

# Semiconductor Localization: China Makes Advances

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Over the past five years, the US relationship with China has increasingly moved from one of strategic engagement to one of strategic competition. Several publications and speeches by US government officials have reflected this change, while trade barriers have been introduced and restrictions have been imposed on the technology sector. The era of strategic competition will likely be long lasting and will bring transformational change to many Chinese businesses, notably in the technology sector. Aside from the significant geopolitical impact, this will have important implications for investors in Chinese companies. Against this backdrop, we examine the state of the Chinese semiconductor sector.

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## **The Semiconductor Competition**

Technology is crucial to the development and prosperity of any country because of its role in improving economic growth, living standards, global competitiveness, and military power. Technology is often regarded as the most crucial factor in a country's competitive progress.

The semiconductor, or chip, is the fundamental building block of all modern computing and the key enabling technology of both the third and fourth industrial revolutions. Semiconductors have had a profound impact on a wide range of industries. In smartphones, cars, satellites, and the hardware that powers the internet, semiconductors are indispensable components. Unsurprisingly, countries are competing to win the semiconductor race. The strategic competition between the US and China is now primarily visible in the technology sector:

- In May 2019, the US Department of Commerce announced the addition of Huawei to its "entity list".

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- In May 2020, the US Commerce Department increased export restrictions on Huawei by banning all semiconductor companies that use US technology from selling products to the firm without US government authorization. Companies outside China have also been affected by this stricter ban, including TSMC.
  - In February 2022, the US Commerce Department added 33 Chinese entities to its Unverified List (UVL), including technology companies, two universities and government research labs, due to their inability to verify their end customers.
  - In October 2022, the US placed new restrictions on the export to China of advanced computing equipment and semiconductor manufacturing equipment. According to the US Commerce Department's Bureau of Industry and Security, the new rules are "aimed at restricting China's ability to obtain advanced computing chips, develop and maintain supercomputers, and manufacture advanced semiconductors."

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## China Semiconductor Localization

Undoubtedly, there are geopolitical implications to consider given current tensions in the US-China relationship. But taking time to understand the state of the China semiconductor industry is still a worthwhile undertaking. While the US-China decoupling trend is clearly visible and the semiconductor competition brings disruption, it also presents opportunities. Semiconductor chip localization in China is a structural trend and China has made significant efforts in recent years in this regard. These efforts are motivated by China's desire to develop its domestic semiconductor supply chain and decrease its dependence on foreign suppliers. Four main factors are supporting the localization trend:

- 1 Large domestic market with low self-sufficiency rate
- 2 Government support
- 3 Strong research and development capabilities
- 4 Capital market support

### 1. Large domestic market with low self-sufficiency rate

China is the largest market for semiconductors worldwide, accounting for 24% of world semiconductor consumption, and since 2005 has been the world's biggest importer of chips. However, China's semiconductor self-sufficiency rate is just 16%. In 2020, China imported US\$350 billion worth of semiconductors, which is more than the value of crude oil imported in the same year. The import of semiconductors accounts for the country's largest category of trade deficit. Concerns have been raised about possible disruptions to China's semiconductor supply chain, given the potentially serious impact on China's economy.

## 2. Government support

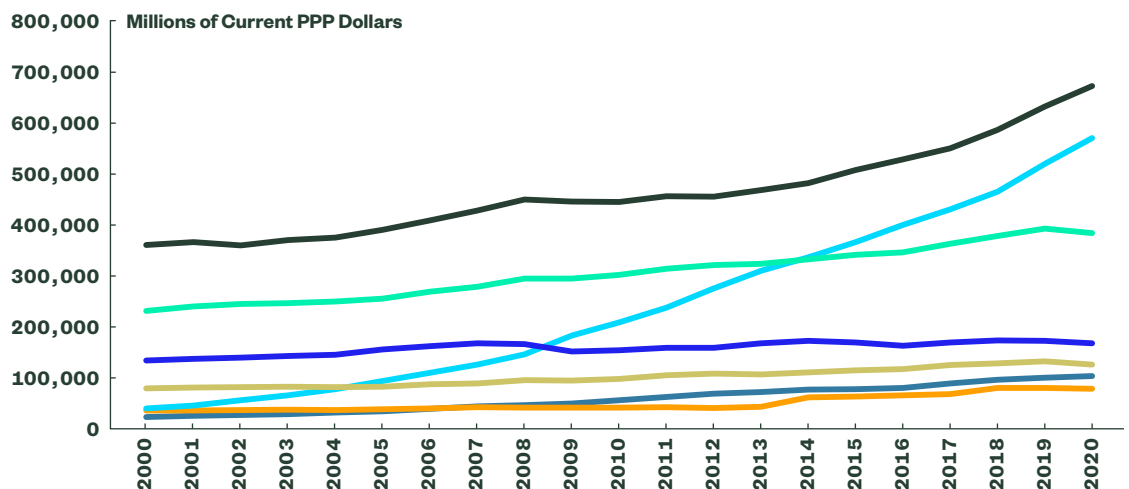
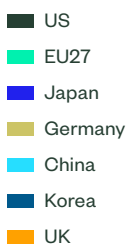
In 2014, China's top executive government agency, the State Council, issued the National Integrated Circuit Industry Development Outline, marking the start of China's current semiconductor policy. The National Integrated Circuits Industry Development Investment Fund (The Big Fund) was established to finance the country's semiconductor industry. The Big Fund received US\$39bn in state financing up to 2021. Both the Central Economic Work Conference and the 14th Five-Year Plan announced in 2021 stressed the importance of China's semiconductor independence to ensure sustainable economic development. In 2022, China announced a US\$143bn package to help boost the semiconductor industry shortly after the US further tightened technology export restrictions. Tax incentives have also been introduced at central and local government levels.

## 3. Strong research and development capabilities

China has been investing heavily in research and development (R&D) in recent years, and this investment is paying off in terms of the quantity and quality of research.

According to Organization for Economic Co-operation and Development (OECD) MSTI (Main Science and Technology Indicators) Data, the gap in funding R&D between the US and China is closing quickly.

Figure 1  
**Gross Domestic Expenditures on R&D (2000–2020), in Millions of Current PPP Dollars**

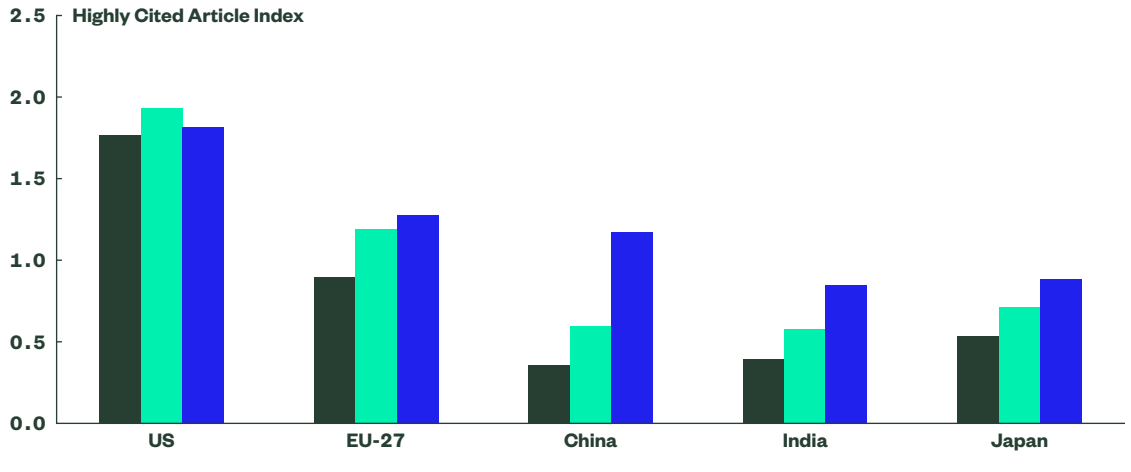


Source: OECD MSTI, September 2022 release.

China has seen significant growth in its research output and quality in recent years. According to Nature Index, which is a database that tracks the research performance of institutions and countries in the natural sciences, China is now the largest contributor to high-quality scientific research. The Science and Engineering Indicators published by The State of US Science and Engineering 2022 shows China is at par with the European Union and is catching up quickly with the US in terms of research quality.

Figure 2  
**Highly Cited Article Index (2000, 2010, 2018)**

2000  
 2010  
 2018



Source: NCSES, special tabulations (2021) by SRI International and Science-Metrix of Elsevier's Scopus abstract and citation database. Note: The Highly Cited Article Index reflects a country's share of the top 1% most-cited S&E publications divided by the country's share of all S&E publications.

China's share of global semiconductor patents granted has also increased considerably in recent years, according to data from the World Intellectual Property Organization (WIPO). In 2021, China accounted for 26.3% of all semiconductor patents granted globally, up from just 6.5% in 2005. This puts China in second place behind the US, which accounted for 29.6% of the patents granted in the same year. These numbers demonstrate the speed with which China is catching up to the US in this area.

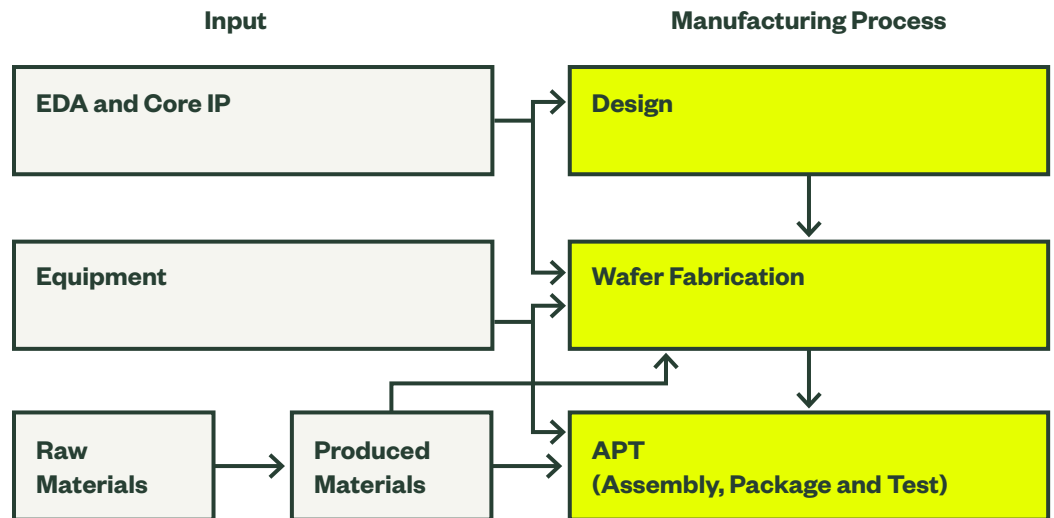
#### 4. Capital market support

According to Pitchbook's database, China captured the majority of global semiconductor venture capital (VC) investments in 2021, receiving \$7.1 billion or 62% of the global total. This compares starkly with 2013 when China accounted for only 7%.

### Chinese Semiconductor Industry Position

Despite the Chinese government's efforts to support the development of a domestic chip industry, China chip localization faces many challenges and limitations due to its weak position in some segments. To assess China's relative position in the semiconductor sector, we need to understand how semiconductors are manufactured. Based on their role in the value chain, we can break the industry down into seven major segments: four input and three manufacturing segments.

Figure 3  
**Breaking Down the Manufacturing of Semiconductors**



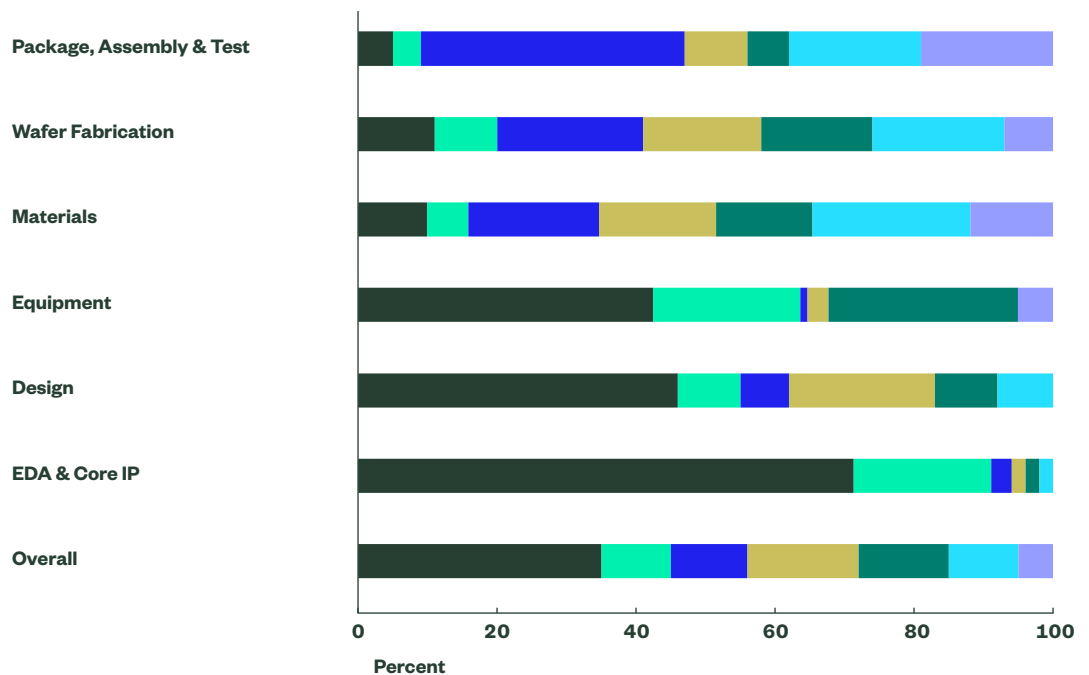
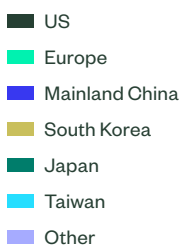
Source: State Street Global Advisors. For illustrative purposes only.

The Semiconductor industry has been a product of global collaboration. This complex industry involves hundreds, if not thousands, of companies globally that specialize in the different segments noted in Figure 3. While China is set to improve its position in the semiconductor industry, it is unlikely that China will achieve full localization in the foreseeable future.

According to Semiconductor Industry Association, China has a relatively strong position in raw materials like silicon, trailing-edge wafer fabrication and APT (Assembly, Packaging, And Testing). However, these are generally low-barrier, low-value segments that lack the strength to exert influence on the industry.

However, China has a relatively weak position in EDA (Electronic Design Automation) and Core IP (Intellectual Property), equipment, produced materials, and leading-edge wafer fabrication. These are the critical areas with high barriers to entry that have been dominated by the US, EU, Korea, and Japan for decades. While it is possible for China to catch up in these areas, it is likely to be a slow process that will require substantial time, support, and investment. According to Stiftung Neue Verantwortung, a European think tank specializing in technology, it is “almost impossible” for China to catch up in the next 10 years with global leading competitors in areas like Core IP, cutting-edge wafer fabrication, equipment (especially cutting-edge front-end equipment such as EUV lithography). And it is “unlikely” that China will catch up in the next 10 years with global leading competitors in areas like EDA and produced materials.

Figure 4  
**Global Distribution  
of Semiconductor  
Supply Chain (%)**



Source: Capital IQ and BCG, as of 2021.

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## Chip Design: An Opportunity

Chip design is the high value-add segment that could give Chinese firms the best chance of competing with global players during the coming decade. According to a Semiconductor Industry Association forecast, China's chip design global market share will increase from 9% in 2020 to 23% in 2030.

There are several tailwinds driving the prospects of Chinese chip design companies:

- The chip design entry barrier is relatively low compared with other semiconductor manufacturing segments. Some Chinese chip design companies like HiSilicon are already tier-one global players.
- Chip design markets are becoming more diverse due to the need for applications-specific chips (like AI, IoT, Cloud, or Auto). This has encouraged competition and allowed room for latecomers.
- The chip design industry is skilled workforce intensive, something in which China has an advantage. The Chinese government has invested heavily in engineering education and developing its engineering workforce. China had more than a million engineering graduates in 2018 compared to 140,000 in the US.
- Chinese chip design companies have successfully attracted venture capital funding. Data from CB Insights, a market intelligence platform, shows that there has been a steady rise in VC investments in the Chinese semiconductor industry.
- Chip design has been impacted less, on a relative basis, by US technology restrictions as chip design capabilities are not a key chokepoint in the global semiconductor supply chain and it is difficult to restrict completely across borders.

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## Conclusion

China has a significantly stronger position across the entire semiconductor value chain today compared to 10 years ago. With its large domestic market, strong government and capital market support, and world-class R&D capabilities, China should be expected to continue strengthening its national position in the global semiconductor value chain in the next decade. However, China chip localization also faces many challenges and limitations. A realistic expectation would be that China will continue to make progress, but it is unlikely to achieve full localization in the foreseeable future. Furthermore, high barriers to entry and continuous technology restrictions imposed by foreign governments mean it will likely take China decades to catch up on cutting-edge technology. As investors, we prefer the chip design segment as this plays to the strength of the investment that China has made to upskill its workforce and attract VC funding. It is also less impacted by foreign technology restrictions that we expect will remain in an era of strategic competition.

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\* Pensions & Investments Research Center, as of December 31, 2021.

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