

How China Could Leapfrog US Chip-Making Bans

Description

by David P. Goldman via [Asia Times](#)

New 'advanced packaging' techniques could help China elude bans on selling DUV lithography equipment to its chip makers. Photo: Twitter

NEW YORK – China's semiconductor industry has lagged the US in patents and lagged South Korea and Taiwan in fabrication, but it hopes to leapfrog its competition by adopting

revolutionary new chip design technologies.

Advanced chips used in 5G smartphones and some workstations squeeze billions of transistors onto a fingernail-sized chip by shrinking the dimensions of the transistor itself to 3 to 5 nanometers. Most chips have gate widths of 28 nanometers and higher. Etching tiny circuits on silicon is enormously difficult.

Only the Dutch manufacturer ASML makes the lithography machines that use the short wavelengths at the extreme end of the ultraviolet spectrum to shrink transistors to such tiny dimensions. And the fabrication plants are extremely expensive, costing up to US\$20 billion each.

In 2020, the US forced the Dutch government to ban exports of ASML's most sophisticated lithography machines to China. ASML uses American intellectual property, giving Washington leverage.

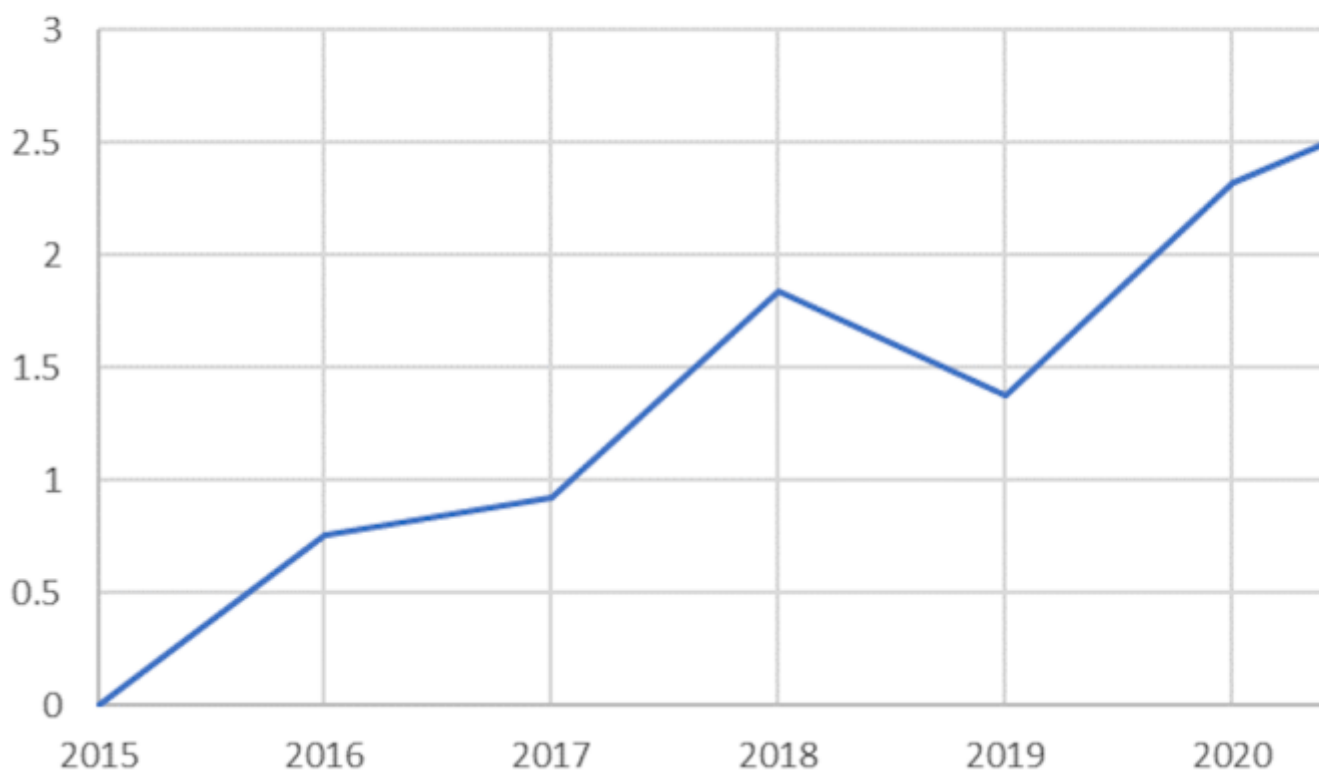
But ASML continued to sell its previous generation of lithography equipment, which etches 14-nanometer transistors using "deep ultraviolet" (DUV) light. China bought 81 such machines in 2021 alone.

China's largest fabricator, Semiconductor Manufacturing International Corp (SMIC), now produces 14-nanometer chips. With 5% of the world's fabrication market, SMIC lags its Taiwanese and Korean competitors but it is expanding rapidly.

As [Scott Foster](#) and [Jeff Pao](#) reported in Asia Times, Washington last month asked the Dutch government to stop ASML from selling the older DUV machines to China as well. Semiconductor Industry executives told Asia Times that the Dutch would not accede to the American demand. ASML's China sales exceeded \$2.7 billion in 2021, including the 81 DUV lithography machines.

The American intellectual property (IP) content of the older machines isn't big enough to justify an American ban, analysts and executives say.

ASML Sales to China



In the meantime, chip designers have learned how to build three-dimensional chips using what the industry dubs “advanced packaging.”

In the process, which has been used in various forms in chip-making for decades, layers of chips with larger transistors stacked on top of each other can produce computation speeds equal to one-dimensional configurations of the tiniest chips.

[Intel](#) has bet the company’s future on recent advancements in advanced packaging. Taiwan Semiconductor Manufacturing Company (TSMC), the industry leader, has likewise invested heavily in newer forms of the process. [Samsung](#) has just established a task for advanced packaging, hoping to leapfrog Intel and TSMC, which now account for 32% and 27% respectively of investment in the process.

China, which had little capability in semiconductor equipment before the Trump administration bans imposed on chips and chip-making equipment three years ago, is catching up. In February, Shanghai Micro “successfully delivered the first 2.5D3D advanced packaging lithography machine, which is of great significance to the domestic integrated circuit industry,” according to [China’s trade press](#).

The American tech website [Tom’s Hardware](#) explained:

When SMIC was barred from manufacturing tools advanced enough to make chips using its 10nm-class (and sub-10nm-class) nodes in late 2020, the

company said it would focus on developing advanced packaging technologies to make sophisticated multi-chiplet designs out of tiles produced on 14nm and thicker nodes. That would enable Chinese chip designers to build sophisticated and capable processors with tens of billions of transistors even without using an advanced process technology.

In addition, the company announced multi-billion-dollar expansion plans that would triple the output of chips made on advanced nodes.

To a large degree, advanced packaging technologies could be SMIC's way to work around the US export restrictions. As a result, China would gain access to advanced computing capabilities that could be used for military purposes.

The US administration certainly understands SMIC's options and risks that it brings to America and its allies, so it wants to further crack down on China's access to sophisticated chipmaking tools.

China won't be able to produce the 3 to 5-nanometer chips that TSMC and Samsung fabricate in their latest plans, but it may be able to package the older 14-nanometer chips into 3D configurations that achieve the same results – and at considerably lower costs. The Biden administration's belated attempt to suppress China's semiconductor industry appears to have backfired. China has found workaround technologies that bypass the aging American IP that Washington has embargoed.

In 2011 China produced just 12.7% of its domestic chip consumption and imported the rest. By 2021, it produced 17% of domestic consumption and by 2030 it is expected to produce 30%.

China's chip imports in 2020 totaled \$378 billion, the single largest item in its international trade. American pressure has prompted China to push for self-sufficiency, raising the possibility that China's chip industry may become the world's dominant producer by the end of the decade.

One of the star performers in China's stock market this year is semiconductor equipment maker Shanghai Micro Fabrication (HK 1385), with a 25% year-to-date gain while industry leader ASML fell by 45%. Shanghai Micro's net income rose to 573 million yuan (\$85.2 million) in 2021 from 133 million yuan in 2020 as the upstart equipment maker benefited from restrictions on sales of advanced semiconductor equipment to China.

The global chip shortage has turned into a glut with widespread cancellation of orders as most of the major economies are in or close to recession. Semiconductor stocks are among the worst performers year to date, except in China, where geopolitics has given the sector a tailwind.

The Biden administration is considering new measures to prevent China from buying chip-making equipment. This appears to be a response to Chinese advances in chip-making methods, including advanced packaging.

It seems to be yet another effort by Washington to close the barn door after the horse has bolted. China's chip-making equipment companies are the main beneficiaries of the tech

war, and eventually will fill the gap.

Shanghai Microelectronics, China's leading producer of lithography equipment, can meet the country's needs in older-generation chips of 90 nanometers and above, and reportedly has shipped its first 28 nanometer machines.

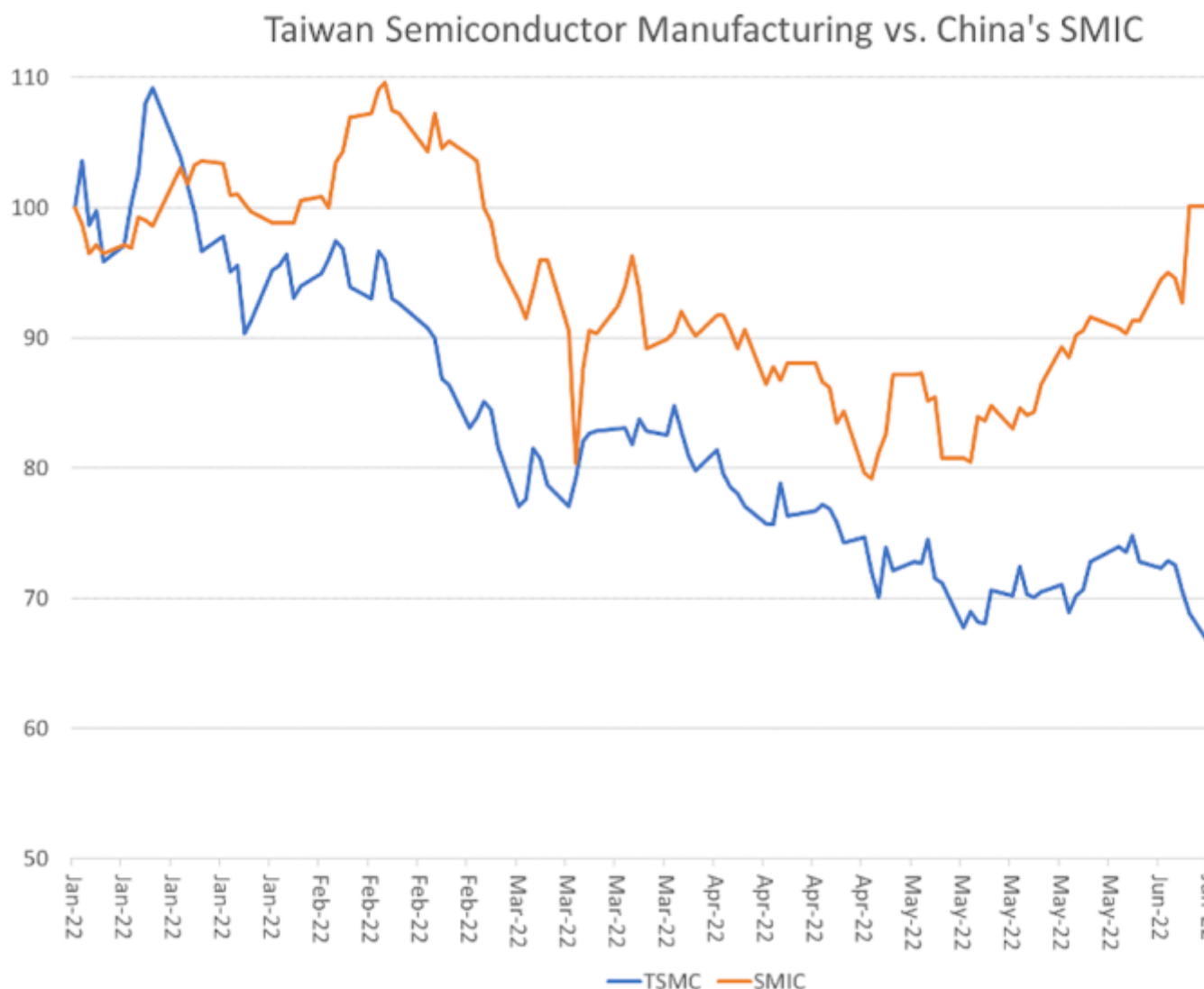
China's share of world semiconductor manufacturing capacity was 11% in 2010 and is forecast to rise to 24% by 2030. China's \$170 billion National Integrated Circuit Fund accounted for 86% of all government grants of below-market equity to chipmakers between 2014 and 2018, according to an [OECD study](#). Meanwhile, the US Congress has been unable to pass a \$52 billion package to subsidize semiconductor production in the United States.

In response to the legislative delay, Intel called off a July 22 groundbreaking ceremony for a chip fabrication plant in Ohio, and TSMC has warned that its projected fab in Arizona may not be built. According to US chip industry sources, Intel is relieved that the Ohio project may be put on ice.

The sudden softening of the semiconductor market and the threat of a chip glut following the global shortages of 2020-21 remove the need for additional capacity. Intel has \$10 billion a year in free cash flow and can finance its own expansion – if it has the customers. The US Commerce Department in early July told the business press off the record that it was considering extending restrictions on semiconductor equipment exports to China to include older technologies that make less advanced chips.

The threat of such restrictions and the important advances in home-grown Chinese capabilities have supported the stock prices of domestic Chinese equipment manufacturers, which also benefit from government subsidies.

China's SMIC has lost about 8% of its market capitalization during 2022 to date, while TSMC has lost 36%.



A key bottleneck in China's efforts to achieve a high degree of independence in chip manufacturing is lithography. ASML is the world's only manufacturer of Extreme Ultra-Violet (EUV) lithography machines that etch circuits for the most advanced chips with gate widths of 7 nanometers or less.

Only TSMC and Samsung can produce them. The Trump administration banned exports of these chips, shutting down the 5G handset business of Huawei and ZTE, and also persuaded the Dutch government to ban sales of EUV machines to China.

China's largest semiconductor foundry SMIC has only 5% of world market share, but its revenue has doubled over the past 18 months. It can produce 14-nanometer chips. Except for smartphones and a few specialist applications, chips of 14 nanometers and above make up 95% of world chip demand.

Although Huawei's 5G handset business collapsed without access to 7-nanometer-and-below chips, China had no problem building out its 5G base station network with wider chips.

But a revolution is underway in chip design, or perhaps several revolutions. New technologies, including new forms of "advanced packaging", provide an alternate path to

ever-smaller gateway width and at possibly lower costs.