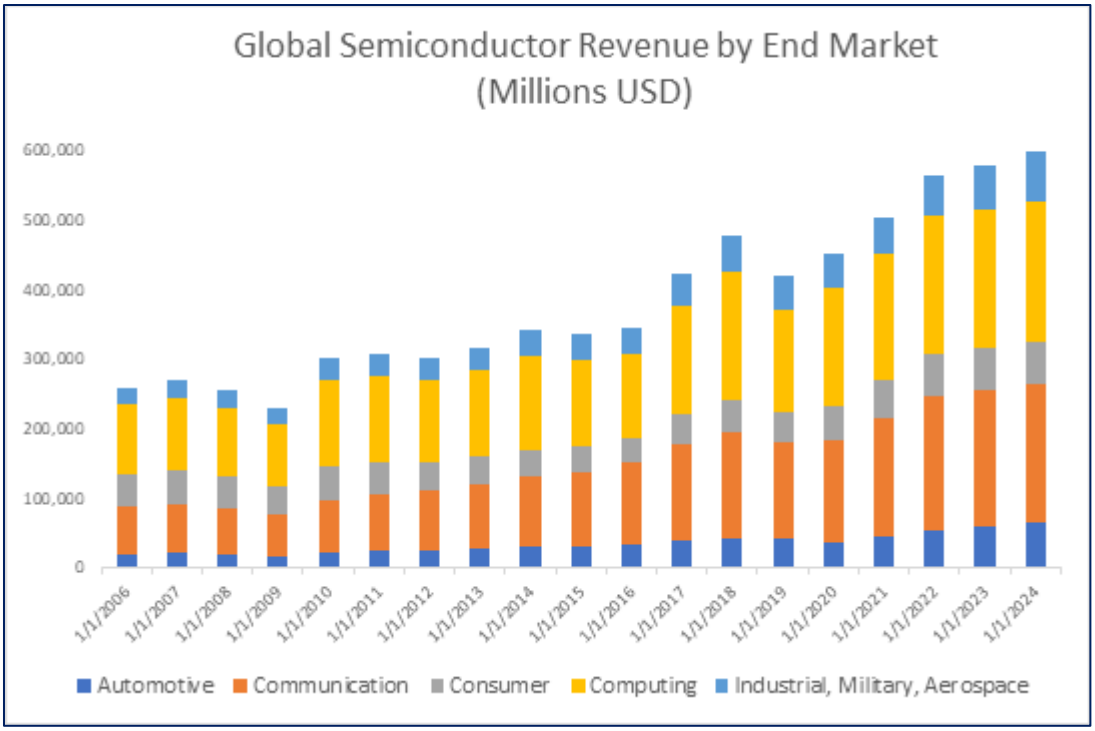
The Global Semiconductor Shortage

April 26, 2021

As if we needed another reminder, the recent sixty-week delay in router orders – one of the latest in a long line of delays, outages, or other disruptions affecting a number of global supply chains because of a shortage of semiconductors – brought the world's missing chips into sharp focus. The shortage is in large part a result of an unanticipated pull-forward in demand during the pandemic for everything from laptops to automobiles, layered on top of an already robust demand schedule for semiconductors as the world becomes more digitally integrated and "smarter." In fact, analysts expect global revenue in the semiconductor industry to grow by ~33% between end 2020 and end 2024 as indicated in the table below.



Source: RockCreek, Bernstein

The Players

Who are the cast of characters that make up the global supply chain for this high growth industry? Let us start by breaking the industry down into four supply chain sub-groups: design, manufacturing, capital equipment, and testing & assembly.

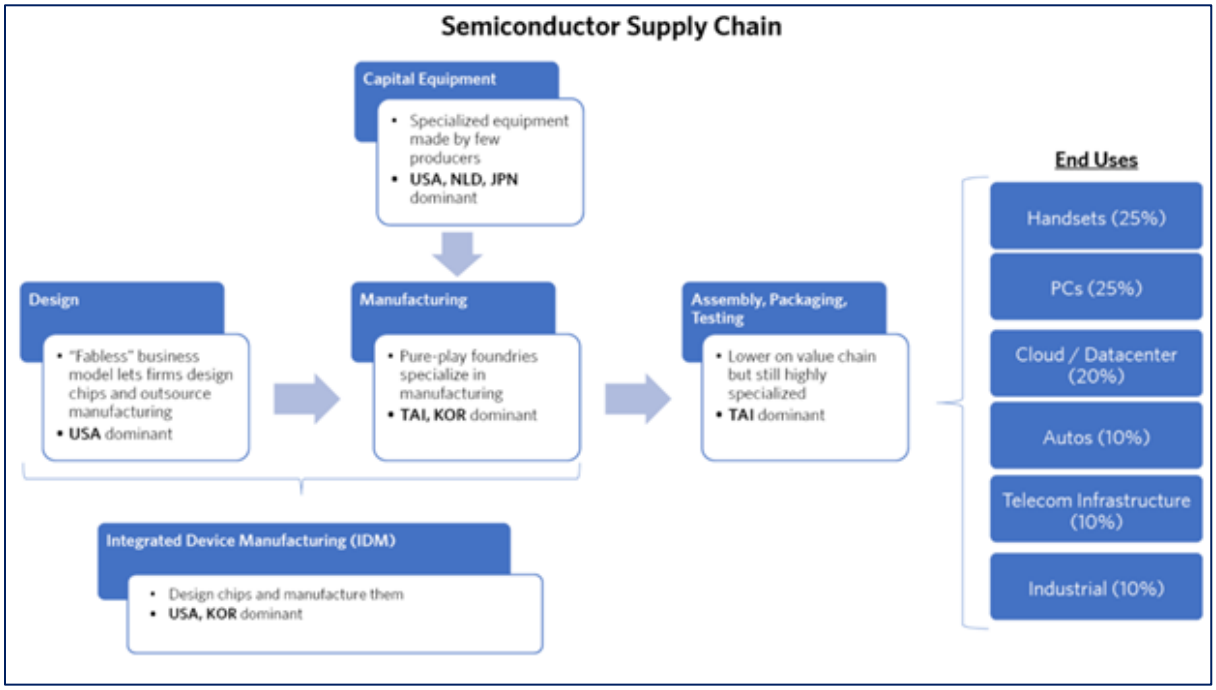
The household semiconductor names tend to reside in the design category and include well-known companies such as Nvidia, Qualcomm, NXP, and AMD, just to name a few. The design segment – which literally designs the chips – is highly competitive and heavily reliant on intellectual property. Although there are a handful of integrated device manufacturers (IDM) – Intel being perhaps the most notable – that still make their chips in house, the industry has long been trending toward specialization.

Manufacturing, known as foundry, has increasingly become a specialized, standalone function, and it is currently dominated by two players globally: TSMC and Samsung. The foundry business is quite attractive

for incumbent firms, as it is protected by barriers to entry through customer captivity and economies of scale. Because foundries do not design chips there is little risk of intellectual property theft. Thus, design firms are willing to share their plans early in the development process, allowing foundries to plan production for each specific new product. In addition, the large foundries can spread their fixed costs over a very large number of chips, which bolsters profitability.

The suppliers to foundries, the capital equipment companies, are also high margin businesses that benefit from specialization in different parts of the manufacturing process. No company exemplifies this better than ASML, which manufactures photolithography equipment needed to physically make the chips. Notably, the Dutch company is the sole provider of extreme ultra-violet (EUV) photolithography machines, which are essential for cutting-edge chip production; as such, ASML machines are needed in any new foundry designed to produce the latest chips. Other highly specialized suppliers include Tokyo Electron, LAM Research, Applied materials, and KLA.

Assembly, testing, and packaging companies are also crucial to the chip production process, but these tend to be lower margin businesses. Examples of companies in this industry include Amkor, ASE Technologies, and JCET Group.

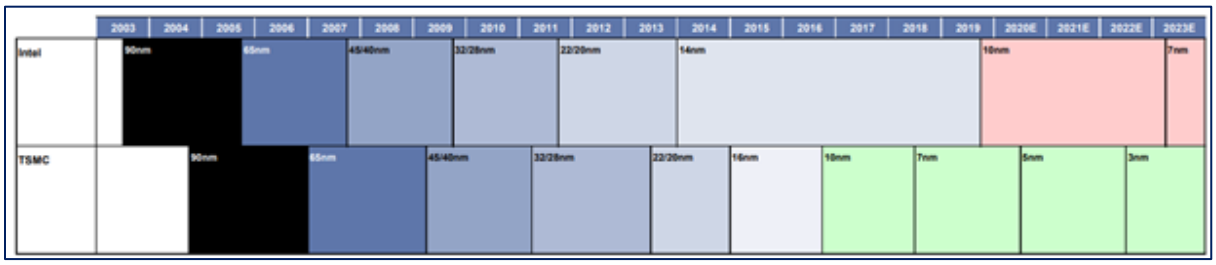


Source: Bridgewater, Semiconductor Industry Association, Credit Suisse

Supply Expansion

As the need for additional capacity is becoming apparent, semiconductor manufacturers have announced a slew of capital spending. TSMC announced $100 billion of capital expenditures over 2021 to 2023, while Samsung is in the early phases of a more than $110 billion, 10yr investment plan, after which it hopes to be on par with TSMC. Intel is entering the standalone foundry business with the creation of Intel Foundry Services (IFS) and plans to spend an initial $20 billion on an EUV-ready plant in Arizona. It remains to be seen whether its efforts will be successful. Intel had tried to enter the foundry business before and failed; as such, history is not on its side. In addition, Intel has lagged technological innovations for its own chips

for some years, forcing it to outsource some of its own production. Finally, it remains to be seen if chip designers will trust a rival (i.e., Intel) with their IP.



Source: Goldman Sachs Global Investment Research

Additional capacity, however, cannot be turned on with the flip of a switch or the signing of a check. Building chip foundry plants is a multi-year and multi-billion-dollar process, not to be undertaken on a whim. TSMC, for example, is very deliberate with its capital expenditure planning and will not build on speculation, i.e., they need enough concrete customer intent to start adding capacity. Even once completed, however, this investment in new capacity may not completely solve existing issues.

One big issue relates to node maturity. Most, if not nearly all, new capital expenditures by the major firms will be spent on leading node technology (5nm and smaller, see chart above) to support growing areas such as smartphones and supercomputers. These leading nodes are importantly more profitable. The auto industry, however, which is expected to be the largest source of growth in demand for semiconductors, currently relies heavily on mature node technology. With little incentive for companies to invest in mature node capacity, the auto shortage may persist until chips for cars evolve (which will happen overtime as the need for onboard computing increases) and/or enough mature node capacity is opened by other industry evolution. There are some firms that are investing in mature node capacity, but in many instances, they are small firms, and sourcing production technology for older nodes can be difficult. Moreover, these companies are mostly Chinese firms, including SMIC, which under the current sanction regimes may not be able to contribute to global supply. The shortages here will eventually work themselves through the system.

Ongoing Risks

The future of the supply chain remains in flux with risks facing the security of semiconductor procurement around the world. Geopolitical tensions are front of mind with ever increasing sanctions on Chinese companies impacting supply and demand globally. The blacklisting of SMIC is the most obvious example, but the Biden administration's addition of several Chinese supercomputing entities will likely impact orders to TSMC and other manufacturers. In addition, building a new factory on the other side of the world in Arizona is a new challenge for TSMC, and one that comes with cost inefficiencies that had to be subsidized before the project was agreed. The political issues are not insulated to the Sino-American sphere – Italian Prime Minister Mario Draghi recently announced that his government had blocked Shenzhen Investment Holdings from buying a 70% stake in Milan-based semiconductor company LPE.

Weather has also been a troublesome factor, and likely will continue to be in the future. The freak February snowstorm in Texas temporarily shuttered semiconductor factories in the Lone Star State operated by Samsung, NXP, and Infineon. Meanwhile, an ongoing drought in Taiwan – the worst in half a century – is threatening its water-intensive chip production, although the government has recently decided to prioritize getting water to factories rather than farmland.

The Biggest Beneficiaries

The semiconductor and semiconductor services industry has benefited from the global shift towards digitalization with the MSCI ACWI Semiconductor and Semiconductor Equipment index outpacing the total ACWI by approximately 50 percentage-points since the end of 2019. The largest name in the sub-index, TSMC, is +88% over the same time period. The next two largest are Nvidia and ASML, each of which has more than doubled since the end of 2019. Rounding out the top five, Intel and Broadcom are +2% and +55% respectively. This very strong performance has left much of the index priced to perfection, with valuation multiples at decade highs. That being said, there are strong secular tailwinds in place that will keep demand for chips elevated long after any near-term supply chain disruptions dissipate. Management of both TSMC and ASML speak to this repeatedly in their most recent earnings calls.

So how should an investor position to take advantage of this secular trend? Dominant firms protected by barriers to entry which can thus generate long-term returns above their cost of capital, such as TSMC and ASML among others, are attractive long-term plays. In this phase of the cycle, the capital equipment companies seem most immediate to benefit as foundries have entered a cycle of heavy capital expenditures, which will be paid to the equipment makers. With ASML the sole supplier of EUV equipment they are positioned to be a prime beneficiary of the upcoming capital expenditures by foundries. Other equipment makers stand to benefit as well – particularly as production ramps up and everything from chemicals to scanning equipment are needed in production. As chip demand persists, the foundries will also benefit, although free cash flow will be impacted by CapEx in the near term and operational risks persist.

At RockCreek our preference for North Asia has been, and continues to be, driven by that region's exposure to the opportunities presented by the semiconductor industry. Not only are Samsung and TSMC based in the region, but Korea and Taiwan in particular are filled with a multitude of smaller specialist firms that integrate into the overall supply chain. We work with specialists in the region to uncover and gain exposure to the less well-known opportunities in addition to the dominant firms.

RockCreek

Confidential – not for public disclosure.

This information contains confidential and proprietary information that cannot be disclosed to any third parties or used for any purpose unrelated to the investor's investment in the fund or the account referenced herein. You agree that you will not distribute any information regarding this investment without the express written approval of the investment manager and that the investment in the fund or the account must be maintained on a strictly confidential basis by the investor and its advisors.

The contents herein are intended for informational purposes only. There can be no guarantee that the information presented is accurate. The information presented does not constitute tax, legal, investment or regulatory advice, and we encourage you to consult your legal and/or tax advisors should you have any questions relating to the materials presented herein. Opinions expressed reflect the current opinions of the Rock Creek Group as of the date appearing in this material only.

This material is intended only to facilitate your discussions with RockCreek; it is not intended to be used as a general guide to investing, or as a source of any specific investment recommendations, and makes no implied or express recommendations concerning the manner in which any client's account should or would be handled, as appropriate investment strategies depend upon the client's investment objectives. Information included herein may be provided to discuss general market activity; industry or sector trends; or other broad-based economic, market, or political conditions. Discussions herein concerning general economic conditions and political developments are not intended to be used as a general guide to investing, or as a source of any specific investment recommendations, and RockCreek makes no implied or express recommendations or warranties concerning the manner in which any account should or would be handled, as appropriate investment strategies depend upon the investor's unique investment objectives. This material does not constitute an offer or solicitation with respect to the purchase or sale of any security in any jurisdiction in which such an offer or solicitation is not authorized or to any person to whom it would be unlawful to make such offer or solicitation. As such, the information contained herein has been prepared solely for general informational purposes. None of RockCreek or any affiliates or employees makes any representation or warranty, express or implied, as to the accuracy or completeness of the information contained herein and nothing contained herein shall be relied upon as a promise or representation as to the past or future performance. Information and opinions are as of the date of this material only and are subject to change without notice.

Discussions regarding potential future events and their impact on an account are based solely on historic information and estimates and/or opinions, are provide for illustrative purposes only, and are subject to further limitations as specified elsewhere in this material. No guarantee can be made of the occurrence of such events or the actual impact such events would have on the account's future performance. In addition, the opinions, forecast, assumptions, estimates and commentary contained in this material are based on information provided to RockCreek on both a formal and informal basis. Further, any such opinions, forecasts, assumptions, estimates and commentary are made only as of the date indicated, are subject to change at any time without prior notice and cannot be guaranteed as being accurate.

Please note that the investment outlook and opportunities noted above (and throughout this material) are prospective and based upon the opinion of RockCreek and there is no guarantee of success in our efforts to implement strategies that take advantage of such perceived opportunities.