve the issue of ramping these technologies. The winner of the GaN/SiC race may turn out to be a larger company with more manufacturing experience (think STMicro or onsemi) that figures out how to scale these new technologies.

What Could Go Wrong With The Stock

- Larger competitors successfully ramp GaN and SiC production, lapping Navitas.
- Overexposure to the consumer market (phone chargers, PC chargers, etc.) limits Navitas' growth.
- The company never reaches profitability.

Company	**Navitas Semiconductor Corporation**
Stock Symbol	**NASDAQ: NVTS**
Semiconductor Category	Fabless
Stock Price	$6.30 (as of 10/11/2023)
Market Capitalization	$1.1 billion
Headcount	230
Key End Markets and Products	Phone chargers, PCs, data centers, and industrial power applications
Major Competitors	Infineon, GaN Systems, Power Integrations, TI, Wolfspeed, onsemi, Qorvo, and STMicro.
Total Revenue (ttm)	$54 million
Gross Margin	33%
Revenue Breakdown	Not provided
Notable Customers	Samsung, Dell, Lenovo, LG, Xiaomi, OPPO, Amazon, and vivo.

Revenue % From Big Tech	30%
Revenue % Subject To The In-House Silicon Revolution	30%
Net Cash (Debt)	$173 million
2023 EPS Estimates	-$0.23
Forward P/E	NM
2023 Sales Growth Estimates	103.8%
2024 Sales Growth Estimates	89.3%
The Great Semi Shift Rating	**3.5**

Himax Technologies, Inc. (NASDAQ: HIMX)

Background

Himax Technologies, Inc. is a Taiwanese company that specializes in display imaging processing technologies. The company is known for its advanced solutions for display drivers, touchscreen controllers, and semiconductor products. Founded in 2001, Himax has been instrumental in providing key technologies for a variety of display devices, including TVs, laptops, monitors, mobile phones, and tablets. Beyond conventional displays, the company also delves into emerging areas like automotive, augmented reality (AR), virtual reality (VR), and artificial intelligence (AI).

Business Model

Himax's revenue is overwhelmingly concentrated in display products. In 2022, 87% of the company's sales were attributable to display drivers that were incorporated into TFT-LCD panels used in TVs, computer monitors, smart glasses, etc. These are relatively low-margin products and Himax faces significant competition from many other Asian producers.

Our Outlook

Himax is not a fast-growing company, but it has shown remarkably stable profitability despite operating in a fiercely

competitive and commoditized market. The company's revenue will be down substantially this year due to weakness in many of its cyclical end markets, but analysts expect demand will return to normal levels next year. Himax currently pays an 8.4% dividend which is one of the higher rates in semiconductor stocks we have analyzed, but that is not enough to get us excited about investing in a Taiwanese low-tech semiconductor company.

What Could Go Wrong With The Stock

- The inventory glut takes longer to work through than Himax currently expects.
- Himax's profitability stays lower for longer and the company is forced to cut its dividend.
- Himax falls behind other Asian competitors that manufacture their own products.

Company	**Himax Technologies, Inc.**
Stock Symbol	**NASDAQ: HIMX**
Semiconductor Category	Fabless
Stock Price	$5.85 (as of 10/11/2023)
Market Capitalization	$1 billion
Headcount	2,181
Key End Markets and Products	Notebook computers, desktop monitors, televisions, smartphone, tablet, automotive and consumer electronics products.

Major Competitors	Fitipower, FocalTech, Novatek, and others
Total Revenue (ttm)	$955 million
Gross Margin	29%
Revenue Breakdown	Display Drivers: 87% Non-driver products: 13%
Notable Customers	Samsung, Sharp, Panasonic, HP, LG, Huawei, Sony, and Logitech.
Revenue % From Big Tech	30%
Revenue % Subject To The In-House Silicon Revolution	5%
Net Cash (Debt)	$182 million
2023 EPS Estimates	$0.25
Forward P/E	23.4
2023 Sales Growth Estimates	-21.4%
2024 Sales Growth Estimates	10.6%
The Great Semi Shift Rating	**2.5**

Indie Semiconductor, Inc. (NASDAQ: INDI)

Background

indie Semiconductor is a pure-play fabless company designing custom automotive semiconductor solutions. They have a focus on edge sensors for autonomous vehicles and user experiences. Their portfolio encompasses a range of products related to advanced driver-assistance systems (ADAS), connectivity, user interfaces, and electrification. indie came public via a SPAC in June 2021 at a price of $10/share.

Business Model

indie primarily designs semiconductors for legacy automakers and is benefitting from the switch to electric powertrains and the growing use of infotainment centers, automation, etc. in modern vehicles. indie has completed a series of acquisitions recently, including:

- the 2023 acquisition of Silicon Radar for roughly $10 million
- the 2023 acquisition of GEO Semiconductor for $180 million
- the 2021 acquisition of Symeo GmbH from ADI for $30.4 million
- the 2021 acquisition of ON Design Israel Ltd. from onsemi for $20 million

- the 2021 acquisition of Teraxion for $146 million.

Its largest customer is Aptiv, a leading Tier 1 supplier to the auto industry, which accounted for 37% of indie's revenue in 2022.

Our Outlook

indie is not profitable and is being forced to raise additional funds to continue on its current trajectory. In August 2022, the company announced a potential secondary offering of $150mm, and in November 2022, the company issued $160 million in 4.5% convertible notes. We think the company's aggressive pursuit of acquisitions along with its significant capital raises is bad for shareholders. The company's status as a "pure-play" supplier to the auto industry looks a lot like a hype tactic and essentially ignores the fact that indie competes with many established players like Monolithic Power, STMicro, and Infineon offer very similar products to those indie. In fact, it is entirely unclear what makes indie's chips different from those of its competitors. The company is growing fast but given its rapid pursuit of acquisitions, it is unclear how much revenue growth is organic. Throw in the fact that most of indie's customers are legacy automakers that we think could go bankrupt in the next few years, and we would probably short indie before we would buy it.

What Could Go Wrong With The Stock

- indie is unable to continue its strategy of rapid acquisitions to stimulate growth.
- Larger competitors like STMicro or Infineon take market share.

- Legacy automakers go bankrupt or otherwise fail to make the transition to electric vehicles.

Company	**indie Semiconductor, Inc.**
Stock Symbol	**NASDAQ: INDI**
Semiconductor Category	Fabless
Stock Price	$5.48 (as of 10/11/2023)
Market Capitalization	$841 million
Headcount	600
Key End Markets and Products	Automotive
Major Competitors	Infineon, MPWR, NXP, Renesas, and STMicro.
Total Revenue (ttm)	$156 million
Gross Margin	44%
Revenue Breakdown	Not disclosed
Notable Customers	Aptiv, Ford, GM, Stellantis, and other legacy automakers
Revenue % From Big Tech	0%
Revenue % Subject To The In-House Silicon Revolution	15%
Net Cash (Debt)	$15 million
2023 EPS Estimates	-$0.29
Forward P/E	NM

2023 Sales Growth Estimates	104.2%
2024 Sales Growth Estimates	59.5%
The Great Semi Shift Rating	**2**

Glossary

5G - The fifth generation of mobile network technology, succeeding 4G, designed to offer higher speeds, lower latency, and increased connectivity.

Accelerated Computing - A computing approach that uses hardware acceleration for specific workloads, often through GPUs or specialized co-processors.

AC - Alternating Current; electrical current that periodically reverses direction, commonly used in household and industrial applications.

ADAS - Advanced Driver-Assistance Systems; technologies that provide automated or enhanced support in driving tasks to improve safety and efficiency.

AI - Artificial Intelligence; the development of computer systems that can perform tasks requiring human intelligence.

Amplifiers - Devices that increase the amplitude of electrical signals, commonly used in both analog and digital applications in semiconductors.

Analog - A signal representation that represents some quantity--such as sound, light, temperature, pressure, or voltage--and is continuous in time and amplitude, as opposed to digital, which is discrete.

Android - Android is an open-source mobile operating system developed by Google, used in a wide range of smartphones and tablets. In the semiconductor context, chips with architectures

that support Android OS are developed, including application processors, connectivity chips, and more.

ARM Architecture - A RISC-based computing architecture developed by Arm Holdings, widely used in mobile devices and embedded systems. Unlike traditional x86 architecture commonly found in PCs, ARM focuses on a reduced instruction set computing (RISC) approach, which enables more efficient use of processor resources.

AR/VR - Augmented Reality (AR) and Virtual Reality (VR) are technologies that alter users' perception of the real world and virtual environments. AR superimposes digital information onto the physical world through devices like smartphones or AR glasses, while VR immerses the user in a completely virtual environment, typically using a VR headset. Both technologies have applications in various fields such as gaming, training simulations, and medical procedures.

ASIC - Application-Specific Integrated Circuit; an IC designed for a specific application, rather than general-purpose use.

Audio Converters - Semiconductor devices that translate analog audio signals to digital and vice versa, often used in consumer electronics and professional audio applications.

AWS - Amazon Web Services; a cloud service platform offering computing, storage, and other functionalities.

BAW - Bulk Acoustic Wave; a technology used for RF filtering in semiconductors.

Battery ICs - Integrated Circuits designed specifically for managing, charging, and monitoring batteries.

BiCMOS - A semiconductor technology that combines Bipolar and CMOS transistors on the same integrated circuit. This technology combines the advantages of bipolar transistors, such as high speed and high output drive, with the low-power and high-input impedance characteristics of CMOS transistors in a single integrated circuit.

BCD - Bipolar-CMOS-DMOS; a semiconductor technology that combines Bipolar, CMOS, and DMOS transistors on the same integrated circuit, enabling the creation of mixed-signal integrated circuits that combine analog and digital components, thus offering higher efficiency and performance in power management applications.

Bluetooth - A wireless technology standard for short-range data exchange between devices over UHF radio waves.

Broadband - High-capacity transmission techniques using a wide range of frequencies, commonly associated with fast internet.

C/C++ - Programming languages commonly used in various computing tasks including system/software development and high-performance computing.

Cable Modems - Devices that provide high-speed Internet connections through the cable television network.

Camera Controllers - Semiconductor components that manage the functionalities and features of digital cameras, often integrated into smartphones and other devices.

Capacitor - An electronic component that stores and discharges electrical energy, often used in filtering applications.

Carbon Nanotubes - These are cylindrical molecules made of carbon atoms, characterized by remarkable mechanical, electrical, and thermal properties. In the semiconductor industry, they are studied as a potential replacement or supplement to silicon, offering advantages like higher electron mobility and thermal conductivity. They have applications in various electronic components, including transistors and sensors, as well as in nanotechnology and materials science.

Carrier - In telecom, a company that provides data communication services via physical infrastructure; in semiconductors, a particle or quantum entity that is free to move and carry an electric charge.

CCP - Chinese Communist Party; political party ruling China, relevant in discussions of technology transfer, intellectual property, and trade.

CDMA - Code Division Multiple Access; a digital cellular technology that uses spread spectrum techniques to allow multiple users to share the same frequency band simultaneously. Unlike other access methods, CDMA codes each conversation to differentiate it from others in the same frequency band, enhancing privacy and capacity.

ChatGPT - Chat-based Generative Pre-trained Transformer; a conversational model developed by OpenAI, used in AI applications like chatbots and virtual assistants.

CHIPS Act - Creating Helpful Incentives to Produce Semiconductors for America Act; U.S. legislation aimed at boosting domestic semiconductor manufacturing and R&D.

Circuit - An electrical network consisting of interconnected components like resistors, capacitors, and inductors.

CIS - CMOS Image Sensors; semiconductor devices that convert optical images into electronic signals, commonly used in digital cameras and smartphones.

Cloud Computing - The delivery of computing services over the internet, including storage, processing power, and databases.

CMOS - Complementary Metal-Oxide-Semiconductor; a technology used for constructing integrated circuits, known for its low power consumption.

Compute Cluster - A group of interconnected computers that work together to perform complex tasks, often used in high-performance computing and data analysis.

Conductor - A material that permits the free flow of electric current, often metals like copper and aluminum.

CPLDs - Complex Programmable Logic Devices; a type of programmable logic device that provides more complexity than basic PLDs but less than FPGAs.

CPU - Central Processing Unit; the primary unit of a computer that performs most of the processing inside the computer.

Cryptocurrency - Digital or virtual currencies that use cryptography for security, with Bitcoin being the first and most well-known example.

CSP (Cloud Service Provider) - A company that offers a range of computing resources and services, such as servers, storage, and applications, via the internet, enabling businesses and individual users to access and utilize these resources without the need for owning and maintaining physical hardware.

CUDA - Compute Unified Device Architecture; a parallel computing platform and programming model developed by NVIDIA.

Current - The flow of electric charge in a conductor between two points having a voltage difference between them.

Data Center - A facility used to house computer systems and related components, typically used by organizations for remote storage, processing, or distribution of data.

Data Packets - Units of digital information that are transmitted over a network, encapsulating the actual data along with metadata such as source, destination, and error-checking information, facilitating more efficient and organized communication between devices.

DC - Direct Current; electrical current that flows in one direction, commonly used in batteries and electronic devices.

Deposition - In semiconductor manufacturing, the process of depositing a material onto a substrate, usually in the form of a thin film.

Dicing - The process of cutting a semiconductor wafer into individual die or chips following the completion of the fabrication process. This is often performed using precision saws or laser cutters to ensure clean and accurate cuts, which are essential for the functionality of the individual components.

Die - A singular, individual piece of semiconductor material cut from a larger wafer, containing integrated circuits that perform specific functions such as computation, data storage, or signal processing. After additional processing and packaging, the die becomes a fully functional chip ready for integration into electronic systems.

Digital - Pertaining to data in the form of discrete values, often binary, as opposed to analog, which is continuous.

Diode - A semiconductor device with two terminals that allows current to flow in one direction only.

Discrete Transistors - Individual transistors that are not part of an integrated circuit, often used in applications that do not require high density or low cost.

Display Driver - Semiconductor components that manage the functionalities and features of digital displays, often integrated into TVs, monitors, and other display devices.

DMEA Category 1A - Designation by the U.S. Defense Microelectronics Activity, indicating a facility certified to perform trusted foundry services.

Dojo Supercomputer - A specialized supercomputer built by Tesla, designed to process vast amounts of data for training neural networks. It uses Tesla's custom D1 chips and aims to

offer unprecedented levels of performance specifically tailored for machine learning tasks related to Tesla's Full Self-Driving software.

DRAM - Dynamic Random-Access Memory; a type of memory that stores each bit of data in a separate capacitor, commonly used in computer main memory.

DRC - Design Rule Check; a process that verifies a designed circuit against a set of rules to ensure manufacturability.

DSL - Digital Subscriber Line is a technology that utilizes existing telephone lines to provide high-speed internet access. In the semiconductor industry, DSL modems containing specialized integrated circuits are designed to enable this form of data transmission.

DSPs - Digital Signal Processors; specialized microprocessors used in processing real-world signals like sound, image, and video.

Duplexers - Electronic devices used in wireless communications to allow simultaneous transmission and reception of signals within the same system, typically by isolating the receiver and transmitter paths and enabling them to share a single antenna. In the semiconductor context, duplexers are integral in applications like mobile phones, base stations, and two-way radios, where they manage radio frequency signals to avoid interference.

DUV - Deep Ultraviolet; a technology used in photolithography processes in semiconductor manufacturing. DUV uses light with a wavelength range of 248nm to 193nm, compared to EUV which uses a much shorter wavelength of around 13.5nm.

EDA (Electronic Design Automation) - A category of software tools used by engineers for designing electronic systems such as integrated circuits and printed circuit boards. The tools automate key design and analysis processes, enabling faster development and optimization of complex electronic systems.

Edge Networking - A distributed computing paradigm that brings computation closer to data sources, often used in IoT applications for faster data processing.

EDS (Energy-Dispersive X-ray Spectroscopy) - A technique used in materials science for the elemental analysis or chemical characterization of a sample, often employed alongside electron microscopy. In the context of the semiconductor industry, EDS is commonly used for failure analysis and quality control to identify contaminants or defects in the material.

EEPROM - Electrically Erasable Programmable Read-Only Memory; a type of memory that can be electrically erased and reprogrammed, used for storing small amounts of data that must be saved when power is removed.

Electro-optics - A branch of physics that involves the study of the electrical properties of materials in relation to light.

Embedded Processor - A processor designed for a specific control application, often embedded within a larger system to perform dedicated tasks.

eMMC (Embedded MultiMediaCard) - A type of flash storage standard that serves as the primary storage memory for low-cost devices such as smartphones, tablets, and other

embedded systems, offering lower performance compared to SSDs but with the advantage of being highly integrated and cost-effective.

Encapsulation - In semiconductor manufacturing, the process of enclosing a chip in a protective layer to prevent physical damage and corrosion.

Enterprise SAS - Serial Attached SCSI used in enterprise settings, often for data storage solutions that require high performance.

Enterprise SATA - Serial ATA used in enterprise settings, usually for data storage that doesn't require high performance but offers cost advantages.

Enterprise Fibre Channel Connectivity - A technology for transmitting data between computing devices at data rates of up to 16 Gbps in enterprise settings.

eNVM - Embedded Non-Volatile Memory, a type of memory that retains its data even when the power is turned off, embedded within another chip.

eHV - Extended High Voltage, refers to semiconductor technologies designed to operate at higher voltages than standard components.

Etching - A process in semiconductor manufacturing where selected areas of material are removed, often by chemical or plasma etching.

Ethernet - A standard for network communications, commonly used in local area networks (LANs).

Ethernet NICs - Ethernet Network Interface Cards, hardware that connects computers to an Ethernet network.

EUV - Extreme Ultraviolet, a technology used in photolithography processes in semiconductor manufacturing.

EV - Electric Vehicle, a vehicle that is propelled by electric motors, often powered by rechargeable battery packs.

Fab - Fabrication plant, a manufacturing facility where semiconductor devices are produced.

Fab-Lite - A semiconductor company that outsources some but not all of its manufacturing needs, maintaining some level of in-house fabrication capability.

Fiber Optics - Transmission of data as light pulses along a glass or plastic fiber.

Filters - Components or circuits that pass signals with a frequency that lies within a certain range and attenuates signals with frequencies outside that range.

FinFET - Fin Field-Effect Transistor, a type of non-planar transistor used in modern processors. FinFET features a 3D "fin-like" structure on the surface of the semiconductor material, enhancing its ability to control electrical current. This design allows for lower leakage and lower power consumption, making it particularly suitable for advanced, smaller-scale semiconductor devices.

Firewall - A system designed to prevent unauthorized access to or from a private network.

Flash - A type of electronic non-volatile computer storage medium that can be electrically erased and reprogrammed.

FPGA - Field-Programmable Gate Array, an integrated circuit designed to be configured after manufacturing. Unlike fixed-function chips like CPUs, FPGAs can be tailored to execute specific tasks more efficiently, making them highly versatile for a variety of applications, such as for use with high-frequency trading systems where the trading algorithms are changed often.

Foundry - A semiconductor manufacturing plant where wafers are produced.

Frequency Converters - Devices that change the frequency of alternating current to match a particular electrical system or requirement.

Full Self Driving - A level of autonomous driving where a vehicle can handle all aspects of driving without human intervention.

GAA - Gate All Around, a transistor design where the gate material surrounds the channel region from all sides. This design offers lower leakage current and lower power consumption compared to traditional FinFET transistors, making it advantageous for advanced semiconductor nodes.

GaAs - Gallium Arsenide, a compound used in some high-frequency semiconductor devices.

GaN - Gallium Nitride, a material used in LEDs and high-power transistors capable of operating at high temperatures.

Gateway - A network node that serves as an access point to another network, often involving different protocols.

Generative AI - A subset of AI focused on generating new data from existing data, often used in natural language processing, image generation, etc.

GPS - Global Positioning System, a satellite-based navigation system used to determine geographical location.

Gross Margin - The difference between revenue and cost of goods sold, expressed as a percentage of revenue.

Hall-effect sensor ICs - Integrated circuits that detect magnetic fields and convert them into electrical signals.

Handset - A mobile phone or other handheld communication device.

Haptic Drivers - These are specialized ICs that control haptic feedback mechanisms in devices, such as vibrations in smartphones or tactile feedback in wearables. In the semiconductor context, haptic drivers are an integral part of the user interface and sensory experience, requiring precise control circuits for accurate performance.

HDD - Hard Disk Drive, a non-volatile storage device that stores data on rapidly rotating disks coated with magnetic material.

Helium (cryptocurrency) - A specific blockchain-based cryptocurrency associated with the Helium network, aimed at wireless services.

High Voltage Semiconductor - A semiconductor device designed to operate at voltages higher than typical silicon-based devices.

HPC - High-Performance Computing, involves aggregated computing power for solving complex problems in science, engineering, or business.

HPMS - High-Performance Mixed Signal, a type of semiconductor that combines analog and digital capabilities.

HSDPA - High-Speed Downlink Packet Access, a mobile telephony protocol used in some 3G networks.

Hyperscaler - Large companies like Amazon, Google, and Microsoft that provide infrastructure for cloud computing on an enormous scale.

IC - Integrated Circuit, a set of electronic circuits on a small flat piece of semiconductor material.

IGBTs - Insulated Gate Bipolar Transistors, used in high-power applications like industrial motors and power grids.

In-House Silicon - Refers to chips that are designed internally by a company rather than outsourced.

Inductor - A passive electronic component that stores energy in the form of a magnetic field.

Infotainment - An information and entertainment system in vehicles, providing media, navigation, and connectivity features.

InP - Indium Phosphide, a material used in high-speed fiber-optic communication.

Insulator - A material that resists the flow of electric current, used in electrical and electronic applications to prevent unwanted flow of current and to protect against electrical shock. In semiconductors, insulators are often used as a gate dielectric or as a layer to isolate different components.

Integrated Module - A single electronic component that combines multiple functions or subsystems, such as processing, memory, and input/output functionalities, into a unified unit. In the semiconductor industry, these modules often contain ASICs, processors, and other elements to perform specialized tasks and are used in various applications like communication devices, automotive systems, and industrial automation.

Interconnect - In the context of a chip, metal lines in a semiconductor that electrically connect transistors and other components. In the context of a data center, the term "interconnect" refers to the networking hardware, protocols, and technologies that facilitate communication between different components within the data center, as well as between the data center and external networks. This encompasses everything from the physical cabling and switches to the high-level networking protocols that enable fast, secure, and reliable data transfer.

Interposers - An electrical interface that reroutes existing connections.

iOS - iOS is a proprietary mobile operating system developed by Apple Inc., exclusively used in Apple's mobile devices like iPhones and iPads. In the semiconductor industry, Apple

designs its own custom chips, such as the A-series and M-series, optimized for iOS performance.

IoT - Internet of Things, a network of physical devices connected to the internet for data collection and sharing.

IP - Intellectual Property, legal property rights over creations of the mind, both artistic and commercial.

Isolated gate driver - A component that isolates a logic signal from high voltages and currents, ensuring safe operation of power transistors.

I/O - Input/Output, refers to the communication between a processor and the outside world. I/O functions in a chip serve as the gates through which data enters and exits. These I/O "pins" or "ports" on a chip can be configured to read signals (input) or send signals (output) to other components in the system.

LED - Light Emitting Diode, a semiconductor device that emits light when current flows through it.

LED drivers - Circuits or ICs that manage the electrical properties for LEDs, ensuring optimal performance and longevity.

Logic - A type of digital circuit used in computing and data processing.

LoRa - Long Range, a low-power wide-area network protocol designed for IoT applications.

LoRaWAN - Long Range Wide Area Network, a protocol for WANs designed to support long-range communications with low power consumption.

M&A - Mergers and Acquisitions, the consolidation of companies or assets through various types of financial transactions.

Market Cap - Market Capitalization, the total value of a company's outstanding shares of stock.

Memory - Refers to devices or systems that can store data for short-term or long-term retrieval.

Memory Module - A circuit board with DRAM chips that connects to a computer motherboard to provide additional RAM.

MEMS - Micro-Electro-Mechanical Systems, miniaturized mechanical and electro-mechanical devices or systems made through microfabrication. These systems are capable of sensing, actuating, and controlling various physical or environmental conditions. MEMS are commonly used in a multitude of applications such as accelerometers in smartphones, microphones, pressure sensors, and optical switches.

Millimeter wave chip - Chips designed to operate in the extremely high-frequency millimeter wave spectrum, often used in 5G networks and radar.

Mixed-Signal - Semiconductor circuits that process both analog signals and digital signals.

Microprocessor - A silicon-based integrated circuit that serves as the central processing unit (CPU) in a computer, responsible for executing instructions, performing calculations, and managing data. It is a fundamental component in a wide range of computing devices, from desktops and laptops to embedded systems.

Moore's Law - The observation that the number of transistors on a microchip doubles approximately every two years.

Monolithic Die - A single, continuous piece of semiconductor material that contains all the integrated circuits and components required for a complete functional unit, such as a processor or memory module. In the context of the semiconductor industry, monolithic die designs can offer advantages in performance and power efficiency but may be more challenging and costly to manufacture.

MOSFET - Metal-Oxide-Semiconductor Field-Effect Transistor, a type of transistor used for switching or amplifying signals.

Motion encoders - Devices that convert the position or motion of a shaft or axle to an analog or digital code.

NAND - A type of non-volatile flash memory that is used for storage and to transfer data between a computer and digital devices.

Networking - The practice of connecting computers and other devices together to share resources.

NoR - Not OR, a type of flash memory that allows random access capabilities similar to a computer's RAM.

NVIDIA A100 - A graphics processing unit (GPU) designed by NVIDIA, based on the Ampere GA100 architecture. It is engineered to handle data center, cloud, AI, and high-performance computing workloads, offering significant performance improvements over previous generations.

OEM - Original Equipment Manufacturer, a company that makes products that are then used in the products of another company.

ODM - Original Design Manufacturer, a company that designs and manufactures products specified and eventually branded by another company.

On-premises - Software and technology that are located within the physical confines of an organization rather than being cloud-based.

Optical interconnect - A type of data connection that uses light signals, typically via optical fibers, as opposed to electrical signals.

Optical Isolation - A technology used to electrically isolate a circuit to protect it from voltage spikes.

Optical transport system - Equipment that transmits digital signals via optical fiber.

Optocouplers - An electronic component used to transfer electrical signals between two isolated circuits through light.

Oxidation - The process of adding a layer of silicon dioxide to the surface of a wafer during semiconductor manufacturing.

Packaging - The final stage of semiconductor device fabrication in which the chip is encased in a protective shell.

Parallel computing - A computing resource that carries out multiple operations or tasks simultaneously.

PCIe (Peripheral Component Interconnect Express) - A high-speed interface standard for connecting add-on cards like graphics cards, SSDs, and network cards to a computer's motherboard. It serves as a replacement for older standards like PCI and AGP, offering faster data transfer rates and more flexibility in terms of form factors. PCIe slots can have different numbers of data lanes, commonly referred to as x1, x4, x8, and x16 configurations, affecting the bandwidth and speed of the connection.

PCIe switches - Devices that expand the number of available PCIe slots, which can be used to connect various internal components like graphics cards or SSDs.

P/E Ratio - Price to Earnings Ratio, a valuation ratio calculated by dividing the market value per share by the earnings per share.

Photolithography - A process used in semiconductor manufacturing to transfer geometric shapes onto a substrate, typically a silicon wafer, using light-sensitive materials and ultraviolet light. This technique enables the miniaturization of circuit designs, laying the foundation for the fabrication of integrated circuits and microprocessors.

Photonics - The technology focusing on the generation, emission, transmission, modulation, signal processing, and detection of light.

PHYs - Physical layer devices in a network that handle the physical connection between devices.

Planar Manufacturing Process - A traditional method of creating silicon wafers and transistors where components are built on a flat surface.

PLD (Programmable Logic Device) - A digital electronic component used to build reconfigurable digital circuits, offering a more flexible alternative to fixed logic gates. Unlike a logic gate, which has a fixed function, a PLD can be programmed to perform multiple functions and can be reprogrammed if needed.

Polishing - In semiconductor manufacturing, the process used to planarize a wafer or to reduce surface roughness.

PON - Passive Optical Network is a fiber-optic network that uses passive splitters to deliver data to multiple endpoints. In the semiconductor context, integrated circuits like Optical Network Units (ONUs) are often developed to facilitate this technology.

Power converter - An electronic device that converts energy from one form to another, such as AC to DC or vice versa.

Power ICs - Integrated circuits designed specifically for managing electrical power.

Powertrain - In automotive applications, refers to the main components that generate and deliver power to the vehicle surface.

Process Node - A set of technology design rules in semiconductor manufacturing.

Professional visualization - Graphics hardware and software solutions used for design, modeling, and complex data visualization tasks, such as geospatial analysis.

PRC - People's Republic of China, a significant player in the global semiconductor market.

Quartz-based timing - Timekeeping technologies that utilize the oscillating properties of quartz crystals. Quartz crystals oscillate at a precise frequency when subjected to an electric field, serving as a highly stable timekeeping element. In a chip, this oscillation is used to generate a reliable clock signal that synchronizes the operations of electronic circuits.

Rad-Hard ICs - Radiation-hardened integrated circuits designed to withstand extreme radiation environments such as outer space.

RAID controller - Redundant Array of Independent Disks controller, manages hard drives to work in parallel to increase performance or reliability.

RF (radio frequency) - A frequency or rate of oscillation corresponding to radio waves, typically ranging from 20 kHz to 300 GHz.

RF filter - An electronic filter that allows signals within a specified frequency range to pass through.

RF power transistor - Transistors designed to operate at radio frequencies, often used in high-power applications such as RF amplifiers.

RibbonFET - Intel's branding for their upcoming gate-all-around (GAA) transistor technology.

RISC-V - An open standard instruction set architecture based on RISC principles. RISC-V was developed by researchers in the Computer Science Division of the Electrical Engineering and Computer Sciences Department at the University of California, Berkeley.

ROC - Republic of China, also known as Taiwan, home to TSMC and other key players in the semiconductor industry.

ROICs - Readout integrated circuits, often used in imaging sensors to read the data.

Router - A networking device that forwards data packets between computer networks.

SAW - Surface Acoustic Wave, a type of filter used in radio frequency applications.

SAS controller - Serial Attached SCSI controller, manages hard drives and SSDs to interface with a computer system.

SCSI (Small Computer System Interface) - A set of standards for connecting and transferring data between computers and peripheral devices such as hard drives, CD-ROM drives, and printers, characterized by high data rates and the ability to chain multiple devices together.

Sensor ICs - Integrated circuits specifically designed for sensor applications, often including functionalities like data conversion, signal conditioning, and data acquisition.

SerDes - Serializer/Deserializer, technology used to convert parallel data to serial form and vice versa. This essentially takes a bunch of data signals that normally travel side-by-side and puts them into a single file line, like funneling a crowd through a narrow doorway, so they can be sent over a single cable and then puts them back into their original formation at the other end.

Set-top box - A device that converts digital television signal to analog for viewing on a conventional set, or that enables cable or satellite television to be viewed.

SiC - Silicon Carbide, a semiconductor material used in high-temperature and high-power applications.

SiGe - Silicon Germanium, a semiconductor material used in ICs for higher-speed, lower-power applications.

SKU - Stock Keeping Unit, a specific item for sale, such as a product or service, and all attributes associated with the item that distinguish it from other items.

Snapdragon - A family of mobile systems on a chip by Qualcomm.

SOI - Silicon On Insulator, a layering material made of insulating silicon oxide and silicon, used in manufacturing of ICs.

SoC - System on Chip, an integrated circuit that contains all components of a computer or other system.

Supercomputer - A highly-capable computer, usually used for specialized calculations like scientific simulations, data analysis, etc.

Superconducting ICs - Integrated circuits made from superconducting materials, which have no electrical resistance at extremely low temperatures.

Switches - In networking, devices that filter and forward packets between LAN segments. In electronics, devices used to break or complete an electrical circuit.

Taped out - The final stage of a design cycle for integrated circuits or printed circuit boards.

Temperature Compensated SAW - A type of SAW filter that compensates for temperature-induced performance variations.

Tesla D1 - A custom chip designed by Tesla for its Dojo Supercomputer. The D1 chip is manufactured using a 7nm process and aims to provide a significant boost in performance for training machine learning models, particularly for Tesla's Full Self-Driving software.

TFT-LCD - Thin-Film Transistor Liquid Crystal Display, a variant of LCD which uses thin-film transistor technology for improved image quality.

Tiles (Intel) - A term coined by Intel to describe chiplets, or smaller, modular pieces of silicon that can be interconnected to create a more complex and integrated chip package. Intel’s tiles

can include various types of intellectual property blocks and can be manufactured using different process technologies. They are part of Intel's advanced packaging solutions, and are interconnected using methods like EMIB (Embedded Multi-Die Interconnect Bridge) and Foveros 3D stacking technology.

TPU - Tensor Processing Unit, an application-specific integrated circuit developed by Google specifically for neural network machine learning.

TTM Revenue - Trailing Twelve Months Revenue, a financial metric that calculates the revenue of a company for the past 12 months.

UFS - Universal Flash Storage, a high-speed interface and protocol for digital data storage.

USB - Universal Serial Bus, a standard connection interface for computers and other devices.

Video Compression - A technique used to reduce the size of a video file by using algorithms to eliminate redundant data, making it easier to store or transmit. In the semiconductor industry, specialized chips or modules may be designed to handle video compression tasks more efficiently.

Wafer - A thin, flat disc of semiconductor material, usually silicon, on which multiple integrated circuits (ICs) are fabricated. Wafers serve as the substrate for semiconductor devices and undergo a series of complex manufacturing steps including doping, etching, and layering to produce finished chips.

Wi-Fi - Wireless Fidelity, a technology for wireless local area networking.

Wire Bonding - A method used in the semiconductor packaging process to electrically connect a silicon die to an external circuit, usually via a substrate or lead frame. Fine wires, commonly made of gold or aluminum, are used to create these connections, typically utilizing techniques such as thermosonic bonding or ultrasonic bonding.

Wireless - Communication without the need for a physical connection via cables.

WLAN - Wireless Local Area Network, a wireless network that links two or more devices using a wireless distribution method.

Workstation - A specialized computer designed for technical or scientific applications.

x86 architecture - A family of instruction set architectures initially developed by Intel but now used by various chip manufacturers, geared towards high-performance computing.

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