Our Analysts' Take: Semiconductor Industry

Introduction

Semiconductors have become the backbone of the world's economy. That is not a ground-breaking, yet the paramount consequences should be appreciated. Semiconductors (or chips) are used in every modern piece of technology, ranging from phones and laptops to cars and military equipment. Control over the supply chain will determine who will have the economic and political leverage over its rivals. The fact that Taiwan, which produces 37% of world's logic chips, with its independence not recognised by China, places the industry at the forefront of the Sino-American economic contest.

Industry's current state of affairs

The semiconductor industry is highly cyclical. The demand for chips is influenced by the state of economies around the world – in simple terms, how many new laptops, phones, and cars are ordered. Currently, after almost 3 years of a constant chip shortage because of the pandemic, we are entering a period of "moderate to severe surplus", according to Gartner.

Last year was arguably the height of the "chip craze" – combined revenues soared to $618bn, compared to $471bn in 2020. This year revenues are projected to level at $596bn. That said, the weakness in demand will likely dent revenues only in 2023, as the market is projected to bounce back by 16.3% in 2024 (according to Gartner's estimates). What will be impacted more severely is the capital spending. Capex and wafer fab equipment investment are projected to decrease by almost 20% this year.

Further, the current geopolitical landscape is likely to play an ever-increasing role in the capital allocation process. The Sino-American dispute, mostly economic now, could potentially grow to a political one, involving military means. Tensions over Taiwan, already high (recent Chinese drills around the island), could easily escalate if a political miscalculation occurs. This single factor will negatively impact industry's prospects. Investment in China could become more treacherous for the likes of Samsung or TSMC if they want to continue dealing both with the US and China. Fears of an escalation have led Warren Buffet to selling 86% of his $4.1bn stake in the Taiwanese producer.

That said, despite the flurry of investment programmes announced (IRA in the US, European Chip Act), chip production chain is profoundly difficult to alter. The EUV technology (extreme ultraviolet lithography), central to "patterning" the finest design details onto the silicon wafer (chip) is controlled by ASML, a Dutch company. Each EUV machine costs over $100m and requires highly trained specialists to operate. It requires exactly 457,329 components to be assembled. The Dutch company has received investment form Intel ($4bn), and relies on components from, among others, the US (Cymer) and Germany (Zeiss) to produced and maintain the machines. All factors combined make it almost impossible for an effective competitor to emerge. The barriers to entry are simply too big of an obstacle.

Main players, supply chain (upstream and downstream), and impact of the Sino-American trade disputes

The Semiconductor industry and its relevant supply chains remain one of the most critical industries supporting worldwide technological development and growth. Semiconductor manufacturing remains structurally unique due to the consolidation of fabrication and design firms, and the marked cyclicality of the industry. Because of the

technical difficulty involved with designing, manufacturing, and implementing semiconductors effectively, we can categorize the industry supply chain into upstream, midstream, and downstream activities.

Upstream

This industry segment includes the design of integrated circuits. These designs can be broadly broken down into three segments Memory Integrated Circuits (ICs) such as DRAM and ROM, Micro-Component ICs such as CPUs and APUs, and Logic ICs such as ASIC chips, which are tailored for more specific use cases. IC design is accomplished by designers using Electronic Design Automation, or EDA tools. The EDA subsector is an effective oligopoly, with United States firms Cadence, Synopsis and Ansys maintain the overwhelming majority of market share. Most chip designers such as Qualcomm, Broadcom, Nvidia and Apple do not operate their own foundries (known as a "fabless" model), with the notable exceptions of Samsung and Intel, who both design and produce their own Silicon. Hence, these firms are strong players in both the upstream, midstream, and downstream segments which we will expand on below.

Midstream

Once an Integrated Circuit has been designed, the demanded quantity and production schedule is accomplished through the usage of foundries, or "fabs". The manufacturing process may be broken down into sic rough steps: Wafer, target sputtering, coating photoresist, photomask lithography, etching, and photoresist removal. Different industry players specialize in different steps of this supply chain, with Dutch Holding company ASML Notably leading the industry in the lithography stage.

The midstream production phase is largely governed by technology or process nodes – a nanometre reference to a semiconductor manufacturing process. As the size of process nodes shrinks, designers can fit more transistors on a given chip, allowing for increased performance and efficiency. It is important to note that although the node designation once held a specific meaning (referencing the gate length and M1 half-pitch), recent nodes such as 22nm, 16n, 14nm and 10nm do not refer to a specific measurement but are rather marketing names which refer to subsequent iterations of a manufacturing process. Process nodes are also not comparable across manufacturers. Some of the most important midstream manufacturers include TSMC (53% market share), Intel, Qualcomm, Broadcom, Micron, NVIDIA, and Applied Materials.

Downstream

Downstream manufacturing processes include the application testing, packaging, and sale to consumers of semiconductor products. After circuits are formed into completed integrated circuits, they are fragile and exposed. Downstream firms package these ICs into fully formed chips, allowing for their final testing and distribution to end-applications.

Impact of Sino-American trade disputes

Although many of the firms are located in Taiwan, the USA, or Europe, recent escalation in semiconductor-specific trade disputes between the United States and China pose a significant threat to the market. As Horizon Technology reports, about a quarter of global installed semiconductor wafer capacity is located in China, which also leads in Outsourced Semiconductor Assembly and Test (downstream activities), with a 38% market share. After Huawei and SMIC were added to a government entity list, China has reduced its manufacturing of logic nodes. Following this action, the US banned the sale of Nvidia chips to Chinese customers, significantly stunting their artificial intelligence computing capability. In Mid-December, the Biden administration famously expanded restrictions on 36 Chinese chip manufacturers, blocking them from accessing US chip technology.

These overt actions by the United States have sent China scrambling to bolster its domestic industry. In March, China released semiconductor investing mogul Chen Datong from state detention, indicating their willingness to support further investment into the industry. Coupled with the recently announced Chinese investigation into Micron Technology, an Idaho-based memory manufacturer. China maintains a strong domestic memory manufacturing industry, making Micron an approachable target for a ban, as doing so would refrain from crippling Chinese firms' ability to procure memory chips.

In its battle to ensure American trade secrets and national security are preserved, the Biden administration had built up significant hurdles for free semiconductor trade between the United States and China. Doing so has clearly stoked the flame of domestic semiconductor innovation for China, which aims to match the production capability of the well-established Western semiconductor supply chain.

European and Western Angle

European chip industry overview

Chips are extremely important for Europe. They are essential to produce cutting-edge technologies and are at the core of the current technological revolution.

In the chip industry, there are several European players, such as ASML, a company based in the Netherlands, which is a global leader in the production of lithography machines. More precisely, extreme ultraviolet lithography devices (EUV) are necessary to produce the most advanced semiconductors. Thanks to this, Europe has a discrete advantage in the manufacturing of innovative chips.

However, the fact that 80% of manufacturing semiconductor companies are located outside of the European Union is the real issue. To give an example, despite the presence of a few significant chip manufacturing companies in Europe, none of them can be nearly compared to TSMC (Taiwan) or Samsung (South Korea). Because of this, Europe is at a considerable disadvantage in the fabrication of chips, a situation that has been well-known even by the public since 2020, when there has been a severe semiconductor shortage throughout the world because of the pandemic. As we've already seen, the supply chain for these chips is extremely vulnerable to shocks because of how intricately connected companies are. To give an idea, a large semiconductors company may depend on up to 16,000 highly specialized suppliers spread across many countries. As a result, the global supply chain is vulnerable.

Geopolitical concerns and global events can have severe impacts on it. The COVID-19 outbreak gave an example of supply chain disruption, but also recent geopolitical events like the war in Ukraine must be considered. The scarcity situation has been made worse by additional threats, such as fires and droughts, which devastated many manufacturing sites all over the world.

European incentives for the industry

Earlier this year, the European Union passed a law known as the "European Chips Act" to solve this long-lasting supply-side issue. The "Chips joint undertaking" is an investment instrument designed to assist the long-term expansion of European businesses in this area adopted to strengthen this decree, and that was intended to encourage a rise in the manufacture of semiconductors in Europe. The approximate total amount of funding devoted to this ambitious project is €11bn. Currently, Europe produces 9% of all the chips produced worldwide. The European Parliament's goal is to reach 20% by 2030 through these actions.

Therefore, Europe can be defined as a net importer of semis since it uses roughly 20% of the world's supply while producing just about 9% of it. To make a forecast, despite the best efforts of the EU Chips Act, Europe could continue to be a net importer of semis as of 2030 given the rate of expansion in the semis industry and the ability

to build new plants quickly. As has been shown over the past few years, semis are essential to the automobile industry. Although certain parts are required by European automakers, the supply may still not necessarily come from European factories. As a disclaimer, even though the proposed conclusion may be plausible, the level of geopolitical and economic uncertainty we observe today may lead to very different conclusions.

However, what can be observed is that the European position in the semiconductor and chip industry is both challenging and promising. The absence of a robust domestic chip manufacturing industry and the potential effects of global geopolitical developments like the IRSD, the global pandemic, and the war in Ukraine present the region with significant challenges even though it has a strong position in the equipment manufacturing industry and a large demand for chips.

Can Intel stage a comeback?

Even the US is experiencing a similar situation. The CHIPS and Science Act is an act that has been approved in recent months by the Federal Government, to face this issue. Through this measure, the US government aims at making the domestic semiconductor industry more competitive and bringing supply chains back to the United States. The budget is estimated at $50bn, and it includes $39bn specifically for semiconductors. The role played by Intel in this environment will be particularly interesting for the current economic scenario. The company is currently experiencing a process of restructuring, and the management is strongly motivated to make the company regain its leadership in the semiconductor industry, competing against Samsung and TSMC.

Thus, three elements should be considered: (1) the company is investing heavily, (2) it is operating in a slowing market, and (3) the competition is way ahead in terms of production capabilities. Therefore, Intel is experiencing poor operating results, but it is plausible to think that it will be able to take the lead in the semiconductor ecosystem in the years to come, thanks to the huge Capex upfront. Intel 4 is anticipated to be the first fruit of Intel's turnaround efforts in 2023, and this may give investors reason to believe that Intel's leadership.

Asian Angle

In 2022, the United States stepped up its competition against China in the semiconductor industry. In August, the CHIPS and Science Act, an $52.7bn policy aimed at enhancing research and its supply chain, as well as increase protection of American production, was signed. Furthermore, in October, the US government announced that it will require licenses for companies exporting chips to China that use US tools or software, no matter their geographical location. This will affect China's ability to develop high-end semiconductors that are needed for artificial intelligence, to power supercomputers and for military hardware. As a result of the restrictions, China is now forced to accelerate its efforts to de-Americanize its technological supply chains. On the short term, China will struggle to maintain its ongoing expansion in AI, supercomputing, and cloud computing, but in the long term it will lead to an increase in their internal production and development capabilities. Furthermore, the size of the hit for US company will depend on how strictly the export ban is applied as China was the biggest market for plenty American chip and chip tools companies.

Among the three largest semiconductor companies, Intel, Samsung, and Taiwan Semiconductor Manufacturing Corporation (TSCM), two are based in Asia. Furthermore, over the past years China has been increasing their semiconductor production capacities, aiming to reduce their dependence on other nations.

Samsung

The South Korean company is one of the largest semiconductor companies. Along with TSCM they are the only two companies in the world capable of manufacturing 3-nm microchips. Furthermore, Samsung is aiming to produce 2-nm microchips by 2024 and 1.4-nm microchips by 2027. Also, the company is aiming to expand their

production capacity by more than three time by 2027, compared to their 2022 capacity. Additionally, the company, in its efforts to catch-up to TSCM is planning on building a $230bn facility in the Seoul area throughout the following 20 years to develop computer chips. Finally, South Korean companies, including Samsung, got a one-year exemption to the controls issued in October 2022 by the US government to China regarding chips.

Taiwan Semiconductor Manufacturing Corporation (TSMC)

The Taiwanese company is the world's most valuable semiconductor company and largest contract-chip maker. TSMC produces about 90% of the advanced chips, and controls over 50% of the global semiconductor foundry market. Currently, TSCM is in the capacity of producing 3-nm microchips, which were first used in Apple's M2 MacBooks in 2023 and expects to produce 2-nm microchips by 2025.

TSCM is deeply reliant on both the United States and China. On one hand, it made a $40bn investment in Arizona, United States, and is expected to be one of the beneficiaries of the CHIPS and Science Act. One of the plants is expected to open in 2024, the second in 2026, and both, along with existing investments, it will produce sufficient advanced chips to meet the annual US demand, of 600,000 wafers per year. On the other hand, a considerable amount of TSCM revenues comes from China, 10% in 2021, which even though it is substantially less than in past years, it still is an important amount. Furthermore, TSCM was given a 1-year license to continue ordering US made chipmaking equipment for their plants in China following the October 2022 restriction.

Chinese Production

Over the past years, China has been pushing to grow its semiconductor manufacturing capacity. According to China's National Bureau of Statistics, on 2021 China's chip manufacturing capacity grew by 33.3%. In 2022 it was reported that China was finally able to produce a 7-nm microchip after years struggling to advance after the 14-nm chip. However, it is said that China lacks the technology to produce chips under 7-nm as several of their global competitors are already able to. Furthermore, in the present year, the Chinese government pledged the equivalent to $150bn to expand the national production and become more self-reliant. Additionally, China has the advantage of possessing vast amounts of several of the rare-earth elements that are critical components for the development of advance technology.

Among the largest Chinese semiconductor companies are Semiconductor Manufacturing International (SMIC), Hua Hong Semiconductor and Huawei, as well as equipment supplies Naura and Advanced Micro-Fabrication Equipment Inc China. All these are expected to benefit from the government subsidies.

However, even though the ongoing governmental efforts to expand production are significant, China, especially in the semiconductor industry, has a history of misallocating resources. For example, according to a Chinese chipmaker, since 2006 there have been attempts to make lithography equipment for chipmaking, with the outcomes only being theoretically usable. Furthermore, there are many reasons behind the fraud, ranging from the fact that semiconductors regulators are generally bureaucrats with limited technological backgrounds to problems in the way incentives to attract high-tech investments are awarded to Chinese officials. Consequently, all the efforts made to increase chip manufacturing have to go in hand with transformations within the government that will allow an increase in efficiency.

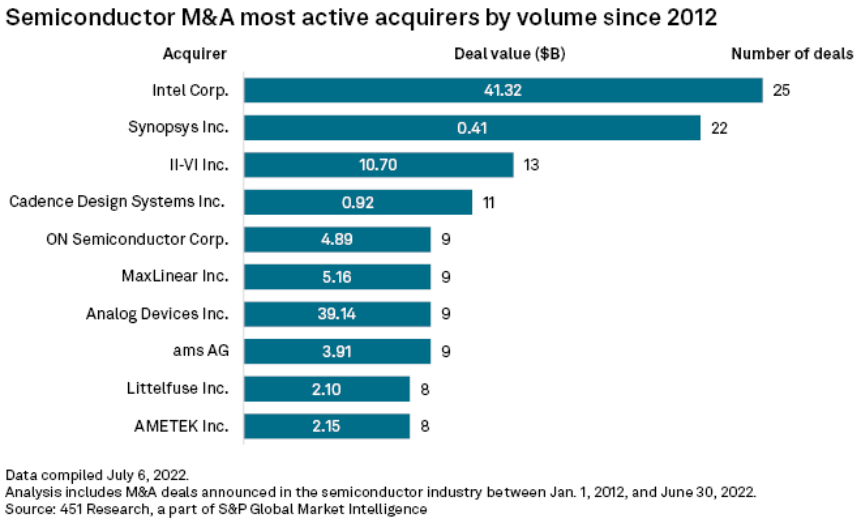
Recent M&A activity - biggest deals, outlook for 2023

Mergers and Acquisition in the semiconductor space have been booming since 2021 – when semiconductor designer Marvell acquired cloud-computing powerhouse Inphi for $10bn, later followed by Analog Devices' $20.8bn acquisition of Maxim Integrated. The year closed out with intel's Sale of its Solid-State Drive (SSD) business to SK hynix for $7bn. Moving into 2022, AMD completed their $50bn acquisition of Xilinx, with a focus

on synergies in Xylinx field programmable chips which helped build up AMD's 5G, AI, Automotive, and Aerospace / Industrials semiconductor presence. Also in 2022, Intel purchased Tower Semiconductor for $5.4bn. Notably, the largest proposed semiconductor M&A deal in history failed to go through when NVIDIA's $40bn offer for UK-based chip design firm Arm was blocked by US and UK antitrust regulators.

Given the exceptionally high semiconductor demand experienced during the COVID-19 recovery, these large-scale M&A deals were prioritized as efforts to meet demand. Moving forward, supply frame forecasts indicate lower semiconductor pricing growth. However, this does not necessarily imply a slowdown in M&A, as reactions to increased semiconductor demand take significant lengths of time. The semiconductor process scan takes up to 15 weeks, making it difficult for firms to organically add capacity in times of high end-user demand for semiconductors and integrated circuits. However, large deals may experience increased regulatory scrutiny, as a wide range of firms tend to rely on semiconductor design and fabrication firms – as seen in the proposed Arm deal mentioned above. To mitigate this regulatory risk, we may see an increase in strategic partnerships. For example, S&P reports on Qualcomm and Samsung's licensing agreement for 5G and 6G cellular chips. This agreement allows both firms to realize mutual benefits, without incurring regulatory headwinds.

Therefore, although deals to increase semiconductor capacity will likely continue to spring up, the size and scope may decline as the industry continues to consolidate, with some of the largest firms such as Intel snapping up dozens of firms in acquisitions since 2012. While megadeals may still be announced, we expect to see a continued resurgence of cooperation between industry players across the Semiconductor supply chain.



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