



# Chip Semiconductors: The Development Trend of Global Supply Chain and the Challenges Faced by China

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**Abstract.** Japan, the United States, China and other countries have different chip development histories. With cooperation and competition in the process of development, different countries explore and research into different sub sectors, and ultimately occupy an important part of the global chip industry chain. In recent years, China's chip semiconductor industry has shown an upward trend. After years of precipitation, Huawei has come to the fore, occupying a key link in the world's semiconductor industry chain and becoming an integral part of it. However, countries led by the United States have gradually begun to put pressure on China to limit the development of China's chip semiconductor industry. From the perspective of the global chip semiconductor industry chain, this paper understands the development process of chips and analyzes the challenges faced by China today.

**Keywords:** chip · semiconductor · supply chain

## 1 Introduction

The military, economic and geopolitical forces in the world today are all based on computer chips. The global chip industry has grown rapidly, and five regional patterns have quietly formed. Nowadays, the deep integration of the chip semiconductor industry among Japan, the Asia Pacific region, Europe, China and the United States has led the development of the global chip industry [1]. In the modern military field, everything from missiles to microwaves is operated by chips, which can achieve precise strike targets. In terms of economy, chips can be used in automotive, smart phones, stock markets and other fields. Artificial intelligence has gradually occupied this era, and the innovative development of chips can promote economic growth. The effective application of chip semiconductors between military and economy can enhance the strength of a country and make it more competitive in the world. The purpose of this paper is to summarize the development and application of chips, explore the development trend of chip semiconductor industry in the global supply chain, and analyze the challenges faced by China from the perspective of chip semiconductor industry.

## 2 Development History of Chips

### 2.1 Source of Chip

The Second World War was described by Japanese soldiers as a “steel typhoon”. The result was determined by industrial output. It was obvious that new technologies were changing military forces, and the steel age was gradually replaced by the new atomic age. In the late 1800s and early 1900s, the development of government and enterprises required office workers to carry paper and pen and simple mechanical calculators to calculate. With the increasing demand for calculation, engineers invented electronic calculators to improve the accuracy of calculation. Early electronic calculators used vacuum tubes. The code of the opened tube was 1, while the code of the closed vacuum tube was 0. In order to find a better “switch” to control the vacuum tube, Shockley used the material of semiconductor. Bardeen and Brattain built a device called transistor to control the current flowing through germanium. Gordon Moore predicts that the computing power of each chip will increase exponentially, and the chip will gradually develop to miniaturization, and more micro transistors will be embedded in each chip. This will not only improve the computing power, but also reduce the price of each transistor. If the price decreases and the number of users increases, it will bring more benefits. Therefore, chip design companies need to constantly invest capital to create inventions. As photo lithography is a process of patterning transistors using special chemicals and light, designing better transistors requires stronger photo lithography technology, which many enterprises cannot escape. Because transistors can replace vacuum tubes only when they can be simplified and sold on a large scale, engineers have finally integrated multiple electronic components on a piece of semiconductor material after continuous attempts and research. Since then, integrated circuits (semiconductor chips) have been created.

### 2.2 Shift of Chip Application Focus

Chips were initially used in the military. The development of rockets and mortars has given chips a broader market. At the same time, the U.S. military has deployed chips in various types of weapons, from satellites to radio and sonar, from torpedoes to telemetry systems. However, with the development of the times, the focus of chip application has gradually changed from military to civil, such as zenith hearing aids, civil computers, mobile devices, intelligent products, etc. the innovative development of civil products has made the chip have a broader market.

### 2.3 Subdivision of Chip Functions

The functions of the chip are divided into three types: the first is the memory chip, which is used to memorize data (DRAM provides the short-term memory required for computer operation, flash memory is also known as NAND, which will memorize data over time); The second is the logic chip, which is used to process data. Logic refers to the processor running smart phones, computers and servers; The third is analog chips, sensors that convert visual or audio signals into digital data, RF chips that communicate with mobile networks, and semiconductors that manage how devices use electricity.



**Fig. 1.** Distribution of the global chip industry chain

### 3 Distribution of Chip Industry Chain

Upstream: chip design companies (Intel, NVIDIA, apple, Huawei, Samsung); Mid-stream: chip manufacturing companies (TSMC, Samsung, Intel, SMIC); Downstream: chip assembly and testing company (Foxconn) (Fig. 1).

### 4 Development of Chip Semiconductor Industry in Japan

At the end of the Second World War, during the cold war between the United States and the Soviet Union, the U.S. government supported Japan to re develop into a scientific and technological power. The purpose was to help Japan rebuild its economy, bind Japan to the U.S. - led system, and make Japan a transistor salesman, which was the core of U.S. strategy during the cold war. American chip companies dominate the forefront of chip production and provide Japanese companies with many chip related businesses. Some American chip manufacturers even transfer their technology to Japanese companies. Sony has a low wage advantage in Japan and is good at identifying new markets. It uses the latest circuit technology in Silicon Valley to produce new products to target these markets. Sony's specialty is not designing chips, but designing consumer products and customizing the electronic products they need. The Japanese government has strongly subsidized the chip industry to help its development. With the rapid development of the Japanese chip industry, trade competition between Japan and the United States has increased day by day. From the late 1980s to the 1990s, the Japanese semiconductor industry, which was severely weakened by the United States' repression, encountered two major changes in the structure of integrated circuit products and integrated circuit industry, and fell behind in the trend of the two changes because of its own conformism [2]. Later, a semiconductor symbiotic relationship emerged between the United States and Japan, involving complex balancing behaviors, and relying on each other for both supply and client.

## **5 Development History of Important Chip Semiconductor Companies in the United States and China**

### **5.1 GCA**

In 1981, GCA was a company transformed from an air force officer to a physicist, known as one of the “hottest high-tech companies” in the United States. After GCA launched the first stepper in 1978, the company’s revenue soared. However, with the rise of Japan’s chip industry, GCA began to lose its advantages. In addition, the company’s excessive behavior and improper timing led to serious excessive expansion during the decline of the chip semiconductor industry, which led to the decline of GCA.

### **5.2 Intel**

In 1968, Bob Noyce and Gordon Moore establish Intel, and two years later launched the first chip called dynamic random access device or DRAM. Since then, Intel plans to dominate DRAM chip business and decides to specialize in memory chips. Mass production of such chips will generate economies of scale. In 1972, Intel had the most advanced assembly line in the world, which was ready for its industrial revolution.

### **5.3 TSMC**

After Li Guotai, the Minister of Taiwan, persuaded Ti to set up the first semiconductor factory in Taiwan in 1985, the Taiwan government strongly supported the chip industry, built an industrial technology research institute to carry out chip development, and helped Zhang Zhongmou set up TSMC. The Taiwan government provided 48% of the initial capital. Later, Zhang Zhongmou persuaded Philips, a Dutch semiconductor company, to invest US \$58million to transfer its production technology and obtain intellectual property licenses in exchange for 27.5% of TSMC’s shares. The Taiwan government also provided tax incentives for TSMC. Zhang Zhongmou promised to only manufacture chips and became a reliable partner for all chip designers. TSMC’s business flourished in the 1990s, and its manufacturing process has been continuously improved. It is on the road of leading the world’s most advanced chip production. Until 2020, the output value of TSMC accounted for 85% of Taiwan’s chip manufacturing industry and 43% of the semiconductor industry. As it is the only manufacturer in the world with advanced process technology for mass production of 5nm, TSMC has become the exclusive supplier of high-end chips in the world [3].

### **5.4 SMIC International**

Half of the initial capital of SMIC international was invested by American investors. After its establishment, it set up a semiconductor foundry in Shanghai. At the same time, the Chinese government gave enterprise subsidies and policy support. The enterprise strategy is similar to TSMC, hiring good engineers, purchasing good tools, focusing on mature technology and professional training for employees. Later, it played an increasingly important role in the assembly of electronic equipment, Most chips in the world are

installed in it. SMIC has been continuously upgrading its industry and has been listed successfully. It has always been the leader of OEM in the chip industry in mainland China.

## 5.5 Huawei

In 1987, engineer Ren Zhengfei established an electronic trading company called Huawei in Shenzhen. Huawei began to compete with foreign countries at the beginning of its establishment. He adopted the concept pioneered by foreign countries, first purchased telecom equipment from Hong Kong at a relatively low price, and then sold it at a higher price nationwide to earn a price difference. By the beginning of 1990, Huawei had hundreds of R & D personnel, mainly focusing on the construction of switching equipment. Since then, the telecommunications infrastructure has been integrated with the digital infrastructure. During the domestic development period, Huawei has vigorously carried out independent technological innovation activities and accumulated rich knowledge, experience and technology [5]. Although Huawei admitted some previous infringements, it could not explain its success. Huawei has developed effective manufacturing processes to reduce costs and produce high-quality products. Huawei will also spend a lot of money on R & D, which is a multiple of other Chinese technology companies' R & D expenditure. Huawei spent a lot of money on R & D because it visited some semiconductor companies in the United States and spent a lot of money to hire the Consulting Department of IBM. Thanks to IBM and other Western consultants, Huawei learned to manage its supply chain and sell products worldwide. Huawei has also received strong support from the Chinese government, such as subsidies, tax relief and so on. The rise of Huawei has seized market share and embedded its equipment into the world telecom network. With the development of Huawei, the existing western companies selling telecom equipment are forced to merge or withdraw from the market. Later, Huawei also started selling phones and quickly took the lead in the smartphone market. By 2019, its sales volume was only behind Samsung. Huawei has also made progress in designing its own chips, but due to the complexity of semiconductor manufacturing and the need for the most advanced chip manufacturing technology, it chose chip manufacturing outsourcing. Huawei's success stems from its learning and production of advanced technologies, winning the global market, investing in R & D and challenging the technology leaders in the United States.

## 6 Advantages and Disadvantages of Today's Competition Between the Chip and Semiconductor Industries in China and the United States

### 6.1 China's Advantages and Disadvantages in Competition

China has the following six advantages in competition: 1. The government gives policy support and large subsidies; 2. Having relatively cheap labor; 3. Huawei and other technology companies have emerged and led the development of China's chip industry; 4. As the world's factory, China's manufacturing industry is very strong, and OEM factories

are all over China; 5. The domestic integrated circuit industry has made great progress [4]; 6. The enterprise focuses on the research and development of new semiconductor materials, from made in China to created and developed in China, and continues to innovate. There are six deficiencies as follows: 1. Lack of core chip design technology; 2. There are few types of chip manufacturing, and the ability of independent research and development needs to be improved; 3. China's semiconductor enterprises have been suppressed by the United States and other countries, which has hindered their development; 4. Insufficient tax incentives; 5. Talent shortage; 6. The relevance of the upstream and downstream of the industrial chain is low, and the coordination is insufficient [6].

## 6.2 Advantages and Disadvantages of the United States in Competition

The advantages of the United States in the competition are as follows: 1. The enterprise has the world's most advanced chip design technology, leading the world's chip industry; 2. American investors invest in semiconductor companies in many other countries, participate in the production and manufacturing of these companies, and can obtain more profits; 3. As a world power, the United States has many allies and many small countries are dependent on the United States to better realize the globalization of the chip industry chain. There are four deficiencies as follows: 1. The United States has long ignored that it is only one link of the chip industry chain from the perspective of maximizing interests; 2. There is no cheaper labor force; 3. The government has not invested much in the chip industry.

## 7 Conclusion

The outcome of the Second World War was determined by industrial output, and new technologies are changing the world pattern. The development of chips shows the wisdom of people at that time and the importance of the country for the development of chips. The development of the chip semiconductor industry in Japan, the United States, China and other countries is inseparable from policy support and large subsidies. Some enterprises first introduced high-end technology, produced better products and went abroad, and invested a lot of money in research. Nowadays, with the development of chips, there are cooperation and competition among chip industry companies in each country. Any country is a part of the globalization of the chip industry chain and cannot be left alone for a lifetime. Specifically, the global chip and semiconductor industry pattern has the following characteristics: first, the characteristics of regional specialization are prominent; Second, the market concentration is high; Third, the new crown pneumonia epidemic has impacted the global semiconductor supply chain, resulting in the short-term aggravation of the "core shortage" dilemma; Fourth, the process of digitization is accelerating, and the demand for chips continues to rise. It is expected that the "core shortage" dilemma will continue, and the adjustment of the global semiconductor industry chain is imperative [7]. Therefore, the development of the chip semiconductor industry is very important. The development of China's chip semiconductor industry has driven China's economic development. The information industry has become the first pillar of China's 40 major categories of industrial economy, and the semiconductor chip is the core and foundation of the information industry. The seemingly small

semiconductor chip plays a role of driver and multiplier to promote the development of national economy [8]. However, with the change of the global chip semiconductor industry pattern, and the increase of domestic labor costs and foreign pressure, China's chip semiconductor industry is facing unprecedented challenges. China's restrictions are gradually exposed. We must be aware that we can't rely too much on foreign and Taiwan's technology, and the core technology of the industry must be firmly in our hands in order to be in an advantage in the competition.

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