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为什么美日荷半导体协议围堵不了中国？

‘Why can't the US-Japan-Dutch semiconductor agreement contain China?’

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The United States recently reached an agreement with Japan and the Netherlands to limit the export of equipment needed to manufacture advanced semiconductors to China. After the news came out, the stock prices of global semiconductor-related companies fluctuated to varying degrees. Taiwan's **Liberty Times** newspaper believes that the agreement reached by the United States, the Netherlands, and Japan is equivalent to "nuclear bomb-level sanctions" on the semiconductor industry in mainland China. "We fully agree with the strategy of depriving China of the most advanced chips, we cannot allow China to obtain the most advanced technology. There is a very strong alignment between the EU and the US on restricting China's access to technologies such as microchips, quantum computing and artificial intelligence," Thierry Breton, the Commissioner for Internal Market of the European Union, said.

The author believes that if the United States reaches an agreement with Japan and the Netherlands to jointly restrict the export of semiconductor equipment to mainland China, it will have a negative impact on the expansion of the production capacity of mainland (semiconductor) fabrication plants. But how this agreement will be implemented is still unknown, moreover, it has many loopholes that can be exploited. In general, this agreement is both a challenge and an opportunity for the semiconductor industry in mainland China.

The semiconductor equipment market is basically monopolized by European, American, and Japanese manufacturers.

The semiconductor industry can be roughly divided into five parts: equipment, design, raw materials, manufacturing, packaging and testing. The division of labour in the global semiconductor industry is in the form of a "flying goose." The semiconductor equipment and design segment which require the highest technical threshold and yields the highest profit is dominated by the United States and its European allies. Japanese and American companies control the raw material segment. Taiwan and South Korea occupy the manufacturing segment. Finally, Taiwan and Mainland China occupy the packaging and testing segment.

As far as semiconductor equipment is concerned, three American companies, viz. Applied Materials, Lam Research Corp., and KLA-Tencor rank among the top five semiconductor fabs in the world. According to statistics, the global semiconductor equipment market was valued at US$100 billion in 2021, and the operating income of Applied Materials, Lam Research Corp., and KLA-Tencor was US $24.1 billion, US $16.5 billion, and US $8.1 billion, respectively. The total revenue of the three companies stood at US $48.7 billion, with a global market share of more than 45%. Etching equipment, ion implantation equipment, physical vapour deposition equipment and chemical vapour deposition equipment are all strong areas of American equipment companies. Applied Materials occupies more than 30% of the global market share of physical vapour deposition equipment, and more than 50% of the global market share of chemical vapour deposition equipment.

Although Japanese semiconductor equipment manufacturers are going downhill after lithography machines of Nikon and Canon are routed by ASML (Advanced Semiconductor Materials Lithography), just like "a starved camel is bigger than a horse," Japan still has semiconductor equipment companies such as Tokyo Electronics and Nikon. In 2021, among the top 15 equipment manufacturers in the world by revenue, Japanese companies accounted for 7, with total revenue of US $37 billion, second only to the US equipment manufacturers. As far as the Netherlands is concerned, ASML is well-known as the uncontested top dog in lithography machines. It has basically monopolized the global high-end lithography machine market. Its EUV lithography machine is currently an exclusive business, and the price of a single EUV lithography machine exceeds US $100 million.

At present, Chinese semiconductor equipment manufacturers only account for 17.2% of the domestic market, and nearly 83% of the market is occupied by foreign equipment manufacturers. Noticeably, this figure is also an outcome of a certain policy preference for local manufacturers due to the Sino-US trade friction in recent years. Globally, the market share of Chinese semiconductor equipment manufacturers is only 5.2%. In terms of technological standards, there is a clear gap between Chinese equipment manufacturers and foreign oligarchs. The lithography machines produced by Shanghai Microelectronics for commercial mass production can only process 90nm chips, which is more than 10 years behind ASML. A definite gap also exists between domestic Chinese enterprises and international giants such as Applied Materials, Lam Research Corp., and Tokyo Electron, in the domains of etching, thin film, measurement and detection, ion implantation, coating and development, etc.

Domestic equipment has some bright spots (but) cannot form the entire industrial chain.

Although a section of Chinese media has reported with much excitement the breakthroughs made by local companies in semiconductor equipment in recent years, the overall situation is relatively grim. At present, domestic companies only have some bright spots, and cannot achieve the localization of the whole process. For example, some Chinese companies “self-advertise” – such as Advanced Micro-Fabrication Equipment Inc. China (AMEC) and claim to have successfully developed 5nm etching equipment, as if domestic companies have come out of the foreign stranglehold on the etching equipment. In fact, this 5nm etching equipment is just one of the various equipment in CCP dielectric etching used in the etching process. Nearly 30 types of etching equipment are used in the front and rear processes of ICP and CCP etching. At present, AMEC and NAURA can only complete about 1/4 (of the etching process), and 3/4 is monopolized by large foreign manufacturers. Even cleaning equipment with a relatively low threshold can only achieve a localization rate of 50%. Among them, the performance of domestically produced machines for glue removal equipment is already close to that of foreign companies, but 30% of the equipment still cannot be produced locally.

Chinese chipmaker caught in US-China tech war
Source: caixin.com

In recent years, some domestic companies have begun to lay out de-Americanized production lines to ease the pressure from the United States sanctions on domestic chips. It mainly involves replacing American equipment with European and Japanese semiconductor equipment. Some action is also visible in localisation substitution. For instance, cleaning equipment still mainly uses foreign equipment in photolithography, thin film deposition, etching, measurement and detection, ion implantation, glue coating and development, etc. An example is the newly installed fab of SMIC Beijing1 28nm production line in 2022. Its localization rate in the first phase is only 25%, and that too is mainly concentrated in fields with relatively low technical.

Whether it can be done is one thing, and whether it is useful is quite another. From the perspective of SMIC, due to the purchase of domestic equipment and the increase in the proportion of domestic equipment, the certification standard had to be lowered, which led to a decline in the yield. The yield rate of SMIC's 28nm (fab) lines having American equipment is about 85%, whereas the yield rate of the non-American lines with a localization rate of 25% is expected to reach 75%. If the proportion of localization is further increased, the yield rate will only be lower. In comparison, the yield rate of TSMC's 28nm line is 96%.

According to industry practice, the yield rate of a fab must reach more than 80% to be profitable. This makes it impossible for the domestic fabs to make profits while continuing the operation of localized production lines, thus, they end up relying on state subsidies. If fabs across the country start suffering huge losses at the same time, it will be difficult to stably retain talented human resources, which then will turn into bad news for technology research and development, and will also cause a considerable burden on local finances. Cash flow of the fab can be maintained in the short term through financial subsidies, but state subsidies are only a stopgap measure, not a long-term solution.

It can be said that the process of reaching something from nothing, and then from something to something good requires repeated grinding and practice in the market, continuous accumulation of experience, and optimization and change from generation to generation. It is a process of spiral improvement. Continuous technological updates are behind the good quality equipment of major foreign manufacturers and the high-yield rate of TSMC's production lines. This requires us to invest manpower, capital, and more than ten years of perseverance to catch up. It cannot be achieved overnight, let alone in a single leap.

The agreement may not be strictly implemented and there are loopholes.

Broader Crackdown on Chinese Chipmakers
Source: CGTN

At present, the United States, Japan and the Netherlands have only reached an initial agreement, and how it will be implemented is still not clear. I think this agreement may not be strictly implemented, and there is room for manoeuvre in the process of implementation.

This is because as far as the Netherlands is concerned, sanctioning China will not do it any good, on the contrary, it will make ASML lose the Chinese market. This is also why the Netherlands has been erratic on the matter. On January 15, the Netherlands stated that it has its own judgment and will not hastily accept the American request, yet at the end of January it joined the tripartite agreement. Meanwhile, on January 30, the Dutch Foreign Minister Wopke Hoekstra held a telephone conversation with the Chinese Foreign Minister Qin Gang. The

[1] https://cntechpost.com/2021/02/23/smic-builds-7-7-billion-fab-in-beijing-expected-to-be-completed-by-2024/

Netherlands has also made overtures to China through an important commitment that it will continue to handle economic and trade-related matters with China in a responsible manner, and that it also hopes to strengthen cooperation with China in various fields.

It follows then that the Netherlands is not determined to make life difficult for China, but is subject to political pressure from the United States and has succumbed to it. Therefore, the Netherlands will inevitably find a middle ground between political risks and commercial interests. It will adjust its policy to the international situation, so that no one is too offended, while continuing to make money.

The situation is similar in Japan, which also has high ambitions. The semiconductor industries of China and Japan can easily complement each other. Although Japanese raw material companies are still strong, semiconductor equipment manufacturers have been beaten badly by European and American manufacturers such as Applied Materials, ASML, and Lam Research Corp. High-end lithography machines are monopolized by ASML, whereas Nikon can only manage to pick up some leftovers, while Canon's lithography machines are almost extinct.

As the American semiconductor equipment manufacturers comply with the ban to withdraw from the Chinese mainland market (American equipment manufacturers such as Applied Materials, Lam Research Corp., KLA-Tencor are very profitable, with 25-30 percent of their revenue coming from the mainland China market), the situation for the Japanese semiconductor equipment manufacturers, who have taken the downhill road over the years, is like a good rain after a long drought. Without the American ban, commercial interests would have (also) pushed the Japanese companies to sell semiconductor equipment to mainland China through various means. In the future, Japan will most likely adopt a relatively flexible policy to earn money without offending China and the United States too much.

US sanctions are supercharging Chinese chip-making
Source: Gartner

In addition, determining advanced technological standards is a daunting task. In the past, the industry used grid length to name processes. However, after entering the era of Finfet (fin-shaped field-effect transistor), it is very difficult to go further than 20nm grid length, so the transistor density is increased by 3D stacking. With the transistor layouts changing from 2D to 3D, the old way of using grid length to name processes has become outdated.

The naming of their processes by Samsung and TSMC is nothing more than wordplay. Despite the fact that the grid length of the so-called 5nm, 7nm, 10nm chips manufactured by TSMC and Samsung, is not at all 5nm, 7nm, 10nm, they have been named as such by their manufacturers. It is said in the industry circles that the 16nm process of TSMC was originally named 20nmFinfet, but since Samsung claimed its process to be 14nmFinfet, TSMC followed suit and started claiming its process to be 16nmFinfet, thus causing a joke in the industry that Samsung 14nm process is inferior to TSMC 16nm process. That is why Intel has suggested that the manufacturing process should be measured by the transistor density, rather than the "XX nm" process used in the past.

However, Samsung and TSMC had tasted success by naming their processes in "XX nm" manner, so they were absolutely not ready to abandon this method. Much like how the bad coins drive out the good coins, Intel was forced to abandon its naming method of "10nm +++" and follow the precedence set by Samsung and TSMC, thus "crying up wine and selling vinegar" by naming its chips as Intel 7, Intel 4. Given differences in the nomenclature of processes and the actual performance of chips manufactured by different manufacturers it becomes very difficult to set a uniform standard. So, the chips can only be measured by relatively broad standards, creating scope for manoeuvre.

It is also very troublesome to restrict the operation of the equipment (to have device-specific restrictions). In terms of the lithography machine, the light source can be roughly divided into 5 generations, which are G- line, I- line, KrF, ArF and EUV. At present, the existing domestic lithography machine with ArF as the light source combined with etching and film equipment can actually process 5nm chips, and even the lithography machine using KrF can process chips up to 14nm. Therefore, how to define advanced semiconductor equipment is a problem. If only EUV lithography machines are banned, Chinese companies can use ArF lithography machines to process 5nm chips. If ArF lithography machines are included in the banned equipment list, Chinese enterprises can still use KrF lithography machines to process 14nm chips. They would still get some useful chips but at a low cost-effectiveness ratio.

If restrictions are imposed on both the ArF and KrF lithography machines, let's not mention that the KrF lithography machines are already an old technology and cannot be considered advanced, then such a restriction would have problems of its own since its scope would be too wide. It would also deprive European and Japanese equipment manufacturers of the world's largest single market (Mainland China) and cause them huge losses. As long as there is no extreme political risk, European and Japanese manufacturers have a strong incentive to export equipment to China by bypassing compliance checks in some ways, just as the semiconductor companies in Europe, United States, Japan and South Korea have done during the Sino-US trade war in recent years.

Conclusion

In the short term, even in the worst-case scenario of an outright ban on exports of advanced semiconductor equipment in the United States, Japan and the Netherlands, there will be little impact on existing fabs in mainland China since they won't be able to expand production. At present, the West does not impose restrictions on the export of semiconductor equipment components. We can set up trading companies or find OEM channels to purchase related components and consumables. Since many equipment parts are not produced by equipment manufacturers themselves, but purchased from around the world, this makes management and control over restrictions significantly more difficult. Many manufacturers of parts cannot predict where their parts will be used. We can use this gap to ensure the supply of key parts and consumables. In this way, the normal operation of existing production lines can be maintained even if individual domestic fabs are placed on the sanctions list by the United States.

In the long run, it is necessary to continuously increase the proportion of localization in production lines and build a red industrial chain with dogged perseverance. This process is going to be a lengthy one, but it will exercise the technical capabilities of domestic enterprises. It will be slow at first and then fast, offering great potential for development. For instance, it may take 5 to 8 years to build a locally produced 28nm production line, but following that the construction of a locally produced 14nm and 7nm production line will be much faster. Soft fire makes sweet malt, so it is not appropriate to ask for a locally built production line with the impatience for quick results, but to achieve it with dogged perseverance.

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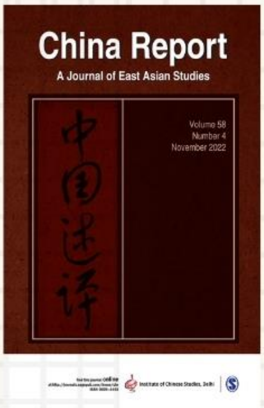

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