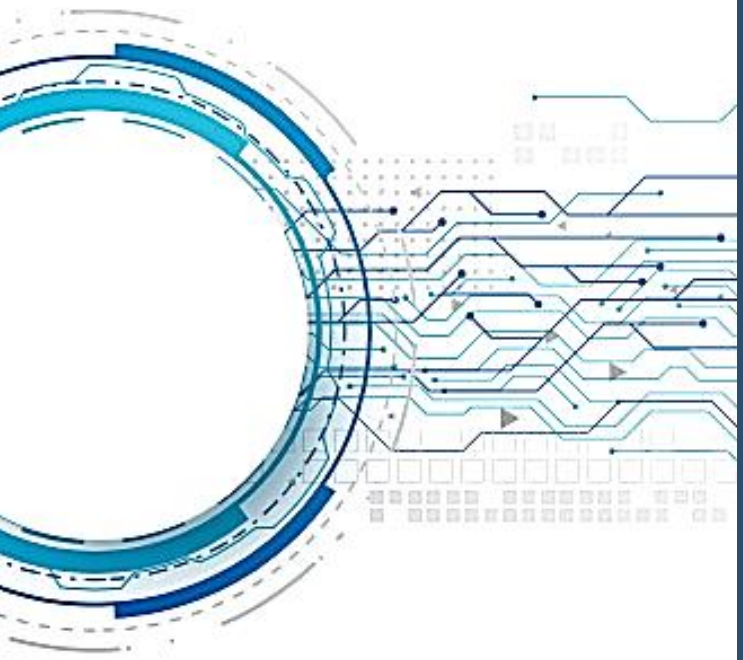
Phillip Capital Management

Industry Report:

Analysis of The Semiconductor Industry -June 2021



Salient Points:

- Events leading to a shortage crisis
- Nature of the semiconductor industry
- Semiconductor supply value chain
- Economics of segment activity

The semiconductor industry has been gripped by a shortage and the reason for the shortfall of semiconductors may be plain to see: The Covid-19 Pandemic upended the global economy and distorted supply chains. The problem was further compounded with the booming demand for consumer technology during "The Great Lockdown", as consumers depended more on digital means to communicate, work and for entertainment. And of course, add geopolitical trade uncertainties into the mix, a perfect storm culminated in a global chip shortage and is now reverberating across a wide swath of industries worldwide…

(continued)

Chronology of Events Leading to Shortage

The chronology of events that led to the current shortage crisis could be first traced back to 2019 when US-China trade tension escalated into a tech war. At the peak of it, Huawei – one of the world's largest telecommunications equipment maker – began stockpiling chips in anticipation of being placed on the US Trade blacklist. The secondary effect led to what the semiconductor industry dubbed as a 'double-booking' situation, in which other equipment makers placed more orders than what was intended for use.

Then in 2020, when the pandemic began to spread across the US, EU, China and other parts of the world, carmaker giants like Volkswagen, General Motors, Ford and Toyota temporarily shut down production lines. Given lower demand and a slowdown in the car market, carmakers scaled down on orders for automotive chips. Yet, demand for cars rebounded faster than expected in 3Q2020, and carmakers found themselves unable to re-secure chip supplies as foundries had reallocated the spare capacity – left by the carmakers – to fulfil orders for consumer electronics which experienced a surge in demand during the lockdown.

As the shortage unfolded, carmakers have to mothball several plants and bracing for substantial near-term output decline. According to an industry source and research firm IHS Markit, 1Q21 may see production loss of an estimated 1.3 million cars and vans due to supply chain challenges. Assuming an average sale price of US$50,000 per vehicle, such production loss would wipe out US$65 billion in sales for carmakers alone.

The US$450 Billion Elephant in The Room

Beyond cars, the dearth of chip supplies is also quickly spilling over to other electronics manufacturers as a slew of smartphone and consumer electronics/appliance makers surfaced and cited output challenges due to chip supply constraints. Apple for instance has cited that up to US$3-4 billion in sales of Macs and iPads will be impacted in its fiscal third quarter 2021.

The ubiquity of semiconductors – found in any electronic device – further accentuated its modern-day significance, even to the extent the industry holds national security importance. After all, global sales of the semiconductor industry is expected to hit US$452 billion in 2021 according to World Semiconductor Trade Statistics[1].

Countries that are major players such as the US, China, EU, Taiwan, South Korea and Japan are all making moves to roll out programmes to invest in cutting edge semiconductor technology and build up capacity onshore. To date, close to US$1 trillion has been earmarked by governments around the world, with South Korea leading the way with US$450 billion committed. Meanwhile, China and the EU are also trying to keep up in the race with US$150 billion and US$160 billion earmarked for tech investment.

Did it take A Shortage Crisis to Trigger a Major Reshuffling?

There is a severe imbalance in the supply chain of semiconductor manufacturing. For one, Asia dominates the contract manufacturing aspect, accounting for nearly 80% of foundries and test/assembly operations. Did it take a shortage crisis to trigger governments to a strategic reassessment? Surely, governments should have known better?

The semiconductor manufacturing sector used to be more fragmented and not always dominated by Asia but by the US, EU countries and Japan. In 2001, nearly 30 firms were producing leading-edge semiconductors. By 2018 – in less than 2 decades – only 5 firms remain from only US, Taiwan and South Korea.[2]

The seismic shift of manufacturing activity from the western hemisphere to the east had to do with the nature of the industry and the highly complex process of chip production. Firstly, setting up a single leading-edge foundry is estimated to cost US$10 billion in

1&2 https://www.semiconductors.org 2020 SIA State-of-the-Industry-Report

capital expenditure, notwithstanding operating costs. Second, as end-devices get smaller and more powerful, there is also massive R&D commitments involved in chip designs.

Then, there is the intangible part where no amount of money could guarantee the longevity of new technological designs or manufacturing techniques and processes. Outside the control of the companies themselves, this element has much to do with the fast pace of innovation in the industry.

Over the last two decades, it became increasingly difficult for companies to manage both the R&D at the design front and Capex intensity at the manufacturing front. Where efficiency and scale become vital, specialization occurs. Asia, which have had cost advantages over the west, benefitted from the 'export' of semiconductor manufacturing. As a result, this led to a consolidation of the semiconductor industry as well as a more concentrated supply chain.

Semiconductor Supply Value Chain

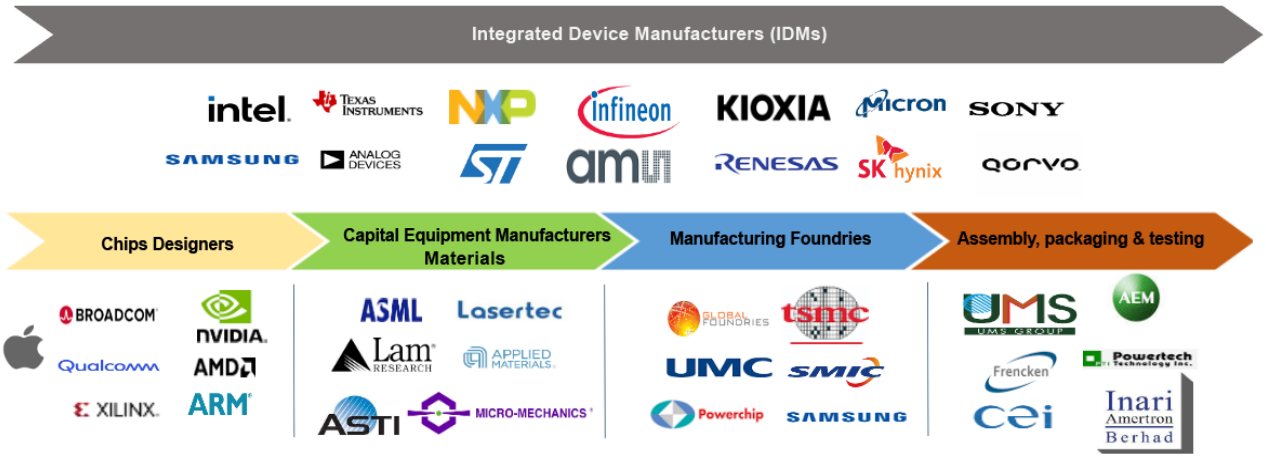
As mentioned, the semiconductor chip supply chain is highly complex and companies tend to be specialised. This also means there is different margin profile of semiconductor companies, depending on the type of semiconductor chips they produce or production activity in which they undertake. Hence, investors should have a general understanding of chip types and the semiconductor supply value chain.

Typically, any modern-day electronic end-product is made up of the following main types of semiconductors chips: Processors – Central Processing Units ("CPU") & Graphics Processing Units ("GPU"), Memory (NAND and DRAM), Analogs, Application-specific or Specialised Chips (FPGA, Wifi, Radiofrequency ("RF") etc). For instance, a smartphone combines most of these types of chips to make the device.

Chip companies typically specialise in one type of semiconductor chip. For instance, Intel takes the lion's share in the CPU space while Nvidia dominates the GPU sector. In the Memory sector, an oligopoly exists comprising Micron, SK Hynix and Samsung. In another instance, Qualcomm and Huawei currently competes for leadership in the 5G RF chips.

The semiconductor supply value chain can be sub-divided into 4 main activities: **Chip designing, Capital Equipment Manufacturers & Materials, Manufacturing Foundries and lastly Outsourced Assembly, packing and Testing ("OSAT").** Companies that partake in one or more activities are called **Integrated Device Manufacturers (IDMs)**. Often, IDMs may still lease some capacities from foundries and OSATs for a portion of their manufacturing needs. The following Exhibit 1 shows some examples of companies positioned along the value chain in the semiconductor industry.

Exhibit 1:



Source: Phillip Capital Management; list is non-exhaustive.

The upstream begins at the chip designing phase. This phase is construed by Core Intellectual Property ("IP") owners, involved in the licensing and the commercialisation of a chip's architecture. They tend to focus more on the R&D aspect and are usually fabless, depending purely on contract manufacturers for production needs. There are a limited number of Core IP owners/chip designers in the world and hence command significant influence. The majority of them are Western companies such as ARM, AMD, Intel, Nvidia and Qualcomm. Only recently, Apple began to design its M1 processor chip for Apple's product line.

Then, there are the capital equipment manufacturers that mainly partake in the design or production of manufacturing equipment/materials or inspection equipment. Such systems are highly advanced and major players are mainly from the US, EU and Japan. Amongst them, ASML is a Dutch-based company leading the manufacturing equipment sub-sector while US-based Lam Research and Japan-based Lasertec are leading players in semiconductor inspection systems. Then, there are also the toolmakers that supply components to equipment manufacturers, situated mostly in Southeast Asia. For example, local-listed ASTI and Micro-Mechanics provide precision engineering tools that go into such systems.

In the mid-stream are the manufacturing foundries. They perform the main task of wafer fabrication where microscopic circuit patterns are imprinted on wafers to make a semiconductor chip. This is also currently where the bottleneck in the supply chain occurred because only a handful possess the most advanced techniques to process chips at lower nodes ("nm"). In wafer fabrication, nodes define the density of transistors and hence shrinking nodes is critical for packing more performance into chips. Currently, less than 5 foundry firms possess sub-10nm technique and only TSMC possess sub-7nm technique.

At the tail-end of the supply chain are OSAT players which offer final assembly, packaging and testing services of chips before shipping to Original Equipment Makers ("OEM") to produce their hardware. OSAT players are typically situated in Southeast Asia, such as local-listed UMS, AEM, CEI, Frencken and Malaysia-based Inari Amertron.

Economics of Chip Production Activity

Table 1 below shows a snapshot of the economic chip production activity. Data is extracted from a report by Semiconductor Industry Association ("SIA") & Boston Consulting Group ("BCG"), titled 'Strengthening the Global Supply Chain in an uncertain era' – April 2021.

In general, upstream semiconductor companies command rather high margins as they bring the greatest value-add compared to downstream companies. This also translates to healthier operating cash flow compared to downstream players.

Diving into IDMs, they command a gross margin of about 52%. On average, capital spending accounts for 34% as a percentage of revenue ("%rev") and is spread between R&D and Capex because they undertake both design and manufacturing aspects. Operating cash flow makes up about 17%rev.

Fabless companies command about 50% gross margin. R&D intensity is the highest in this segment, making up 20%rev. On the other hand, Capex intensity is the lowest at only about 4%rev due to their asset-light model. Overall, operating cash flow in this segment is about 20%rev.

At 45-60%, capital equipment makers command the highest level of margin. Capital spending is mainly focused on R&D lying in the range of 10-15%rev while Capex ranges somewhere 3-5%rev. Like chipmakers, capital equipment manufacturers are also asset-light, operating on a high-value, low volume basis. They enjoy the highest level of operating cash flow at 25-30%rev.

Pure-play foundries see about 40% gross margin with rather relatively low R&D intensity at 9%rev. Most of the R&D goes into developing techniques for shrinking down nodes. However, they incur the highest Capex intensity at 34%rev which goes mainly into procuring equipment from capital equipment manufacturers. At about 45%rev, the segment is the most intense in terms of total capital spend. Nonetheless, they still

generate a rather healthy operating cash flow of about 15%rev.

Lastly, OSATs have the lowest capital spend requirements at 20%rev. They do not perform much R&D and Capex intensity of 16%rev is in the mid-range of the spectrum. Most of the Capex goes into procuring assembly/packaging machinery and semiconductor inspection systems. They also bring the least value-add to the supply chain and hence command the lowest margin at about 17%rev. Due to this, their operating cash flow stands at about 2%rev.

Investment Positioning

Demand for semiconductors is self-reinforcing, in that different chip types are complements and not substitutes. This is because electronic devices need more than one type of chips to produce. Despite its long-term uptrend, the semiconductor industry is also notoriously cyclical in short time frames.

Putting the current dynamics into context, we are about to see a massive spur in a boost in R&D and Capex in the industry. Because governments are incentivizing firms to advance technologies and expanding manufacturing capacities, upstream companies the likes of chip designers and capital equipment makers are likely to be the direct beneficiaries.

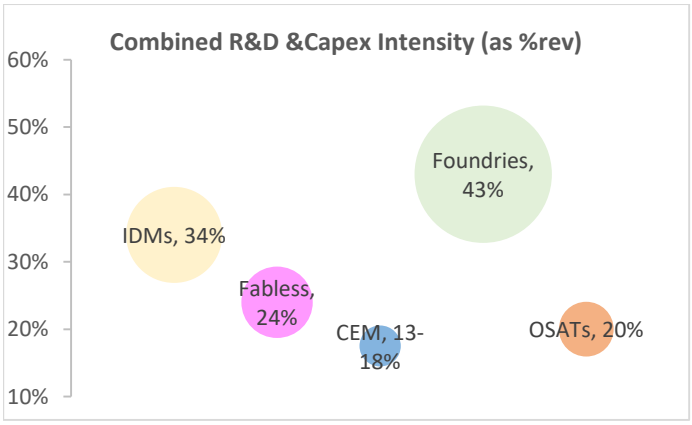
Meanwhile, foundries will also benefit from government incentives as they boost Capex to expand capacities. However, in light that there is a 'double-booking' situation at foundries, it remains unclear what the real demand is. As such, an unprecedented expansion in manufacturing capacities has the inherent uncertainty of whether market demand could absorb the supply.

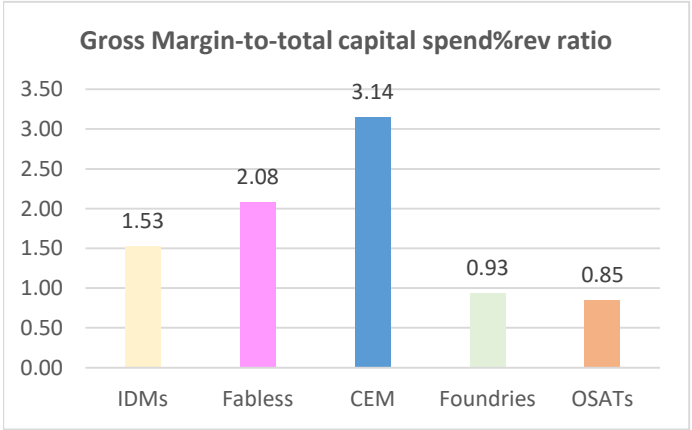
In addition, upstream semiconductor companies are also more preferred in the event that interest rates pick up. Due to their asset-light operations, rising interest rates would have a less significant financial impact as compared to Capex-intense operating models.

Table 1: Snapshot of Segment Economics — **as % of revenue (2016-2019)**

	Gross Margin	R&D	Capex	Operating Cashflow
IDMs	52%	14%	20%	17%
Fabless chip designers	50%	20%	4%	20%
Capital equipment makers*	45-60%	10-15%	3-5%	25-30%
Foundries	40%	9%	34%	15%
OSATs	17%	4%	16%	2%

Source: SIA & BCG. *Not estimated by SIA&BCG. An estimate provided by Phillip Capital Management ("PCM"); exclude capital tool makers. Compiled by PCM.





Source: Compiled by PCM

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