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CHIPS Act, Shortages and More: An In-Depth Look at Trends Reshaping Semiconductors

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The semiconductor industry has been undergoing rapid transformation, driven by technologies like machine learning, cloud and high-performance computing, artificial intelligence, 5G and increased use of semiconductors in industrial and automotive applications. Semiconductors are becoming more complex and specialized to power these cutting-edge applications. At the same time, the industry faces potential headwinds such as a globalized supply chain and geopolitical risks.

In this Q&A, our research analysts, Varun Gupta, CFA, and Jayant Jangra, CFA, provide an in-depth look at the trends shaping semiconductors today. They discuss chip design innovations to overcome Moore's Law's slowing. The geopolitical push to diversify manufacturing beyond Asia is explored. We also learn how GPUs are gaining share from CPUs for AI workloads and how industrial/automotive demand is surging.

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Other topics covered include the impact of the CHIPS Act on US competitiveness, TSMC's dominance of the foundry model, solutions for the chip shortage, concerns over Asia supply chain concentration, growth opportunities like AI and 5G, and specific investment theses from Diamond Hill.

What are the latest trends shaping the semiconductor industry, and how are they influencing the global tech landscape?

Jayant Jangra, CFA: In the fast-paced world of technology, the semiconductor industry is a hotbed of innovation and change. With constant advancements, new trends are continually shaping this dynamic landscape. We are seeing the following four trends as some of the most impactful to the industry today:

- It is becoming more complex and less economical to continue making smaller features as we reach the physical limits. In essence, Moore's Law is slowing down. Therefore, we are seeing innovation in chip design and architecture to pack more performance and efficiency within the same footprint, such as 3D chip designs, packaging, chiplets, etc.
- From a manufacturing footprint perspective, the most advanced chip manufacturing is concentrated in Taiwan. There is a push to diversify that footprint globally via US and European government support.

- The newer workloads in the cloud, artificial intelligence and machine learning are highly parallel and repetitive, which can be more efficiently handled by GPUs (graphic processing units) as opposed to CPUs (central processing units), which are very good at processing complex transactions but less efficient at handling parallel workloads. Therefore, GPUs are taking share of workloads from CPUs.
- Industrial and automotive applications are experiencing a rapid increase in semiconductor content as these products become more intelligent, safer, efficient and connected.

The CHIPS Act was recently passed to provide $52 billion in subsidies for the semiconductor industry. How do you think this will impact the growth and competitiveness of the US semiconductor sector?

Varun Gupta, CFA: At Diamond Hill, we invest with a long-term investment horizon and philosophy. Therefore, we estimate industry trends from a 5+ year time horizon. In our view, the CHIPS Act is expected to benefit the growth and competitiveness of the US semiconductor sector over the long term.

The semiconductor sector has five big sub-segments: 1) Digital chip design, 2) Digital chip manufacturing, 3) Analog chip manufacturing, 4) Memory chip manufacturing, and 5) Semiconductor capital equipment.

Given the importance of semiconductors in our modern life, it is a sector well supported by leading governments worldwide (such as China, South Korea, Taiwan and the EU). Thus, we estimate the US CHIPS Act benefits companies that are technologically leading in their respective sub-segments of semiconductors.

The US CHIPS Act also provides subsidies and grants to foreign-domiciled companies to set up manufacturing in the US. For example, Taiwan Semiconductor Manufacturing Company (TSMC), a Taiwan-based company, announced plans to build a $12 billion semiconductor factory in Phoenix , Arizona. This is the most significant foreign investment in US semiconductor manufacturing in history, and the company announced this expansion because of the benefit it expects to receive from the US CHIPS Act.

As mentioned earlier, the critical factor in the competitiveness of semiconductor companies is whether they have the #1 leading technology in their respective industry, sub-segment or niche. Companies such as Texas Instruments, Analog Devices, KLA Tencor, Applied Materials, Lam Research and TSMC are some of the best technological leaders in the industry. Thus, we expect them to benefit the most.

In summary, the US CHIPS Act is beneficial for the growth and competitiveness of the US semiconductor sector. It is expected to create more semiconductor jobs in the US and geolocate semiconductor manufacturing plants away from Asia to the US.

Taiwan Semiconductor Manufacturing Company (TSMC) is the world's largest contract chipmaker. How has TSMC achieved its dominant position in the foundry business, and what role does it play in global supply chains?

Varun Gupta, CFA: The development of digital chips has two distinct steps: 1) chip design and 2) chip manufacturing. TSMC focuses only on chip manufacturing. The company has established itself as the world's dominant contract chipmaker through a combination of three hard-to-replicate competitive advantages:

1) Its unique "pure-play foundry" business model. TSMC only focuses on manufacturing chips and doesn't compete with its customers, such as Apple, Nvidia, Advanced Micro Devices, Qualcomm and MediaTek, which design chips.

2) Developing leading-edge proprietary chip manufacturing technology with high throughput yields.

3) Relentless focus on customer relationships and making them successful. TSMC's customers value chip performance, quality, yield improvements, faster production cycle time, trust and the partnership attributes TSMC provides.

With the rapid digitization of our society, semiconductors are critical across several sectors, such as communications, defense, finance, power, transportation and health care. Advanced chips are needed for the most demanding cloud computing, smartphone, artificial intelligence, communication and automotive use cases that TSMC manufactures.

The company holds approximately 60% market share in the digital chip manufacturing sub-segment of semiconductors and over 80% market share in leading-edge semiconductor manufacturing. TSMC also has over 30 years of solid execution history, allowing it to be well-positioned to capture the long-term structural growth of semiconductors across all sectors.

Other advantages that TSMC enjoys relative to competitors include:

- Superior semiconductor manufacturing technology and switching costs, which lead to pricing power.
- TSMC's superior ecosystem of chip software, chip IP, chip design and supply chain partners provides unique proprietary capabilities to the company.
- Unlike Samsung's and Intel's foundries, which have competing products with end customers, TSMC benefits from a "pure-play foundry" business model because it does not compete with its own customers. For example, Apple moved its entire chip manufacturing from Samsung Foundry to TSMC because Samsung competes with Apple on smartphones.
- TSMC also benefits from economies of scale in digital chip manufacturing compared to Samsung Foundry and Intel.

TSMC manufactures a wide range of chips used in various applications and devices such as smartphones, personal computers, data centers, high-performance computing applications, wired and wireless communications infrastructure, consumer electronics, automotive and industrial applications. Thus, it plays a critical role in the global supply chain.

With the global chip shortage still ongoing, what can semiconductor companies do to ramp up production and get chips to market faster? Are there any innovations or process changes that could help?

Jayant Jangra, CFA: The shortages in the broader semiconductor industry that were caused by plant closures have been resolved now, and coupled with the slowdown in demand for electronics from pandemic highs, this has resulted in excess channel inventory in the semiconductor supply chain.

In many cases, the chip shortages during the pandemic were seen in pockets — often in simpler devices such as power management chips made on mature nodes. The mature nodes are fully depreciated, have high yields, and are sufficient to meet the performance requirements of simpler devices.

However, new capacity is not being added to these mature nodes, and the chip design companies do not want to migrate these products to the advanced nodes since it does not make sense for them to spend money on redesigning a chip that is working well and will not benefit much from advanced nodes.

That said, the capacity constraints on mature nodes are now starting to bite chip design companies as the foundries have raised prices on these mature nodes sharply over the last two to three years and have also asked customers to guarantee demand for multiple years under NCNR (non-cancellable, non-returnable) contracts if they want the foundry to add capacity.

Design changes in the semiconductor industry are slow to implement so that portion of market remains subject to supply-demand imbalances. Therefore, this problem will likely be solved over time as chips are redesigned on the more advanced nodes with fewer capacity constraints.

How did the pandemic and supply chain issues expose the risks of the semiconductor industry's concentration in Asia? Do you think we'll see more reshoring of chip fabrication back to the US and Europe?

Jayant Jangra, CFA: The pandemic certainly caused some wild shocks in the component supply chain due to its concentration in Asia. Shortages caused by temporary plant shutdowns caused lead times on components to increase, and customers were forced to sit on nearly finished inventory unable to be shipped out because of that one "golden screw."

Besides the supply chain shocks caused by the pandemic, governments also recognize the geopolitical risk of having the most advanced manufacturing concentrated in Taiwan. Therefore, customers and governments have been forced to consider developing a more geographically diverse and resilient footprint. As previously discussed, the US passed the CHIPS Act to incentivize the industry to bring semiconductor manufacturing back within the US. Similarly, the European Union passed the European Chips Act to increase Europe's share of semiconductor manufacturing to roughly 20%.

How could the rise of AI, 5G, ADAS (advanced driver assistance systems) and other advanced technologies impact chip design and manufacturing over the coming decade?

Varun Gupta, CFA: The rise of artificial intelligence (AI), 5G, ADAS and other advanced technologies is expected to significantly impact chip design and manufacturing in the next 5-10 years. These technologies will drive demand for more powerful, efficient and specialized chips, requiring significant advancements in design and manufacturing processes.

Where do you see the most growth opportunities in the semiconductor industry right now? Which applications or market segments have the most potential?

Varun Gupta, CFA: The semiconductor industry has several growth areas. Historically, demand has been cyclical, and we expect cyclical trends to continue for the next 5-10 years. The key growth areas in semiconductors are artificial intelligence, high-performance computing, automotive, industrial and wireless communication.

What specific opportunities has Diamond Hill identified in the industry?

Varun Gupta, CFA, and Jayant Jangra, CFA: First, we would say that Diamond Hill uses an intrinsic value approach to investing, where we focus on identifying businesses trading for less than what they are worth. So, while we've invested in several semiconductor-related businesses, it's always based on our bottom-up stock selection process, not on trends or secular themes within the industry — though we do factor all of these into our fundamental analysis.

We shared some highlights earlier about **Taiwan Semiconductor Manufacturing Company** (TSMC), so we'll briefly summarize our thesis again. TSMC is the world's largest chip manufacturer, with approximately 60% market share in digital chip manufacturing. It enjoys several competitive advantages of having leading-edge proprietary chip manufacturing technology, customer switching costs and pricing power. The company also has over 30 years of solid execution history, allowing it to be well-positioned to capture the long-term structural growth of semiconductors across all sectors.

NXP Semiconductors (NXPI) is another investment we've made in the industry. It is the largest supplier of semiconductors to the automotive market and provides analog and other semiconductor parts to industrial, consumer electronics, mobile and communications end markets. Within the automotive sector, NXP chooses the sub-segments it competes in and is the #1 supplier in several sub-segments. Approximately 50-55% of NXP's revenue comes from supplying custom and proprietary chips to the automotive market.

We expect NXP to be a beneficiary of secular growth trends of increased semiconductor content in the automotive market (advanced driver-assistance systems (ADAS), battery management systems, electrification, infotainment and digital cluster) driven by increased safety, efficiency, automation and connectivity use cases in automobiles.

Texas Instruments (TI) is the world's largest analog chipmaker and a key supplier of embedded chips. Analog semiconductor chips bridge the physical environment signals (such as temperature, pressure, sound, light, speed and motion, etc.) into digital signals (0's and 1's) and vice versa for use in a wide array of electronic devices in industrial, automotive, communication and consumer applications.

We expect TI to benefit from increased semiconductor content in a broad set of industrial and automotive applications where product design cycles are long (5-30 years), and customers face higher switching costs. TI is the only analog chip company that performs internal 300mm wafer manufacturing, which provides a 20% cost advantage over its competitors.

Samsung is the world's largest manufacturer of memory chips. The global memory industry is now concentrated among three players — Samsung, Micron Technology and SK Hynix. The barriers to entry for new players are very high due to intellectual property, technological complexity, availability of talent and high capital intensity. Demand for memory chips is expected to grow, driven by artificial intelligence, cloud, high-performance computing, automotive and industrial applications. The three major memory suppliers have become much more disciplined and rational about adding new capacity to the market. We expect Samsung to benefit from these positive developments in the memory industry.

As of 31 October 2023, Diamond Hill owned shares of NXP Semiconductors NV, Samsung Electronics Co Ltd, Taiwan Semiconductor Manufacturing Company Ltd and Texas Instruments Inc.