



Semiconductors

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Introduction

We have been fans of the semiconductor sector for a long time as we have felt that the market was under-appreciating the value embedded in these companies. During the month of November, the Bloomberg World Semiconductor Index (BWSEMI) increased 15.7% compared to the DJ World Technology which was up 9.7%. For the year, to the end of November, the BWSEMI has been up 35% while the semiconductor holdings in Herald Worldwide Technology Fund (HWTF) have in aggregate appreciated 53% (all percentages in USD).

Semiconductor companies in our portfolio include NVIDIA, Advanced Micro Devices (AMD), Xilinx, Cadence Design Systems (Cadence), Teradyne, Taiwan Semiconductor Manufacturing Co (TSMC), Micron, Samsung Electronics, Kulicke & Soffa (KLIC), and Intel. Earlier in the year, we also had a position in Mellanox which was taken over by NVIDIA. Throughout the year, semiconductor stocks have accounted for about 20%* of our portfolio.

Few of the companies in our portfolio are directly comparable with one another but all are critical enablers of key trends such as cloud computing, artificial intelligence, electric vehicles, robotics and automation, energy efficiency, digital finance, sharing economy, safety, security, autonomous driving, 5G, internet of things (IoT), and digital health.

Historically, Moore's law has been the motor of the semiconductor industry and in turn the semiconductor industry has been a big driver of economic growth. Moore's law was a sort of self-fulfilling prophecy since its pronouncement by Gordon Moore in 1965. It led to a unique mixture of enormous collaboration and competition in the industry which in turn, has propelled the sector forward at a high pace for the last few decades.

In recent years, Moore's law has been under siege from both technological and economical forces. The rate of increase of transistor density has decreased from what it was. Moore's law had predicted the doubling of transistors per unit area, every 18 months with the corollary that the price of transistors decline by 50% during the same period. Currently, we are looking at maybe three years to double the density of transistors per unit area, maybe even more. It has also become ever more difficult and expensive to develop and produce the next generation of chips. Leading-edge, semiconductor fabs which used to cost a few hundred million dollars in the 1990's now cost over \$10billion.

These rising costs and complexity have led to significant consolidation in the industry. Just this year, we have seen bids by NVIDIA to acquire ARM for \$34bn, Analog Devices to acquire Maxim for \$20bn, AMD to acquire Xilinx for \$33bn, and Marvel to acquire Inphi for \$9bn (all are currently pending regulatory approval).

The annual global semiconductor market is expected to be \$474bn[^] in 2021 and has been growing around 6-7%[^] annually. Elements of it, such as the memory market, continue to be quite cyclical, so the annual growth rates vary. However, the cyclicality has been reduced due to two factors:

- 1) The overall breadth of applications has increased dramatically over the last 20 years and continues to do so. Whereas in the earlier days much of the demand was industrial markets and corporate PCs in developed markets, now the usage of semiconductors permeates almost all end-markets and geographies and are therefore less sensitive to economic cycles.
- 2) Manufacturing models have changed, leading to significant consolidation in manufacturing capacity and therefore less pronounced variations in capacity and utilisation levels.

Geopolitical Angst

The semiconductor sector has also been at the crosshairs of the geopolitical tensions as politicians have come to realise the significance of the sector to the broader economy. In 2015, the State Council in China announced its “Made in China 2025” policy, with an objective to be 70% self-sufficient in semiconductors by 2025. The Chinese government has been investing aggressively in the sector and supporting domestic champions such as HiSilicon, Rockchip, Bestech, Goodix, SMIC, YMTC, and many others.

China’s efforts to acquire and subsidise its way into dominance have been curtailed by the Trump administration’s numerous bans on Huawei and other Chinese entities. However, these setbacks are likely to be only temporary. China will continue to invest in and support its domestic leaders.

Many investors have been wary of investing in the sector, especially as US/China tensions escalated in the last two years. The concern has been that Chinese companies such as Huawei and other affiliates of the government are stockpiling components and equipment to protect themselves against the US bans. Therefore, current demand may be a misleading indicator of the future and overall competition is likely to increase.

In all our conversations with company managements during the last year, we have consistently questioned them on their views about Chinese competition, Chinese customers stockpiling products, and the effects of the different US regulations. The answers have varied depending on the individual companies. For example, TSMC’s position was that any reduction in demand by Huawei and Hi Silicon, is being taken up by their other customers who are gaining share from Huawei. Entegris which sells specialty gases to manufacturing facilities assured us that it is unlikely that the Chinese are stockpiling their products as Entegris owns and reuses the gas cannisters and would know if they were being stockpiled. Nevertheless, this uncertainty about inventories in China had caused the sector to underperform.

Backwaters of the Back-end

At Herald our approach to investing has always been holistic. We look through entire supply chains and try to find the bottlenecks and/or new opportunities for growth and attractive valuations. Part of our enthusiasm for semiconductors has been driven by our interactions with the management of companies in the Herald Investment Trust plc. Based on our conversations with the management teams of some long-term holdings such as BE Semiconductor, Nordic Semiconductor, Napatech, and Inphi, we have seen the growing importance of packaging and testing.

This has supported our investments in TSMC, Cadence, Teradyne, and KLIC in HWTF. Although both Cadence and TSMC are industry leaders in design and manufacturing, their growth is also driven by new developments in packaging and testing.

Packaging and testing is referred to as the “back-end” processes in the industry parlance. The manufacturing process of the industry is separated into two unique areas, the front-end and the back-end. The front-end refers to the formation of the devices on the surface of a pizza-like platter, called the wafer. The back-end refers to the testing, thinning, and dicing of the wafer and packaging of the devices into standard units.

The size of the market for capital equipment for back-end processes is about \$9.4bn** annually.

Historically, “back-end” has been viewed as the less “cool” part of the chain. Back-end was deemed as commodity and not therefore attractive for investment.

The slowing down of Moore's law and focus on power savings in mobile, data centre and IoT applications has led the industry to focus on the performance of the chip in its entirety, including the packaging. This has led to a flurry of investment and innovation to design new ways of packaging to lower the power consumption of chips and while at the same time reducing the overall size of the package. A simplistic analogy would be that it isn't only the engine of the car which drives performance, the design of the body also matters. In semiconductors, the front-end processes could be considered equivalent to the engine of the car, while the back-end processes are equivalent to the body of the car.

Teradyne and Kulicke & Soffa are exclusively exposed to the back-end. TSMC and Cadence have dominant positions in the front-end but at the same time both have expanded their businesses to benefit from the growth in back-end opportunities.

Recent Portfolio Changes

In recent weeks we have been taking profits on AMD as it had grown to become close to 5 percent of the fund. Including Xilinx, the position was over 8.5 percent. Under the leadership of Lisa Su, AMD has executed almost flawlessly, gaining share in the PC market and breaking into the server market. Much of their success has been due to their pioneering work in chiplet architectures. Another key driver of AMD's growth has been their decision to partner with TSMC and therefore benefit from TSMC's

leadership in manufacturing. By relying on TSMC for manufacturing and benefiting from TSMC's high manufacturing yields, AMD has been able to assure customers about the reliability and availability of its products and dedicate resources to gaining share in new markets. We are supportive of AMD's acquisition of Xilinx as it expands their opportunities in the datacentre as well as along different points in the communication networks. We, therefore, continue to hold our position in Xilinx.

Summary and Conclusion

We believe semiconductors remain a strategic sector with plenty of opportunities for innovation and growth. Simplistically, one can say we are moving from an era of homogenous computing to an era of heterogenous computing, i.e. horses for courses. Two specific areas of disruption are chips for processing large data applications and chips used for ultra-low power applications.

Semiconductor companies are exploring fundamental changes in computer architecture. The industry has been relying on the von-Neumann architecture, presented by John von-Neumann in 1945, which separated memory and computing in different blocks. This made sense in the era of low bandwidth and low connectivity. The same way that dense urban areas need different transportation systems from rural communities, machine learning and artificial intelligence applications which rely on analysing large amounts of data also need new chip architectures to perform efficiently. We believe these disruptions in computing architecture will create attractive investment opportunities.

Many machine learning and AI applications such as factory automation or health and safety, also rely on ubiquitous sensors to collect data. These devices in turn need to be highly energy efficient as many will be battery operated and it will be too costly to have to change them regularly. This is leading to a resurgence in interest in new materials other than silicon. New materials in turn lead to the need for new systems for manufacturing and testing. We believe the supply chain associated with new materials will also present attractive long-term investment opportunities.

We continue to look for well-managed, attractively positioned, and attractively valued companies in the sector. We believe in the long-term strategic importance of semiconductors and believe the multitude of avenues of innovation will present attractive long-term investment opportunities.

*Precise percentages vary based on market movements

^source: Gartner

** Kulicke and Soffa presentation of December 2020

Important Information

Market and currency movements may cause the value of shares, and the income from them, to fall as well as rise, and you may get back less than you invested when you decide to sell your shares. Certain statements in this report constitute 'forward-looking' statements. Such statements, including the intended actions and performance objectives of the Fund, involve unknown risks, uncertainties and other factors which may cause actual results, performance or achievements of the Fund to differ materially from those implied by such forward-looking statements.

This report has been issued on behalf of Herald Worldwide Technology Fund, and has been approved by Herald Investment Management Limited, its investment manager. Herald Investment Management Limited is authorised and regulated by the Financial Conduct Authority. Contact details:

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