

GLOBAL EMERGING MARKETS



MARTIN CURRIE

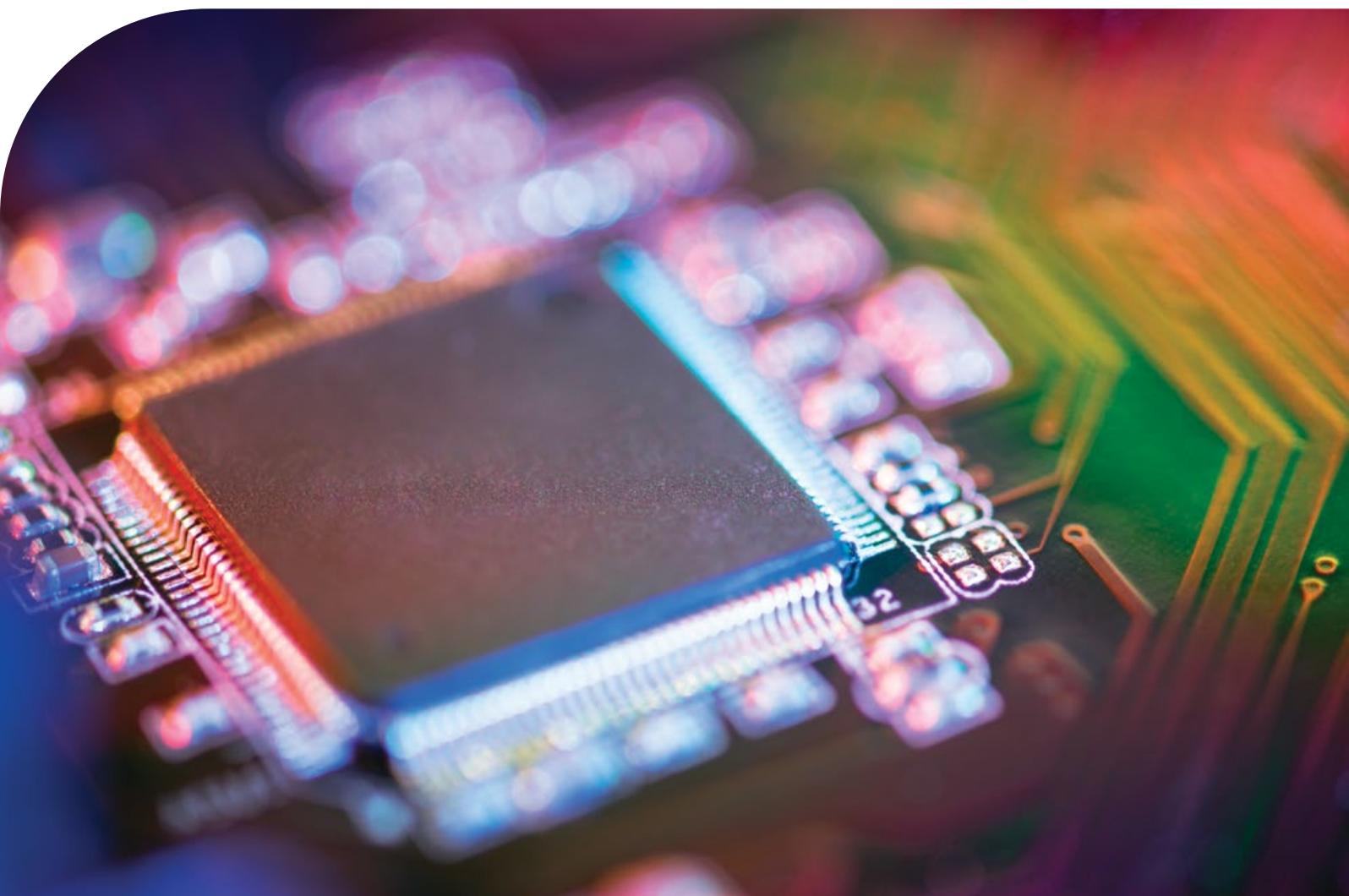
A Franklin Templeton Company

JANUARY 2023

For institutional, professional and wholesale investors only

A BEGINNER'S GUIDE TO SEMICONDUCTORS

An overview of the semiconductor industry, taking a look at the manufacturing process, key industry players and the current shape of the industry.



What are semiconductors and why do they matter?

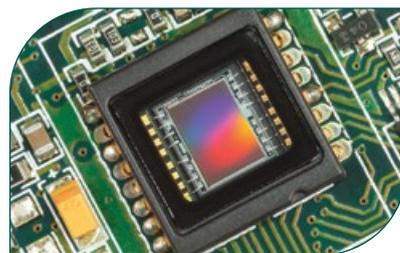
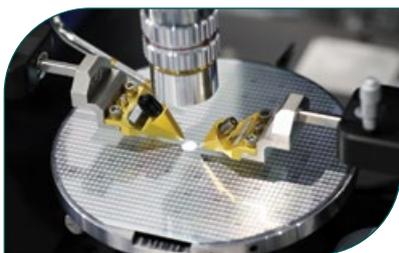
The generic term semiconductor refers to a material which can both conduct electricity (like copper or aluminium) and insulate (like rubber). More commonly when we refer to semiconductors, what we mean is semiconductor devices, or 'chips' (microchips).

Chips are created using semiconductor materials, giving the industry its name. They are crucial elements of almost all electronic devices, varying by function and intelligence. The 'smarter' the device, the more 'intelligent' the chip needs to be, from your mobile phone to your refrigerator or car. As such, semiconductor manufacturers benefit directly from the rise of digitalisation in society provided they invest in their businesses sufficiently to capitalise on that opportunity.

Semiconductors directly enable technological innovation in other industries and will continue to do so as new products are developed, both in emerging markets and the rest of the world. Firms in this industry are hugely concentrated in emerging markets, especially Taiwan and Korea. Companies in these geographies supply customers across the globe with their products for use across many areas such as computing, communications, consumer electronics, automotive and industrial equipment.

Semiconductor manufacturing process

Semiconductor manufacturing is a critical industry which manufactures integrated circuits - these are sets of electronic circuits on a semiconductor material (or wafer) which is typically made from silicon. The process is highly sophisticated and involves three key steps:



1. Making the raw wafer

The silicon wafer is created from a cylindrical ingot which is then sliced into discs roughly 1mm thick. The ingot can be a range of diameters including 150mm and 200mm but most commonly it is 300mm. The majority of semiconductor manufacturers outsource wafer production, purchasing them from a specialist wafer manufacturer.

2. Making the circuit on the wafer (making the microchip)

The chips are created in batches on the silicon wafer, with multiple chips being manufactured at the same time at a minute scale with thousands of automated steps.

3. Completed components are assembled and packaged

An integrated circuit (IC) is a single semiconductor (semi) chip which has other components all integrated. These may include diodes, resistors, transistors or inductors, for example. ICs help to support complex circuits.

Chips are created in batches on the wafer. The factory in which this takes place is called a fabrication plant, or fab. There are high barriers to entry with costs of building and operating a fab reaching tens of billions of dollars.

Semiconductor industry

The semiconductor industry has two main business models: either the company designs and manufactures its own chips, or it designs them and then outsources their manufacture. Companies operating the former operating model are called **integrated device manufacturers (IDMs)**. Those operating the latter model are called **fabless** semiconductor companies, outsourcing the manufacturing of their designs to foundries. The majority of companies rely heavily on **foundries** for their chips.

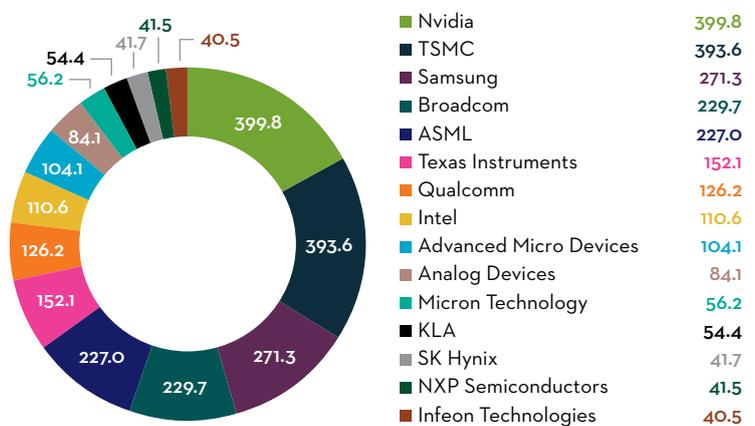
The split of these types of companies across the industry varies depending on the type of chips designed and produced. For example, those focusing on memory are mainly IDMs, including Samsung Electronics, SK Hynix and Micron. The IDM model provides an advantage because by designing and producing the chips themselves, the companies have more control over the whole process.

There has been a shift in recent decades with chip manufacturing whereby it has become more concentrated in Asia and less common in the US, reflecting the prevalence of the foundry-fabless model over IDMs. Currently it is estimated that 12-13% of chip manufacturing is domestic US, having been >30% in the 1990s.¹ Of the ten major US semiconductor companies, only two have in-house chip manufacturing capability (Texas Instruments and Intel), with the others needing to outsource it to a foundry.

The largest semiconductor firms by sales are reliant on emerging market companies; although the top ten includes several developed market companies, most of these are fabless and rely heavily or exclusively on emerging market companies for their chips.

- Five of the top 10, Intel, Qualcomm, Broadcom, MediaTek and Nvidia, use either TSMC or Samsung Electronics founder services.
- Three are US IDMs: Intel, Micron and Texas Instruments.
- Three are emerging market companies themselves: Samsung Electronics, TSMC and SK Hynix

Top 15 semiconductor companies worldwide market capitalisation
(at December 2022 in billion US dollars)



Source: FactSet at December 20 2022. Using market capitalisation denoted in billion US dollars, based on publicly traded companies and Factset industry classification of these companies as Semiconductor companies with the following definition "This industry group consists of companies engaged in the manufacturing of integrated circuits for electronic applications."

¹Source: Morgan Stanley Research, 'Clash of the Chips: TSMC, Samsung, and Intel', May 2022.

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The shape of the industry today

The semiconductor industry has historically been quite cyclical, driven by industry, macro factors and product cycles. Cyclicalities have reduced in recent years as companies invest more in technology and as the manufacture of chips gets increasingly complex. This has increased the barriers to entry, alongside addressing cyclicalities.

- **Inventory cycles:** driven by supply and demand of semiconductor inventory.
- **Macro factors:** sales are correlated with GDP, meaning that the health of the economy can be a key driver of the semiconductor cycle.
- **Product cycles:** these are the cycles of the end markets which use semiconductors. Their product cycles may be wholly different from macro cycles or driven by specific trends in, for example, autos, the Internet of Things (IoT) or smartphones.

There is a mismatch in the industry between suppliers of the technology and those companies using it. It takes time for the companies to adjust their supply to meet demand, given the production timeline, which creates both up and down cycle.

- **Down cycle:** this is where inventory has been over-built and so companies respond by reducing excess levels through under-shipping their end demand. This leads to depleted inventory and helps build up chip demand again.
- **Up cycle:** as demand builds up again, companies work to rebuild their inventory levels at a higher rate than end demand in order to catch up with it.

The industry is currently experiencing a down cycle and is at the point where there are concerns over the build-up of inventory levels and over demand in end markets. This led to some profit-taking in recent months, with valuations being lowered as much as 30% in some cases. However, we believe this correction is to be expected given the cyclical nature of the industry.

The long-term opportunity which is presented by this industry remains a key area in which we have conviction. As enablers of advances in technology, semiconductor firms benefit directly from the rise of digitalisation and innovation in society. The reliance of the global industry on emerging market companies also make semiconductors highly attractive for emerging markets-focused investors.

There does remain an element of geopolitical risk which impacts the industry as a whole. This is largely driven by recent moves by US authorities regarding technology and encouraging domestic US production, including through subsidies. The aim of this is to reduce reliance on certain geographies and to stimulate domestic growth and innovation. The semiconductor industry is one component of this broader drive. For now, the focus area of risk is a small part of the overall emerging market technology sector (specifically, high-powered computing) and we have confidence that companies within the sector will be able to successfully navigate the resulting headwinds.



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