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Semiconductors: The Darkness Before the Dawn

INSIGHTS



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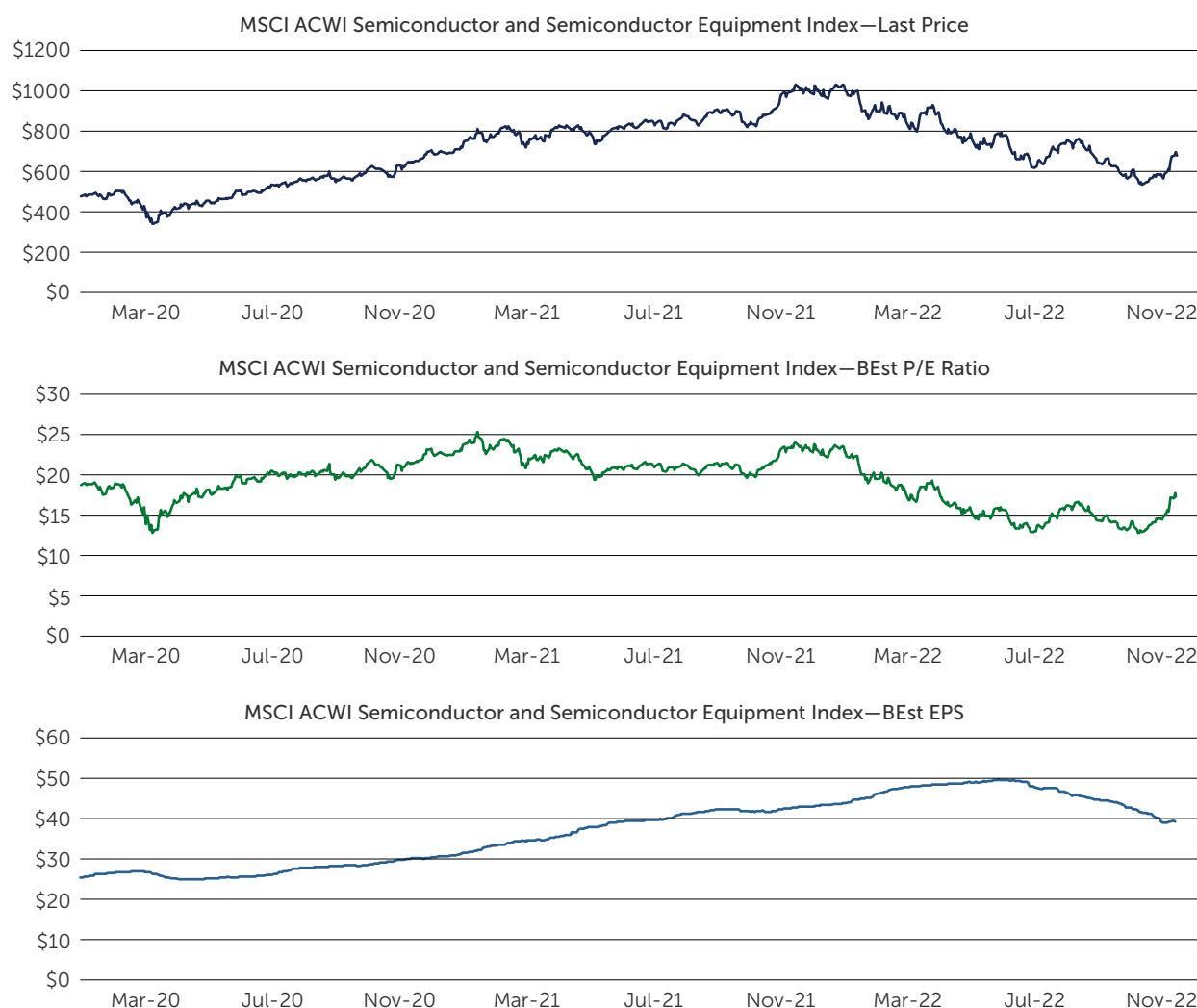
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The laundry list of problems that the broad technology sector has had to endure in 2022 is long and include the external macro impacts of the Russian invasion, faltering demand, sustained price inflation and the feeding through of rising interest rates to the stock valuations. The semiconductor sub-sector has borne much of the pain as it is traditionally seen as the more cyclical end of the technology sector¹, and has also become embroiled in the ratcheting up of geopolitical tensions between the U.S. and China.

The companies have dutifully been reducing earnings guidance in response, while valuations on those earnings have also been falling. However, there are reasons to believe that the underlying secular growth trends for the semiconductor sector remain firmly in place—and that as the shorter-term headwinds become better understood, the time to look through the cyclical trough for opportunities in the semiconductor sector is now.

Figure 1: A Challenging Year for Semiconductor Companies



Source: Bloomberg. As of November 17, 2022.

1. The MSCI ACWI Semiconductor index fell -33% year-to-date. As of November 17, 2022.

A Pandemic Hangover

The well-publicized semiconductor supply chain disruptions that crippled, among others, the automotive industry during the pandemic led to a build-up of inventory in other components that were easier to source. For example, inventory of memory chips for the PC and smartphone device markets had been building up over the last year as the original equipment manufacturers (OEMs) waited for other parts that were in shortage to be delivered. The incremental damage to end market demand throughout the summer exacerbated these problems, leading to a sharp slowdown and a period of inventory digestion for the companies affected. To give a sense of the size of the downdraft, leading U.S. memory chip supplier, Micron, has seen the consensus revenue forecasts for the coming 12 months fall by -32% in the last three months².

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In addition, a recent ratcheting of tensions between the U.S. and China has culminated with the U.S. Bureau of Industry and Security (BIS) implementing restrictions, adding more fuel to the fire. The new restrictions announced in October aim to prevent the sale of advanced chips to restricted entities in China, and limit access to the tools and engineers required to make them. This pressure on the Chinese domestic semiconductor industry has added a greater sense of urgency to the reappraisal of global supply chains, which began with the pandemic disruptions. All of this has simply added to the uncertainty faced by investors in semiconductor companies.

The Devil is in the Detail

The BIS restrictions indicate certain definitions of advanced semiconductors based on processor performance and the geometries of the transistors printed onto the chips. Essentially, the aim of the restrictions is to slow China's progress toward their stated ambitions of leadership in foundational technologies such as Artificial Intelligence (AI) and their ability to enhance their military capabilities.

2. Source: Bloomberg Estimates. As of November 17, 2022.

As a result, the first notable victim was a U.S. company, nVidia, with their dominant share of processors used for the machine learning stage of AI. Their current generation, the A100, and the imminent H100 models, which are more sophisticated, are both now banned from sale to Chinese buyers. In response, nVidia initially indicated that Chinese buyers had shifted their focus to predominantly buying the older V100 model, which was not captured by the BIS restrictions. nVidia has since launched another version of their A100 chip, which specifically performs below the level of the restrictions.

Figure 2: BIS Restrictions Target Very High-end Computing Chips

Product Information			U.S. Export Control (I/O Rate \geq 600GB/s & TOPS*Bit \geq 4800)				
GPU	Launch Year	Applicator	Node/ Manufacturer	I/O Connectivity	Performance	TOPS* Bit	Covered by U.S. Export Control?
Nvidia							
H100	2022	HPC & AI	4nm (TSMC)	NVLink: 900GB/s	100/2000 TFLOPS for FP16	16,000 (w/o Sparsity)	Yes
A100	2020	HPC & AI	7nm (TSMC)	NVLink: 600GB/s	312/624 TFLOPS for FP16	4,922 (w/o Sparsity)	Yes
V100	2017	HPC & AI	12nm (TSMC)	NVLink: 300GB/s	28 TFLOPS for FP16	448	No
Intel							
Ponte Vecchio	2022	HPC & AI	5nm (TSMC)	Unknown	839 TFLOPS for FP16	13,424	Likely
AMD							
MI200	2021	HPC & AI	6nm (TSMC)	800GB/s	383 TFLOPS for FP16	6,128	Yes

Source: Company Reports and Bernstein Analysis.

Therefore, the most likely consequence is that Chinese buyers who are investing in machine learning infrastructure will be forced to curtail plans to buy the higher performance chips—and instead simply buy more of the slower, less economic chips to try and make up the difference. The cost of doing so will be damaging to the buyers and will crimp their demand, but the immediate impact on nVidia is relatively small. Other leading U.S. chip companies supplying AI chips, such as Intel and Advanced Micro Devices, will likely find their competing processors are also in the firing line. But their share in this market is considered to be much smaller, so the impact on their earnings is even less noticeable.

AI functions are not exclusive to the high performance computing and Cloud markets, as consumer devices such as smartphones can also contain chips used for AI processing. However, these fall short of the maximum performance restrictions, meaning that international players such as Qualcomm, Mediatek and companies such as Apple that design their own ARM-based processors are not directly affected at this juncture.

Figure 3: Processors Used in Smartphones Appear to Avoid BIS Restrictions

Product Information			U.S. Export Control (I/O Rate \geq 600GB/s & TOPS*Bit \geq 4800)				
Smartphone Chip	Launch Year	Application	Node/ Manufacturer	I/O Connectivity	Performance	TOPS* Bit	Covered by U.S. Export Control?
Qualcomm							
Snapdragon 8 Gen 1 (Hexagon DSP)	2021	Smartphone	4nm (Samsung)	Unknown	27 TOPS	864	No
MediaTek							
Dimensity 9000 (APU 5.0)	2021	Smartphone	4nm (TSMC)	Unknown	Unknown	Unknown	Likely not

Source: Company Reports and Bernstein Analysis.

Further, AI is not just enabled by processors, it also requires vast amounts of memory chips on which to store the data used to train the AI models. As a result, much of the focus immediately turned to the large memory fabs based in China and owned by international competitors including Hynix, Samsung and Intel³, as well as the high profile domestic fabs owned by ChangXin Memory Technologies (CXMT) and Yangtze Memory Technology Corp (YMTC). The limits on device sales to restricted customers and the limits on access to advanced production tools within China will be severely detrimental to China's progress in becoming self-sufficient in the memory sector.

Hynix and Samsung have already confirmed that they have obtained licenses from the U.S. that exempt them from the restrictions for one year, giving them some time to re-appraise their capital expenditure plans in terms of where to build incremental capacity. Both players have significant capacity within China for manufacturing the two most popular types of memory chips used in PCs, servers and smartphones, namely DRAM (dynamic random-access memory) and NAND (non-volatile storage memory). 49% of Hynix's DRAM bits are produced in China, while 32% of the company's NAND bits are produced in China, and 42% of NAND bits for Samsung are produced in China. As memory chips are relatively commoditized, the need to build them in China is not as critical. This means we would expect to see more capacity announcements outside of China as both players look to diversify their production footprint beyond just China and Korea.

For Chinese domestic manufacturer YMTC, the new restrictions are particularly frustrating. Their NAND memory chips have just been qualified for Apple's iPhones and expectations were rising that they would win some share of the domestic iPhone shipments. Apple has since frozen plans to use YMTC. Further, YMTC's technology roadmap was to move to the next generation of NAND with 232 layers, but the BIS

restrictions prevent this by blocking access to the tools required. According to the Gartner technology research service, YMTC has a 2.7% share of global NAND production for 2021. While this may appear to be small, the broader damage is to their future ability to disrupt the pricing of leading edge 3D NAND chips in the future, supported by Apple's efforts to help them qualify into the iPhone. At the same time, while this is disruptive to China's domestic champions, many international competitors will be comforted by the effective removal of a disruptive new entrant. Micron, in particular, is notable as it does not manufacture their memory chips in China.

While it's difficult to isolate the likely impact on growth in memory bits sold from Chinese facilities in the coming year, it seems safe to assume the number is now lower than it was. Given much of the semiconductor inventory build-up has hampered share prices in response to a decline in demand, the recent BIS regulation should accelerate efforts to clear inventories, offering support to the valuations of these international memory device makers as supply imbalances are moderated.

Looking at the medium-term outlook, the cut to demand for production tools is a further hindrance to expectations of industry supply growth. This is an attractive supply side discipline, as the lack of tools limits supply growth, which improves pricing and the investment outlook for memory makers in the longer term. China had attracted a large proportion of global investment in semiconductor production for good reasons, namely the cost of building and operating the fabs, as well as access to the ecosystem of suppliers and customers that coalesced around the centers of excellence established there. However, building new capacity elsewhere is more expensive, which in turn reduces the incentive to build more fabs. This problem leads to the discussion of the outlook for production tool makers.

3. Intel has agreed to sell their Dalian fab to Hynix, but given that the second phase of the deal was not due to close until 2025, there is a risk that it does not complete.

Linewidths, Layers & Lithography

ASML, the dominant supplier of lithography tools—arguably the most important tool in the semiconductor fabrication process—has been at pains to point out that the BIS restrictions actually have a greater impact on the suppliers of the tools used for the deposition and etch processes. These are a series of steps to apply and selectively remove chemical layers on a silicon wafer, and are therefore more exposed to semiconductors produced using 3D technologies (vertical layers for the transistors), rather than lithography.

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Essentially, ASML’s tools are limited by the wavelength of light and the numerical aperture of the lenses they use, meaning that to make devices with features smaller than the BIS restrictions today requires leading-edge deposition and etch tools. In the meantime, ASML highlighted that their order book is 40% bigger than their capacity to ship tools. Any cut in demand from restricted Chinese buyers is easily made up for by the 150 or so domestic Chinese producers of chips for markets such as electric vehicles and industrial automation based on less advanced technologies that do not trip over the restrictions, and are still desperately trying to serve their own large order books. ASML’s Q3 2022 earnings and lack of significant impact on their financial guidance underlined this point.

In contrast, all three of the leading deposition and etch tool suppliers, Applied Materials, Tokyo Electron and Lam Research, have already announced significant cuts to revenue guidance based on both the memory market weakness described above, and the new restrictions on the ambitious Chinese memory producers such as YMTC.

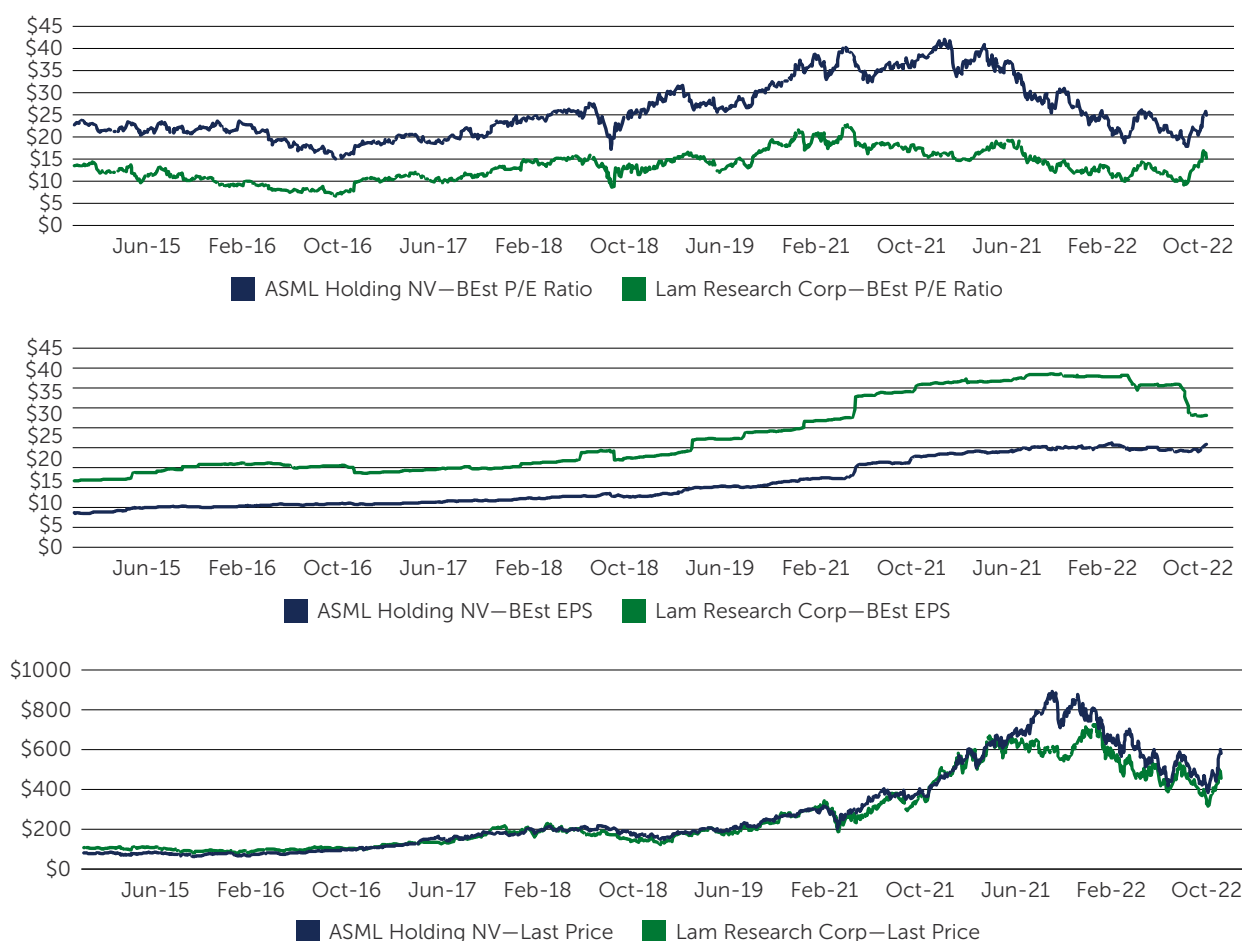
The effective removal of YMTC from being able to produce leading edge NAND chips, should the restrictions remain in place, makes for a more concentrated industry and points to more discipline in supply growth—which in turn should lead to higher through-cycle profit margins. While they may limit the height of the peaks in demand for production tools from the likes of Lam, Applied and Tokyo Electron, it does make for a more stable environment to operate in and should be reflected in higher valuation multiples applied to these companies over time.

Conclusion

While the semiconductor sector is clearly suffering major headwinds from the cyclical downturn in demand, high inventories in consumer electronics and commodity memory, not to mention being in the eye of the geopolitical storm raging between China and the U.S., there are a growing number of reasons to be optimistic about the share prices over the medium term.

Both the memory companies and their production tool suppliers have already cut financial guidance to reflect as much of the deterioration in demand as they can foresee. The valuations based on these reduced expectations had trended toward the bottom of the 5-year range, indicating that they were depressed based on forecasts for the next peak in earnings. The very recent share price recovery suggests that the market may be trying to look through the immediate concerns detailed above. The inventory build-up, especially in the memory sector, remains the most obvious short-term risk, should it take longer than hoped to work through. However, the impact of the BIS restrictions on Chinese-based production adds to our conviction that supply growth will be less than currently feared, creating more optimistic expectations of chip prices rises as we move through 2023.

Figure 4: Semiconductor Companies' Valuations are Depressed



Source: Bloomberg. Lam and ASML's P/Es reached the lower end of the 5-year range in October 2022. Earnings' estimates for Lam have been hit much harder due to exposure to memory capex and China restrictions. ASML's order book exceeds their ability to supply by 40%, so EPS expectations are more stable. All data in U.S. dollars.

The threat to the longer-term supply outlook before the BIS restrictions was in large part the rise of the domestic Chinese producers and fears over lack of capital discipline. The removal of access to U.S. intellectual property, and the skilled engineers required to drive the evolution of the Chinese industry, has disrupted these aspirations. However, this disruption is not easily mitigated by greater investment, and a concerted centralized push to focus on R&D will likely not make up for the damage caused by the BIS restrictions, with the current leading edge developed over years of specialized expertise and intricate technological advancement.

Assuming the restrictions remain in place, the rate of recovery for the rest of the industry will be dependent on a number of secular growth factors, including:

- Extent of government subsidies to cover the higher costs of locating fabs outside of China.
- Share gains within Enterprise IT by Public Clouds that use more powerful chips in their datacenters.
- Growth in demand for AI applications across an expanding list of industries.
- The digitization of automobile and industrial production, which cuts across silicon for Internet of Things and AI. These chips are typically manufactured on lagging edge technology and therefore don't suffer from the BIS restrictions. Many are also still in shortage.

We have high conviction in the power of the demand drivers above and are excited by the opportunities offered by the current cyclical downturn. In our view, the depressed valuations that we see for the established industry-leading semiconductor producers and tool suppliers—which are best placed to profit from the demand growth—are becoming increasingly attractive.

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