Red Supply Chain versus Blue Supply Chain—what will South Korea choose?

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Today, we will discuss about the mega-trend of the semiconductor industry and South Korea's choice. Semiconductors have become more important than oil during this coronavirus crisis. The current situation in which leading global automakers must reduce production due to the lack of semiconductors shows the importance of semiconductors.

The importance of semiconductors grows day by day, but it is not easy to increase the supply. Therefore, there is a fierce competition between the U.S. and China over Korea and Taiwan, which are capable of manufacturing semiconductors. It's as if the Great Game, which was a fierce rivalry between Great Britain, Russia, and Japan over Joseon, is being reproduced. If something were to go wrong, the fate of the country could fall into great depths. First, let's look at the trend related to the semiconductor industry.

The first trend related to semiconductors is the surge in demand. The demand for semiconductors, which had been rapidly increasing, has seen a massive increase as the coronavirus crisis continues. Employees were telecommuting and children were taught online at home. Also, instead of going to the supermarket, people began to shop online at home. As a result, the demand for better PC computers has significantly increased. Platform companies, such as Google, Naver, and online shopping companies are also increasing the capacity of their servers as traffic increases. Everyone needs semiconductors and lots of it.

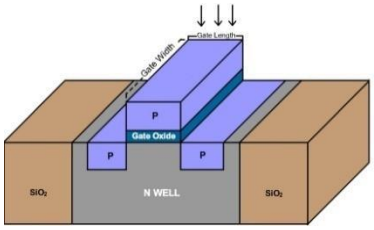
Semiconductor consulting firm, Omdia, predicts that the global semiconductor market, which was $451.5 billion in 2020, will increase by 8% to $489 billion in 2021, and will increase again by 10.8% to %5,423 billion in 2022.[1] Using our Korean currency, the market size, which used to be 500 trillion won, will grow to 600 trillion won in 2 years. The World Semiconductor Trade Statistics (WSTS) is expected to grow much faster. It is said that 2021 will be 10.9% larger than the market size in 2020.[2] It seems clear that demand for semiconductors will rapidly grow.

The second is about the supply. The number of semiconductor manufacturers is decreasing. In 2000, there were 30 high-tech semiconductor manufacturers, but now, there are only three companies left: Samsung, TSMC in Taiwan, and Intel in the U.S. There are signs of Intel dropping out again. It seems likely that they will only design and leave the manufacturing to TSMC. If we are talking about 7 nanometers or less, Samsung and TSMC are the only ones left in the game, which can be reduced again. Contrary to the increase in the number of design companies, the number of manufacturing companies are decreasing.

There are two simultaneous physical and economic causes for the creation of a winner-take-all structure in the semiconductor manufacturing industry. Physically, it is becoming very difficult to reduce the width of semiconductors. You've probably heard of Moore's law. It refers to a

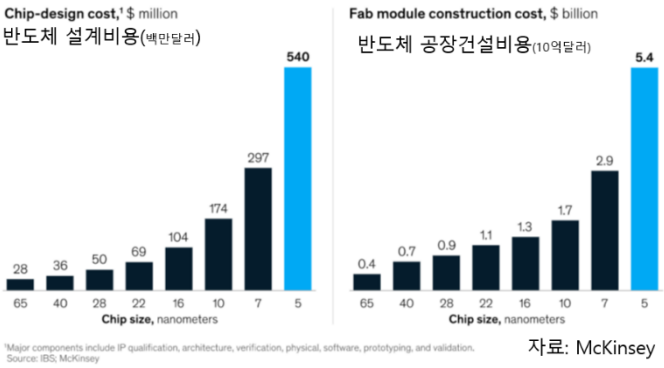
[1] https://www.edaily.co.kr/news/read?newsId=04372246628948880&mediaCodeNo=257
[2] Worldwide Semiconductor Market Growth is expected to accelerate in 2021, https://www.wsts.org/76/Recent-News-Release

phenomenon in which the number of transistors that can be inserted into an integrated circuit (IC) that doubles every 18 to 24 months. Many believe Moore's law is practically at its limit. The numbers, like 7-nano and 5-nano, originally refers to the gate length of the transistor.[3] It was until 2005 when it was at 30 nanometers, but it became very difficult to reduce the size.[4] However, companies have increased integration in several ways. And we used 10-nano, 7-nano, 5-nano, and such, for the new method. After 30 nanometers, the number doesn't mean the length of the gate, but the actual effect. The numbers are meaningless. Therefore, Intel's 10-nano semiconductor is similar to TSMC's 7-nano technology.



https://nptel.ac.in/content/storage2/courses/103106075/Courses/Lecture21.html

This means that it has become very difficult to create high-tech semiconductors. It costs a lot of money to overcome difficulties. So, the higher the integration of semiconductors, the higher the exponential cost. McKinsey presented the data regarding this.[5] The construction cost for a manufacturing facility is $5.4 billion to build 5-nano technology. That's approximately 6 trillion won. This amount is 3.2 times more than the 10-nano technology, which cost $1.7 billion. This is because we need high-precision devices like ultraviolet exposure equipment. It costs as much to design a semiconductor as it is to build a facility. It is said that it would cost $5.4 billion to build 5-nano technology while it takes $300 million for 10-nano technology.



Source:
https://www.mckinsey.com/industries/advanced-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities

[3] https://en.wikichip.org/wiki/technology_node
[4] https://asia.nikkei.com/Business/China-tech/Semiconductor-tech-trends-favor-China
[5] https://www.mckinsey.com/industries/advanced-electronics/our-insights/semiconductor-design-and-manufacturing-achieving-leading-edge-capabilities

This huge cost of construction and design goes in regardless of the production costs. It's the same whether you make one or 10,000. Even if production increases, the additional cost is not great. As a result, chicken games are frequently played in the semiconductor industry, and the winner-take-all industrial structure is formed. For this reason, the number of manufacturing companies decreased as the process has become more high-tech. There are only three high-tech semiconductor companies left from the 30 in 2000 because of this economic principle.

The following table shows the number of manufacturers from each country's semiconductor process. There are five countries in the world that have proper semiconductor manufacturers: Korea, the United States, Taiwan, Japan, and China. The lower the precision, the higher the number of manufacturers. The manufacturer that produces 180-nano technology is 94, and the 130-nano technology is 72. The higher the precision, the fewer the manufacturers. There 20 manufacturing 32-nano technology and there are 5 manufacturing 10-nano technology. 5-nano and 3-nano technologies are currently under development, but Samsung Electronics, TSMC (Taiwan), and Intel (U.S.) are the only ones pursuing these technologies. Among them, Intel has practically given up, so it's just between Korea and Taiwan.

<Table> Number of manufacturers by country by semiconductor process

Process node (nm)	180	130	90	65	45/40	32/28	22/20	16/14	10/7	5	3
Number of semicondutor manufacturers working at each process node											
US	24	18	11	8	4	4	4	4	1	1	1
South Korea	4	4	3	2	2	2	2	2	2	1	1
Taiwan	9	9	6	6	6	6	5	3	1	1	1
Japan	18	10	7	6	5	1	1	1			
China	19	18	16	13	8	6	3	1	1		
Other	20	13	5	1	1	1	1				
Total	*94*	*72*	*48*	*36*	*26*	*20*	*16*	*11*	*5*	*3*	*3*

Note: Some companies in the above table have fabrication facilities located in countries outside of where they are headquarted but have been included in country totals. The table also does not distinguish between producers of different types of semiconductors, such as CPU/GPU, application-specific semiconductors, and memory, each of which is driven by different market requirements around feature size.

Source: Paul Triolo and Kevin Allison, "The Geopolitics of Semiconductors," Eurasia Group, 2020.

To summarize, demand for semiconductors is increasing, but it is not easy to increase production facilities. The number of consumers and designers is increasing, but manufacturing companies are not easy to increase. The automotive semiconductor crisis that has been taking place since the second half of 2020 indicates that it is not easy to increase the supply of semiconductors. Automakers around the world, including Volkswagen, GM, and Nissan, have drastically reduced production because they couldn't find semiconductors for their vehicles. They are unable to get semiconductors for the vehicles' dashboards, sensors, and such.

There is a reason for the semiconductor crisis for automobiles. Automakers have reduced orders for semiconductors as vehicles sales sharply declined due to the coronavirus in early 2020. Like most, automakers didn't even stock spare semiconductors because they expected the coronavirus crisis to continue for a long time. Fortunately, Hyundai Kia Motors did not cancel their order, so

they are not experiencing a direct crisis of semiconductor shortages. However, the automobile market has unexpectedly revived in the second half of the year. The problem is that it has become difficult to get semiconductors for the vehicles.

Semiconductor suppliers are also frustrated. The top 3 automotive semiconductor companies are Renesas (Japan), NXP (Netherlands), and Infineon (Germany). Most of them do not have or have some manufacturing facilities. These companies are only producing designs to Taiwan's foundry TSMC. However, when the orders were canceled and there were sudden attempts to put the orders back in, the order is backed up.

The cost is also a problem. They don't use advanced processes such as 7-nano or 5-nano technology for automotive semiconductors. Because vehicles have a large space, there is no need to use high-tech semiconductors that are costly. 40-nano technology is enough. The price is low as the precision is low.[6] Semiconductors for smartphones cost $300-$400, while semiconductors for automobiles cost only about $1.[7] As the price is low, the priority will be pushed back even in foundries such as TSMC.

As global automakers with loud voices shouted, each country's president or prime ministers came forward to ask Taiwan for help, and TSMC said it would pay special attention to the automotive semiconductors, but it will most likely not be solved any time soon. This is because expensive semiconductors are also in high demand.

Despite the surge in demand for all semiconductors, such as semiconductors for PC computers, smartphones, and game consoles, it is difficult to suddenly increase the capacity for supply. To make matters worse, there were incidents one after another. When the polar cold wave hit Texas and the electricity was down, it affected Samsung Electronics' semiconductor plant. In Japan, production at the Renesas factory came to halt due to a fire. These incidents worsened the supply shortage. The accidents will be resolved soon, but the technological and economic constraints to build the facilities will be intensified.

The world cannot function properly without semiconductors, but it is becoming more difficult to have advanced manufacturing capabilities. As a result, semiconductor manufacturers are at the center of the struggle in global hegemony. Also, semiconductor self-sufficiency is spreading like a trend. China began to stand on its own feet in semiconductors with 'Made in China 2025.' They began to heavily invest and stated that they would increase the semiconductor self-sufficiency rate from 15% to 70% by 2025. However, China is frustrated by the ambush of U.S. sanctions. Huawei's inability to find new semiconductors thus forcing China to give up its smartphone business shows the current state of the country. However, investing in semiconductor self-sufficiency is getting fierce. Whether they can succeed remains to be seen.

The attitude of the United States is also changing. The U.S. has used international division of labor as an economic principle, not self-sufficiency. But now, the U.S. is also trying to keep semiconductor factories in Korea. It is typical that TSMC and Samsung Electronics have attracted semiconductor factories to the U.S. The Biden administration is likely to come out

[6] https://www.eetasia.com/shortage-of-auto-chips-has-industry-scrambling/
[7] https://www.wsj.com/articles/no-quick-fix-for-auto-chip-shortage-11612883643

strong. President Biden has ordered his staff to create a semiconductor supply chain that excludes China. Dr. Paul Triolo of the Eurasia Group calls it a competition between red supply chain versus blue supply chain.[8] Of course, red means China's central supply chain and blue refers to America's central supply chain. The European Union has also launched a 30-billion-euro project to build a state-of-the-art foundry plant in member states' territories by 2030.

A year ago, creating an industry that completely excluded China was not as easy as it sounds because the market is disappearing. China is the world's largest consumer of semiconductors and consumes 60% of the world's semiconductors, but the U.S. only consumes 10 percent. In that situation, if the market is not separated and sold to China, Western semiconductor companies could be at risk of declining sales. The coronavirus is changing the state. As a result of the surge in demand, products could not be sold because the products didn't have semiconductors. As economic feasibility increases, the possibility of forming a "blue supply chain" excluding China is also increasing.

What will happen to the semiconductor industry in Korea? Above all, the relationship with China is becoming difficult. Korea exports huge amounts of semiconductors to China. Between January and July 2020, exports to China amounted to $22.5 billion, 41.1% of total semiconductor exports, and 20.8% to Hong Kong which amounts to $114.5 billion.[9] Since Hong Kong is technically a part of China, 62% of the total amount of semiconductor exports comes from China. It is not an easy task to cut this off. However, will the U.S. just observe from the sidelines as Samsung Electronics and SK Hynix supplies semiconductors to the Chinese market? Will the pro-China Moon Jae-in administration allow Korean companies to leave the red supply chain for the blue? It would be difficult to predict the answers to these questions. I believe that huge waves will crash into our country soon.

[8] Paul Triolo and Kevin Allison, "The Geopolitics of Semiconductors," Eurasia Group, September 2020.
[9] 한국의 국가별 반도체 수출, 연합뉴스, 2020.9.15. https://www.yna.co.kr/view/GYH20200915000200044