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Protecting the Foundation: Strengthening Export Controls on Semiconductor Manufacturing Equipment

Prepared statement by

Chris McGuire

Senior Fellow for China and Emerging Technologies
Council on Foreign Relations

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Hearing on Export Control Loopholes: Chipmaking Tools and their Subcomponents

Chairman Huizenga, Ranking Member Kamlager-Dove, distinguished members of the subcommittee, thank you very much for the opportunity to testify at today's hearing. I have had the privilege of working to develop U.S. technology protection and export control policies at the White House, State Department, and the congressionally-established National Security Commission on Artificial Intelligence. I believe that export controls related to semiconductor manufacturing equipment (SME) and advanced semiconductors are one of the most powerful tools available to U.S. policymakers in the technological competition with China, and are critical to U.S. efforts to maintain leadership in AI and other emerging technologies. It is no exaggeration to say that the success of these policies could determine if the United States or China leads in the technologies of the future. They deserve sustained, strategic focus at the highest levels of government.

This testimony makes five key arguments:

1. **SME export controls are the single most decisive leverage point the United States has in the technology competition with China.** Advanced chips are critical to leadership in AI and other emerging technologies, and to military modernization. Because advanced chips cannot be manufactured without U.S. and allied SME, and SME is uniquely hard for China to indigenize, strong SME controls are the foundation of America's ability to shape the global technology landscape and preserve its military advantages.

2. **Current controls are working—but not well enough.** U.S. SME restrictions have slowed China's progress in advanced chipmaking, yet remaining gaps, loopholes, and inconsistent implementation still allow Beijing to build, maintain, and expand strategically significant semiconductor capacity.

3. **Allied controls must be leveled-up to match U.S. controls.** Key partner countries, particularly the Netherlands and Japan, have not fully matched U.S. controls on advanced Chinese fabs. This allows advanced Chinese fabs continued access to essential allied tools, components, and servicing, which uplifts Chinese chipmaking capabilities, helps China maintain existing advanced allied tools, and shifts market share away from American firms.

4. **Expanded country-wide restrictions on SME—in addition to comprehensive restrictions on all advanced Chinese fabs and toolmakers—are necessary to close all loopholes.** Only broad, country-wide restrictions on all SME capable of advanced production can reliably prevent Beijing from advancing its chipmaking capabilities or dominating mature-node manufacturing. The United States must also update the Entity List to include all entities affiliated with China's national champions in chipmaking and SME, but entity-based measures alone cannot keep pace with China's rapid buildout and complex corporate structures.

5. **U.S. extraterritorial controls have proven effective and should be expanded to close gaps between U.S. and allied controls.** Key allies are currently exempt from these extraterritorial controls; suspending these exemptions until allies adopt fully matching restrictions would seal some of the most significant gaps in the SME control regime.

The Strategic Importance of Strong Export Controls on Semiconductor Manufacturing Equipment

The semiconductor manufacturing equipment (SME) industry is one of the most strategically important industries on the planet because it serves as the foundation of U.S. and allied technological supremacy. SME describes the highly specialized tools needed to operate a facility that can make semiconductors. SME is by far the most important input into advanced chipmaking, representing 70-80% of the capital expenditure necessary to create an advanced semiconductor fab.[1]

The most advanced SME are the most complicated machines that humans have ever devised and rely on some of the most complicated supply chains on Earth. They rely on innovations from the bleeding edge of optics, materials science, plasma physics, and mechanical engineering—all working together with nanometer precision to manufacture the chips that power our modern world.

Countries must have access to the most advanced SME to build the semiconductor fabs needed to make the most advanced chips. These chips are the lifeblood of modern data centers and the most advanced AI models, are powering breakthroughs in quantum computing, biotechnology, and robotics. They also have critical military applications in the deployment and development of advanced weapons systems, ranging from autonomous systems to the modeling and simulation of nuclear and hypersonic systems. U.S.

[1] Brian Potter, "How to Build a $20 Billion Semiconductor Fab," *Construction Physics*, May 3, 2024, https://www.construction-physics.com/p/how-to-build-a-20-billion-semiconductor.

technological competitiveness in each of these areas rests on it preserving its leadership position in hardware, specifically in the advanced semiconductors used for each purpose.

China lags global leaders in both advanced chip production and SME production, but it has long sought to become a global leader in both areas. Advanced semiconductors are China's single largest strategic dependency on the United States and our allies; in 2024, China's imports of semiconductors totaled $385 billion, more than any other good—including oil. Advanced chips are also the single largest advantage the United States has over China in AI development; the best U.S. AI chips are currently five times better than China's best AI chip, and produced in much greater quantity, granting the United States substantial advantages in access to computing power. The second Trump Administration's AI Action Plan specifically highlighted the need to plug loopholes in semiconductor manufacturing equipment export controls to maintain U.S. leadership in AI.[2]

If China matches the chipmaking capabilities of the United States and our allies, the damage to U.S. technological competitiveness will be severe. And if China is able to make the world dependent on it for any type of semiconductor manufacturing or tooling, it will gain the ability to disrupt supply chains and potentially hold the global technology industry hostage.

The best way to prevent these outcomes from occurring is by restricting exports of the key inputs into China's semiconductor ecosystem that we control: SME and its subcomponents. SME is the foundation of the entire advanced technology stack, and controls on SME are therefore the foundation of all U.S. technology protection efforts. The U.S. ability to regulate exports of advanced semiconductors to China, to include cutting-edge AI chips, is contingent on China not being able to make those chips itself.

If U.S. efforts to control SME are successful at constraining China's advanced chipmaking capabilities, the United States will retain control over all advanced technology supply chains upstream from SME: advanced chips, AI data centers, AI models, quantum computers, advanced robotics, and other emerging areas. If U.S. efforts to control SME fail, China will be able to produce all the advanced chips it needs itself, and the United States will have squandered its single biggest advantage in the technology competition with China. It is imperative that we get this right. Given the stakes, our risk tolerance for failure should be very low.

SME is also uniquely suited to stringent technology controls because: (1) it is a highly concentrated industry in which the United States retains a dominant position and China lags far behind, and (2) SME tools are extremely technically complex and uniquely difficult for China to indigenize. These factors are explained in greater detail below.

Overview of the Global SME Industry

The United States and our allies dominate the industry for SME, particularly advanced SME. Five companies hold 80-85% of the global SME market: Applied Materials, KLA, and Lam Research in the

[2] The White House, *America's AI Action Plan*, July 2025, 21, https://www.whitehouse.gov/wp-content/uploads/2025/07/Americas-AI-Action-Plan.pdf.

United States, ASML in the Netherlands, and Tokyo Electron in Japan.[3] These firms have an even more dominant market position in the most advanced tools, including a 100% market share in all metrology and inspection tools, and in all advanced tools for lithography, etch, deposition, and photomask production. Crucially, advanced tools sold by ASML and Tokyo Electron each rely on extremely sophisticated subcomponents and other equipment that are only made by U.S. firms.

The dominant role of U.S. technology in the SME industry is how the United States continues to exert influence over the global semiconductor supply chain. While the United States made the strategic mistake of outsourcing semiconductor manufacturing early this century, its role in the SME industry that underpins manufacturing remains strong. The fact that it is impossible to make chips without U.S. technology is reflective of the fact that the United States is still an irreplaceable element of the semiconductor supply chain, even while it seeks to reshore manufacturing itself.

By contrast, China's SME industry significantly lags industry leaders, although China is seeking to move up the value chain as fast as possible. As of 2023, Chinese SME had a 3.2% global market share and a 14% domestic market share – still small, although its market share had more than doubled since 2020. If China attempted to build a fab with only indigenous equipment, it likely could only produce a chip at the 90nm node – which was first commercialized in 2004, and is nine generations behind the leading-edge.[4] ASML's CEO stated that China will not be able to indigenously produce technology at the level of ASML's most advanced machines for 10-15 years.[5] Until then, China will remain extremely reliant on U.S. and allied SME to build its semiconductor industry, and on U.S. and allied components to build its SME industry.

Overview of the Technological Complexity of Advanced SME

The unprecedented technological complexity of the most advanced SME tools makes them uniquely difficult for China to indigenize. China has proven extremely capable at reverse-engineering and scaling technology – but its SME supply chain remains farther behind those of industry leaders than in virtually any other technology area. The reason for this is simple: these are the most complicated machines humans have ever made, the culmination of seventy-five years of cutting-edge engineering and physics and trillions of dollars in investment, and are literally the hardest thing in the world for China to copy and scale.

To give an idea of the immense technical complexity of the most advanced SME tools, it is helpful to explain some of the details of how they work.

An extreme ultraviolet lithography (EUV) scanner, which is made only by ASML and is used to etch the precise circuit pattern of each chip on to silicon wafers, is basically a controlled lightning storm built

[3] U.S. Congress, House, Select Committee on the Strategic Competition Between the United States and the Chinese Communist Party, *Selling the Forges of the Future*, 119th Cong., 1st sess., 2025, 9, https://selectcommitteeontheccp.house.gov/sites/evo-subsites/selectcommitteeontheccp.house.gov/files/evo-media-document/selling-the-forges-of-the-future.pdf.
[4] Wency Chen, "Meet AMIES, China's New Hope in Breaking Reliance on ASML's Chipmaking Machines," *South China Morning Post*, October 19, 2025, https://www.scmp.com/tech/tech-war/article/3329508/meet-amies-chinas-new-hope-breaking-reliance-asmls-chipmaking-machines.
[5] Ryan Whitwam, "ASML CEO Claims China's Semiconductor Industry is 10 to 15 Years Behind," *Yahoo! Tech*, December 30, 2024, https://tech.yahoo.com/science/articles/asml-ceo-claims-chinas-semiconductor-120000409.html.

inside a vacuum chamber the size of a bus. It fires a high-energy laser 50,000 times per second at tiny molten droplets of tin, each of which is one fourth the width of a human hair and is falling in a vacuum emptier than that found in low-earth orbit—vaporizing them into a micro-plasma that emits extreme-ultraviolet light. That light then bounces off a series of mirrors that must be polished so perfectly that if scaled up to the size of Earth, their largest imperfection would be less than two centimeters tall. The light is imprinted on to silicon wafers accelerating faster than a jet fighter during takeoff, at levels of precision that vary by the width of two to three atoms. Each machine contains over 100,000 parts, costs hundreds of millions of dollars, and requires three Boeing 747s to ship. It is, by a wide margin, the most complex machine that humans have ever put into serial production.

But deep-ultraviolet lithography (DUV) machines—the second most advanced type of lithography machine, and the workhorses that pattern most layers of every modern chip—are almost equally extraordinary. Instead of creating plasma from tin droplets, they generate intensely pure ultraviolet light inside giant, high-pressure chambers and guide it through a maze of lenses grown from exotic crystals found almost nowhere else on Earth. These lenses must be manufactured so flawlessly that a defect the size of a bacterium would destroy the image. The DUV system must fire light pulses so precisely that their timing cannot deviate by more than a few trillionths of a second—even as the machine is whipping the silicon wafer and the patterning plate beneath the optics at speeds and accelerations that would tear apart almost any other mechanical system, while still keeping their alignment within a few nanometers of the necessary position.

And lithography is only one corner of the semiconductor universe; the other tools are no less astonishing. The most advanced plasma-etch machines carve three-dimensional structures into silicon using ionized gases hotter than the surface of the Sun—yet must stop at exactly the right atomic layer, across billions of features, without ever cutting too deep. The deposition tools that build up thin films do so literally one atomic layer at a time, requiring chemistry so perfect that adding or missing a single layer can ruin an entire production run. Ion-implantation systems accelerate beams of ions to a significant fraction of the speed of light and then fire them into silicon with the precision of a sharpshooter—dosing each region with exactly the right number of atoms, neither one too many nor one too few, while using magnetic and electrostatic fields worthy of a particle accelerator to steer charged particles to their intended destination.

Even the tools that measure or clean wafers are feats of engineering that border on science fiction. State-of-the-art metrology systems use electron beams, X-rays, and interferometers to inspect structures far smaller than a virus, resolving variations on the scale of atomic orbitals while compensating for vibration, temperature drift, and even subtle gravitational effects from nearby equipment. Advanced cleaning systems must remove contamination measured in individual molecules without scratching or disturbing the delicate, freshly patterned features—using precisely tuned chemical baths, megasonic waves, and fluid-control systems so refined that a ripple or bubble in the wrong place would ruin the production run.

Across lithography, etch, deposition, ion implantation, metrology, and cleaning, every machine in a modern chip fab operates at the edge of what physics allows—stabilizing plasmas, lasers, optics, chemicals, particle beams, and motion systems all at once. The subsystems inside these tools are equally extraordinary: each one is a tightly engineered module—vacuum pumps, RF generators, gas- and chemical-delivery units, multi-layer optics, precision stages—that pushes the limits of materials, control electronics, and manufacturing.

Taken together, SME and the critical subsystems that feed and support it form one of the most complex, precise, and demanding industrial ecosystems ever built. This is why China has struggled to achieve the same success at indigenizing and scaling production of SME, as it has in other high-tech industries such as solar panels and batteries. It is a uniquely difficult nut for China to crack.

Review of Existing U.S. and Allied Controls on SME

The Trump administration was the first to utilize export controls on SME to slow down China's advanced chipmaking industry. In 2018 it placed the Chinese fab Fujian Jinhua on the Entity List, making it the first Chinese semiconductor manufacturer restricted from purchasing U.S. SME. In 2019 it convinced the Dutch government not to export EUV lithography machines to any entity in China, thereby cutting off all Chinese fabs from the most advanced chipmaking tool. And in 2020 it placed SMIC, China's semiconductor manufacturing national champion, on the Entity List, restricting its access to U.S. equipment. These actions had a significant effect; Fujian Jinhua nearly went out of business, China still cannot make 5nm or more advanced chips without EUV machines, and SMIC's capability buildout and technology level is degraded relative to if it had unrestricted access to SME.

The Biden administration witnessed the impact of the Trump administration's controls on SME, and concluded that expanding SME controls on China was critical to securing long-term U.S. technological advantage. In September 2022, National Security Advisor Jake Sullivan declared that the past approach whereby the United States applied export controls only to the latest technologies to stay "a couple of generations ahead" of China was insufficient. Rather, he stated that given the foundational nature of advanced logic and memory chips to U.S. technological supremacy, particularly in AI, "we must maintain as large of a lead as possible" over China in chipmaking capabilities.[6]

In October 2022, the Biden administration broadened export controls on SME significantly, and further strengthened these controls in 2023 and 2024. The Biden administration's goal was to deny and degrade China's ability to make any advanced chips, which U.S. export control regulations define as logic chips 14nm/16nm or more advanced, DRAM memory chips 18nm half-pitch or more advanced, and NAND memory chips with 144 or more layers.

The Biden administration could have pursued a broad ban on exports of any SME to China that contain any U.S. technology—which would have effectively banned the export of all SME produced anywhere in the world. However, it opted instead to take a relatively targeted, but multi-layered, approach, in conjunction with allies and partners.

To accomplish this, the United States imposed the following controls on exports of SME to China:

- U.S. Country-Wide Controls on SME Exports: Commerce blocked U.S. exports country-wide to China of a set of tools that are necessary for advanced chip production (in addition to EUV lithography

[6] Jake Sullivan, *Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit*, White House Archives, transcript, https://bidenwhitehouse.archives.gov/briefing-room/speeches-remarks/2022/09/16/remarks-by-national-security-advisor-jake-sullivan-at-the-special-competitive-studies-project-global-emerging-technologies-summit/.

tools), as well as any sophisticated components that are specially designed for those tools.

- U.S. Additional Controls on Advanced Chinese Fabs: Commerce blocked all shipments of any U.S. tools (including non-advanced tools) to any advanced Chinese fabrication facility, and added sixteen Chinese fabs determined to engage in advanced production to the Entity List.

- U.S. Restrictions on Servicing: Commerce restricted U.S. persons from servicing any equipment at an advanced chipmaking facility in China, which caused all U.S. companies to halt all on-site and virtual maintenance support at those fabs.

- U.S. Restrictions on Exports of Components: Commerce added the vast majority of Chinese SME companies to the Entity List, blocking exports of subcomponents to most of the major Chinese suppliers.

The Biden administration also secured agreement from key allies, namely Japan and the Netherlands, to impose export controls on SME to China. This was critically important, as without allied agreement or U.S. extraterritorial controls on allied equipment, SME firms from allied countries could have backfilled many of the U.S. restrictions.

Allies did impose substantial new controls on SME exports, although these measures were not as comprehensive as U.S. controls. Current allied controls, and their key gaps relative to U.S. controls, are outlined below:

- Allied Country-Wide Controls on SME Exports: Allied country-wide controls on SME are aligned with U.S. controls. However, U.S. and allied controls contain critical gaps, as they permit continued shipment of some tools necessary for advanced production to China—namely certain DUV lithography machines, which are only made by Dutch and Japanese companies and without which China could not make advanced chips.

- Allied Additional Controls on Advanced Chinese Fabs: Allies restrict certain advanced tools to advanced Chinese fabs (in addition to the tools that they restrict country-wide), but do not restrict the export of all non-advanced tools to these facilities like the United States does.

- Allied Restrictions on Servicing: Allies largely do not restrict servicing of controlled tools or tools at advanced Chinese fabs. Allied firms continue to maintain an on-site presence at advanced Chinese fabs (including at SMIC and Huawei facilities), which helps China maintain and upgrade their chipmaking capabilities. Without ASML servicing, China likely could not continue to operate its DUV lithography machines.

- Allied Restrictions on Exports of Components: Allies have not restricted exports to Chinese SME companies. There are no restrictions on exports of allied components to China (other than components specially designed for tools that are controlled country-wide).

The differences between U.S. and allied controls have had three significant negative effects:

First, the most advanced Chinese fabs—to include SMIC South, which is China's most advanced fab and houses China's largest 7nm production line—have continued to benefit from allied tool exports and maintenance, despite being completely cut off from all U.S. technology. This has helped these fabs continue to operate, expand their capacity, and improve yields.

Second, allied firms have backfilled U.S. controls at several advanced facilities, allowing allies to profit and gain market share in China to the detriment of U.S. firms. A recent congressional investigation found that from 2022-2024, ASML and TEL revenue from Chinese entities that U.S. firms were restricted from selling to more than tripled—even while their overall revenue from China grew by only 50%.[7]

And third, Chinese SME companies have continued to purchase subcomponents from allied companies, significantly blunting the impact of U.S. export controls on the Chinese toolmakers. Japan and the United States are the two largest suppliers of subcomponent systems, and tools are often designed to be able to incorporate competing subcomponents from multiple vendors. The fact that Japanese and other allied vendors are largely unrestricted is a significant loophole.

Current Extraterritorial U.S. Controls

In 2024, the United States extended its controls extraterritorially by utilizing the foreign-produced direct product rule (FDPR). The Biden Administration decided to implement this extraterritorial restriction when it became aware that U.S. and allied firms were exploiting a critical loophole in U.S. controls, which permitted overseas subsidiaries of U.S. and allied firms to sell certain equipment to certain Chinese fabs on the Entity List without a license, despite the fact that their parent company was restricted from exporting any tools to these fabs. Strengthened extraterritorial measures were needed to fill this gap.

The new extraterritorial controls expanded the existing U.S. country-wide controls on advanced equipment, and existing controls on all tool exports to advanced Chinese fabs, to also capture certain foreign tools. Specifically, the extraterritorial controls stipulated that any controlled tool, or any export to an advanced Chinese fab, was captured if the export was a foreign-produced product that either: (a) contains any U.S. content, or (b) contains any item that is the direct product of U.S. technology or equipment (*i.e.*, if it contains a semiconductor made with U.S. tooling). The control includes a carve-out that exempts foreign-produced items from thirty-three allied countries, including the Netherlands and Japan.[8]

This is an extremely broad control that captures every foreign tool in all impacted countries. It is nearly impossible for a foreign firm to design around, as every tool contains an advanced chip and it is impossible to make an advanced chip without U.S. technology. To create a tool that would not be captured by the control, one would have to design out U.S. technology from the entire semiconductor supply chain—which is effectively impossible, and which no country other than China seeks to accomplish.

[7] U.S. Congress, House, Select Committee on the Strategic Competition, *Selling the Forges of the Future*, 22.
[8] U.S. Department of Commerce, Bureau of Industry and Security, *Supplement No. 4 to Part 742*, Title 15, https://www.ecfr.gov/current/title-15/subtitle-B/chapter-VII/subchapter-C/part-742/appendix-Supplement%20No.%204%20to%20Part%20742.

There are indications that this extraterritorial control has been effective. U.S. toolmakers slowed their sales to restricted Chinese fabs in the three months after it was imposed in December 2024.[9] This also indicates that extraterritorial controls applied more broadly would be feasible to implement and effective.

The Biden administration decided not to apply this broad extraterritorial control to allied countries, including the Netherlands and Japan, as it continued to urge them to strengthen their own controls to match U.S. restrictions. However, significant gaps remain between U.S. and allied controls, even after many years of negotiations. Ultimately, extraterritorial controls on allied equipment may be necessary to close these gaps.

Evaluating the Efficacy of U.S. Export Controls on SME

U.S. export controls on SME to China have proven to be the single biggest constraint on the advancement of China's chipmaking capabilities, and have materially widened the gap between China's leading chipmakers and the industry leaders. However, the controls also have significant flaws and gaps, and must be strengthened to be maximally effective.

U.S. export controls on SME have had the following positive impacts:

- The U.S. and allied lead over China in chip fabrication has widened: As recently as 2019, China's advanced logic fabrication capabilities were only two generations behind those of the industry-leading firms (Intel, Samsung, and TSMC).[10] However, that lead has since expanded to three generations, and the node at which China is not capacity constrained is five generations behind the leading-edge. This lead could expand further if China's progress continues to stall.

- China's chipmaking capabilities have stalled in sophistication: China still is not able to produce a logic chip better than 7nm at scale. It is not clear if China will be able to produce 5nm or more advanced chips without access to certain advanced chipmaking tools, particularly ASML's EUV tools and advanced U.S. etching and deposition equipment—and if it does, the yields will likely be very low, limiting the number of chips they will be able to produce.

- The gap between the best Chinese and U.S. AI chips is large and rapidly widening: China's best AI chips are currently 20% as powerful as the best U.S. AI chips in terms of processing power. This gap is also slated to widen significantly in the coming years, as China will likely remain reliant on the 7nm node while the most advanced U.S. chips use increasingly advanced production processes: according to Huawei and Nvidia's public chip production roadmaps, by the end of 2027 Huawei's best AI chips is slated to be only 4% as powerful as Nvidia's best AI chip.[11]

[9] U.S. Congress, House, Select Committee on the Strategic Competition, *Selling the Forges of the Future*, 25.
[10] Joel Hruska, "Chinese Foundry SMIC Begins 14nm Production," *ExtremeTech*, August 19, 2019, https://www.extremetech.com/defense/296802-chinese-foundry-smic-begins-14nm-production.
[11] Timothy Prickett Morgan, "Nvidia Draws GPU System Roadmap Out To 2028," *Next Platform*, March 19, 2025, https://www.nextplatform.com/2025/03/19/nvidia-draws-gpu-system-roadmap-out-to-2028/; Emiko Matsui, "Huawei Reveals 3-Year Ascend AI Chip Roadmap, 950 Coming In 2026," *Huawei Central Newsroom*, September 18, 2025, https://www.huaweicentral.com/huawei-reveals-3-year-ascend-ai-chip-roadmap-950-coming-in-2026/.

However, China has exploited the significant loopholes in U.S. controls in ways that pose significant risks to U.S. national security:

- China has become by far the largest purchaser of U.S. and allied tools: In 2024, the three leading U.S. toolmakers sold over $20 billion worth of semiconductor tools to China, ASML's China sales were over $11.5 billion, and TEL's were over $5.5 billion. Exports of SME was the number one or two export from each country to China, and every major equipment maker now derives approximately 40% of its revenue from tool sales to China.[12] These tools are being used to help fuel China's expansion of its advanced and legacy chip production capabilities.

- Some of the largest Chinese tool customers are sanctioned entities: A recent report by the Select Committee on Strategic Competition between the United States and the Chinese Communist Party (CCP) discovered that five Chinese fabs that are currently subject to comprehensive U.S. export controls (SMIC Beijing, SwaySure, PST, SiEn, and YMTC) were among the top thirty customers of every major U.S., Dutch, and Japanese toolmaker from 2022-2024.[13]

- China is stockpiling enormous numbers of DUV lithography machines: China has massively surged orders of ASML's DUV lithography machines, without which it could not produce advanced chips and which remain permitted to export under Dutch restrictions. In 2024 it purchased 90 such machines, representing 70% of ASML's DUV immersion lithography machines globally. This is up from 15-20 such machines per year in 2021 and 2022.[14] These machines are again almost certainly going primarily to China's national champions, and will form the core of China's AI chip production capabilities.

- China is using these tools to expand its advanced chip production quantity. China is likely producing some 7nm AI chips domestically, and the number they can make will almost certainly expand in the coming years. Absent strengthened controls that slow its growth and degrade its existing 7nm capabilities, China will be able to manufacture greater numbers of AI chips—and while China will remain compute-constrained due to U.S. export controls on AI chips, this will provide China with the ability to train and operate advanced AI models that it otherwise could not.

- China is also using these tools to dominate the mature chip market. China is rapidly becoming the world leader in mature chip production (defined as chips at 28nm or less advanced nodes), as it seeks to dominate the mature chip market in the same way it dominated the market for other commodity technological goods such as solar panels and batteries. In 2023 China produced 34% of the mature chips, but by 2027 this is projected to surge to 47%, overtaking Taiwan as the world leader. In contrast, the United States produces 4% of mature chips.[15] Almost 60% of all mature chip fabs globally that started production between 2023 and 2025 were located in China.[16] The

[12] U.S. Congress, House, Select Committee on the Strategic Competition, *Selling the Forges of the Future*, 16.
[13] Ibid, p. 22
[14] Ibid, p. 29-30
[15] Sunny Cheung, "Encircling the West: The PRC Gains Ground in Legacy Chips," *China Brief* 25, no. 10 (May 2025), https://jamestown.org/encircling-the-west-the-prc-gains-ground-in-legacy-chips/.
[16] Wen-Yee Lee, "Taiwan's Legacy Chip Industry Contemplates Future as China Eats Into Share," *Reuters*, February 10, 2025, https://www.reuters.com/technology/taiwans-legacy-chip-industry-contemplates-future-china-eats-into-share-2025-02-10/.

only way to stall the growth of China's mature chip production capabilities is to restrict its access to the SME it needs to build mature chip fabs.

Recommendations to Close Loopholes in U.S. Export Controls on SME

The United States should take the following steps to close the most significant loopholes in U.S. export controls on semiconductor manufacturing equipment:

1. **Expand the number of tools controlled country-wide to China:** The most effective way to close loopholes in export controls is to expand the set of country-wide controls on China to capture all tools capable of advanced production. Country-wide controls are relatively easy to implement and create far fewer opportunities for diversion inside China than entity-based controls. The report of the Select Committee on Strategic Competition between the United States and the CCP recently recommended two specific ways to strengthen U.S. controls on SME, which the Department of Commerce should implement with a licensing policy of denial:

    a. Control all SME capable of 300mm wafer processing: The Department of Commerce should expand its country-wide export controls on SME to capture all equipment capable of being used to produce advanced chips, defined as all tools capable of processing 300mm wafers. Advanced chip production exclusively uses 300mm wafers, so this control would ensure no equipment capable of advanced production could be exported to China. 300mm tools are also widely used in most fabs capable of 90nm production or below, which roughly correlates with China's indigenous SME capabilities (the 90nm node debuted over twenty years ago). This action would therefore halt the growth of China's advanced chip production capabilities, and would also substantially slow the growth of its mature chip production capabilities, addressing risks about pending Chinese domination of the mature chip market.

    b. Control all node-agnostic SME already identified as chokepoints: The Department of Commerce has already identified a set of tools that are capable of being used for advanced or mature production but are chokepoints for China, which includes all DUV lithography tools. These tools are currently only controlled to certain Chinese fabs, but should be restricted country-wide to China. These tools are identified in Export Control Classification Numbers (ECCNs) 3B993 and 3B994 of the Export Administration Regulations (EAR).

2. **Add all parent companies and subsidiaries of China's chipmaking and SME national champions to the Entity List, with a licensing policy of denial:** Commerce should add to the Entity List all Chinese fabs known to have an affiliation with China's chipmaking national champions—SMIC, YMTC, CXMT, and Huawei—as well as any other entities of concern, and should apply the strictest possible licensing policy to them. Commerce should also ensure that all Chinese SME companies, and all of their affiliates, are included on the Entity List.

    Of the four largest chip fabrication companies in China, three (SMIC, YMTC, and Huawei) are on the Entity List, and one (CXMT) is not. However, even for those companies included on the Entity List, many fabs that are subsidiaries or have a clear affiliation with the parent company remain unlisted.

Additionally, some subsidiaries of these companies that are on the Entity List have more permissive licensing policies than their parent company (namely SMIC Suzhou, SMIC Holdings Limited, SMIC Hong Kong, SMIC Tianjin, and YMTC subsidiary XMC), which allows them to continue to receive equipment. Imposing comprehensive controls on these fabs would substantially degrade their ability to continue their operations, or to facilitate diversion of SME or subcomponents to other fabs within China. Appendix A includes several examples of Chinese fabs that are affiliated with SMIC, YMTC, CXMT, or Huawei, or that otherwise warrant an Entity List designation, but that are not currently listed.

3. **Apply the FDPR to all SME controls, suspend existing exemptions for Allies but exempt Allies that match U.S. controls:** Commerce should modify the two existing FDPRs that apply to all exports of tools that are restricted country-wide (called the "SME FDPR") and to Chinese advanced fabs (called the "Footnote 5 FDPR"), to suspend the current exemptions for thirty-three allied countries. These controls would therefore apply globally. Commerce should inform allies that once any country imposes controls that are fully equivalent to those of the United States, Commerce will modify U.S. regulations to exempt them from the control.

   This is the same general approach that the United States took to building the allied export control coalition against Russia in 2022. This will ensure that allies fully match U.S. controls before U.S. controls are removed, thereby ensuring there are no gaps between U.S. and allied controls. If allies cannot or will not match U.S. controls, the control could be modified to cover any activities captured by allied controls – thereby filling in gaps between U.S. and allied controls. Commerce should also apply the Footnote 5 FDPR to all Chinese SME companies, which would block them from receiving allied components and ensure a level playing field for U.S. component companies.

4. **Restrict Allied Servicing of Controlled SME in China:** Commerce should implement restrictions on servicing of controlled SME by foreign persons in China, matching existing U.S. restrictions on servicing by U.S. persons. To accomplish this, the Department of Commerce's Bureau of Industry and Security (BIS) should issue guidance emphasizing that General Prohibition 10 applies to advanced fabs in China. Specifically, the guidance should conclude that any advanced fab in China (identified as a fab on the Entity List and subject to FDPR Footnote 5) has likely acquired SME and related components in violation of export controls, and/or are likely to produce chips in violation of export controls. BIS is therefore permitted, pursuant to General Prohibition 10, to impose a license requirement for any firm to "service" or "use" any SME or components installed in these fabs. Any allies that impose equivalent restrictions could also be exempted from this provision.

   Restrictions on servicing would likely cause China's existing advanced chip production capability to degrade. Without these restrictions, China may be able to maintain its existing 7nm production capabilities for the foreseeable future.

5. **Restrict use of Chinese SME globally:** Commerce should issue a rule pursuant to Executive Order 13873 ("Securing the Information and Communications Technology Supply Chain") that prohibits the sale of any Chinese SME in the United States. Commerce should also stipulate that no fab globally that uses U.S. SME is permitted to also use Chinese SME – effectively forcing companies to choose between using U.S. or Chinese tooling.

There are currently no restrictions on the use of Chinese SME in the United States, or elsewhere in the world. Chinese SME poses unacceptable cybersecurity risks if used in a U.S. or allied fab, as it could be manipulated to disrupt or degrade production. Furthermore, U.S. and allied companies should not provide any technological or financial support to the Chinese SME industry, given its strategic importance.

6. **Resource BIS enforcement capabilities:** Congress should increase appropriations for BIS enforcement capabilities related to semiconductors and semiconductor manufacturing equipment. Both the Biden and Trump administrations have sought increased resources for BIS to support these capabilities, which are essential to U.S. technology protection efforts. BIS needs top-tier technical and policy talent, flexible hiring authorities, access to advanced analytical capabilities, and more widespread deployment of classified systems to be able to effectively implement U.S. export controls on dual-use technologies.

Note that many of these recommendations were also included in the Select Committee on the Strategic Competition Between the United States and the CCP's comprehensive and bipartisan report issued in October 2025. That report should be read in full, and I fully endorse all of its recommendations.

Appendix A: Examples of Chinese Semiconductor Companies Not on U.S. Entity List

This table lists Chinese semiconductor companies that are not on the U.S. Entity List, but that currently pose a concern due to their close ties to entities already designated on the U.S. Entity List, or their involvement in activities that circumvent existing export controls.

Company/Sites	Problem with Lack of Entity List Designation
Huawei: subsidiaries and affiliated fabs (e.g., Jing Peng Hi-Tech, Dongguan Guangmao, Wuhan CXT, among others)	These facilities operate under the umbrella of a designated entity (Huawei), and are often physically located across the street from existing Entity Listed fabs, including Peng Chip and Swaysure. These fabs allow Huawei to continue advancing its semiconductor production capabilities outside direct sanctions.
SMIC: subsidiaries and affiliated fabs (e.g., new fabs in Beijing (Jingcheng), Shanghai (Lingang), Tianjin (Xiqing), among others)	These sites are publicly characterized as 28nm development, but evidence suggests they are actively pushing technology and production well below the 28nm threshold. SMIC subsidiaries and affiliates not listed on the Entity List also pose a significant risk of diversion to restricted SMIC entities.
CXMT: parent company, and subsidiaries and affiliated fabs (Key fab sites in Hefei, Beijing, and Shanghai)	While CXMT is subject to the U.S. Persons Rule, the lack of a specific Entity List designation for the fab sites makes enforcement of export controls on equipment and technical support significantly more challenging.
YMTC: affiliated cutouts and subsidiaries	YMTC's network of subsidiaries is designed to aid the parent company in acquiring restricted equipment and technology, effectively bypassing controls aimed at the parent.
GTX Semiconductor	A known "cut out" company explicitly created to bypass restrictions placed on its parent organization (ICRD, which is on the Entity List). GTX's lack of a designation enables firms to provide continuing support to the restricted entity, and potentially enable advanced capabilities at GTX itself.
Huali Semiconductor: parent company, and subsidiaries and affiliated fabs (e.g., fabs in Shanghai, Chengdu, among others)	Huali is developing advanced node 7nm FinFET, which would represent a significant capability leap that would likely cause violations of U.S. export controls.