

CASH OVER COUNTRY

**How Three American Semiconductor
Manufacturing Equipment Companies
Support China's Flourishing Legacy
Semiconductor Industry at the
Cost of American National
and Economic Security**

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EXECUTIVE SUMMARY

On October 7, 2022, the Biden Administration imposed a series of export controls targeting China's advanced chip sector. Unfortunately, the U.S. government has done nothing to restrict the rise of China's legacy chip businesses. As China Tech Threat recounted in its comprehensive [paper](#) *Every Chip Matters* released last April, Chinese semiconductor companies are positioning themselves to dominate the legacy chip market.¹ An American dependence on Chinese legacy chips would be destructive to our national security and economic interests.

Unfortunately, American semiconductor equipment manufacturers (SEMs) have succeeded in lobbying the U.S. government to permit them to sell some of the world's most complex technology to Chinese government-aligned firms making legacy chips. As can be documented from public data, American SEMs Applied Materials, KLA, and Lam Research have grown their combined revenues from China by 103% between 2018 and 2022.² Statements from these companies on recent earnings calls indicate that they intend to continue profiting from China.

Instead of capitulating to industry voices, the U.S. government should promote American security, economy, and integrity. Specifically, the U.S. government should broaden export controls to cut off Chinese chipmakers' access to coveted Western technologies before China can achieve global market dominance in legacy chips, just as China has done in other vital industries such as LED screens and solar panels. Additionally, as part of an overall revitalization of the U.S. manufacturing base to support high-tech industries, the U.S. should use funds from the CHIPS Act to promote the domestic production of legacy chips and other semiconductor-related technologies such as printed circuit boards and computers.

WHAT ARE LEGACY CHIPS, WHERE ARE THEY USED, AND WHY ARE THEY IMPORTANT?

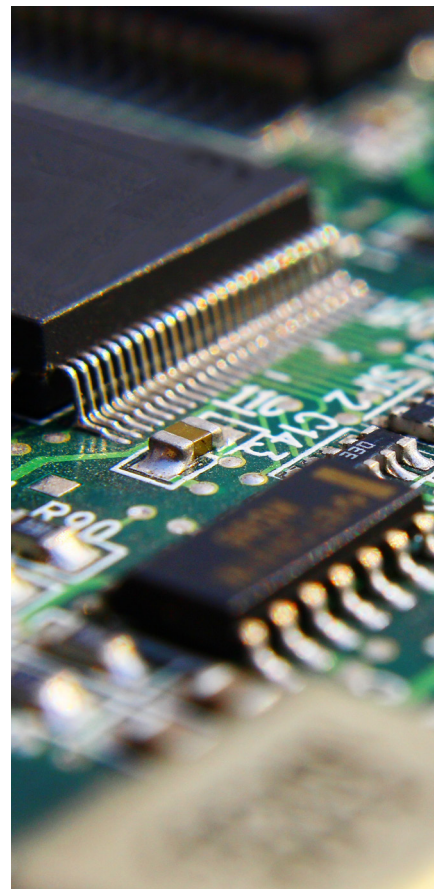
Legacy chips are sometimes defined as those with transistors that are equal to or greater than 28 nanometers (nm) wide, or sometimes as low as 14nm. The terms “legacy chips” or “mature chips” are often used to suggest that chips designed before 2016 are somehow a less important technology than the most cutting-edge chips. To the contrary, legacy chips are used in millions of devices, including virtually all automobiles, home appliances, consumer electronics, as well as most military equipment. As a report from the Center for Strategic and International Studies (CSIS) confirms, they are by no means obsolete, but instead are the “workhorses” of the semiconductor industry, accounting for a majority of the industry’s \$600 billion in annual revenue.³ Mainstream or legacy chips (or “nodes”) are everywhere, and demand continues to grow as more and more devices add intelligent features and internet connectivity.

A good example of the military capabilities of legacy chips is given by Israel’s Iron Dome, one of the most impressive defense systems of modern times. Introduced in 2008, the Iron Dome proved its intelligent defensive capabilities during a 2012 attack from Hamas, which fired 1,500 rockets at Israeli territory. Using radar and rockets powered by Israeli-designed semiconductors, the Iron Dome successfully intercepted 84% of the Hamas rockets, blowing them up in midair.⁴ All the chips inside the 2012 Iron Dome were what we would today term “legacy chips.” The design of the Iron Dome is of course confidential, but many of the chips inside the system are likely still “legacy,” because even ten-year-old chips can provide the computation speeds necessary to track and intercept enemy rockets.

CHINA RACING TO GRAB LEGACY CHIP MARKET SHARE

China is highly focused on developing the capability to mass produce legacy chips at line widths ranging from 28nm up to 90nm. Recently, Chinese chip equipment maker Shanghai Micro Electronics Equipment group (SMEE) announced that its first scanner capable of producing 28nm line width chips will be available by the end of 2023.⁵ China accounted for some 15% of global chip manufacturing in 2020 and is projected to grow that share by to 40% by 2030.⁶ Today, much of that chip production is conducted in fabs owned by Western companies. China is determined to transfer that production to Chinese-owned companies, which in almost every case have significant Chinese government shareholdings, heavy government control, and Chinese Communist Party (CCP) officials in senior positions on company boards.

China has invested over \$100 billion in building a Chinese semiconductor industry, with Yangtze Memory Technologies Company (YMTC), Semiconductor Manufacturing International Corporation (SMIC), and Hua Hong Semiconductor as some of their significant successes so far. Additionally, companies such as ChangXin Memory Technologies (CXMT) are on the rise. As in other globally important industries, China’s strategy is to build capability at the lower end of the industry first, drive down prices to force Western companies out of business, and grab a large and dominant share of the world market. The profits from the lower-end business will pay for the investment as well as the research and development necessary to penetrate the advanced market. As the U.S. technology industry knows from 20 years’ experience, a significant part of Chinese “research and development” is actually intellectual property theft from Western companies.



According to the Rhodium Group, a research firm, "In the next 3-5 years China is due to add nearly as much new 50-180nm wafer capacity as the entire rest of the world." The U.S.'s October 2022 controls, says Rhodium "should not obscure the fact that China is building significant capacity in semiconductor markets that rely on mature process nodes."⁷ State-funded legacy chipmaker SMIC, which supplies the Chinese military and Huawei, is constructing four new factories.⁸ SMIC's growth is all the more notable because the company was put on the Entity List in 2020, but the restrictions focused on advanced chips over legacy nodes. "I certainly think that big Chinese chip makers will be able to survive building legacy chips and there's a very healthy market for legacy, older model chips," said Paul Scharre at the Center for a New American Security.⁹

WALL STREET: CHINESE LEGACY CHIP SECTOR POISED FOR GROWTH

"Huge explosion in demand coming from China lagging edge... they're pouring all their money into lagging edge."¹⁰

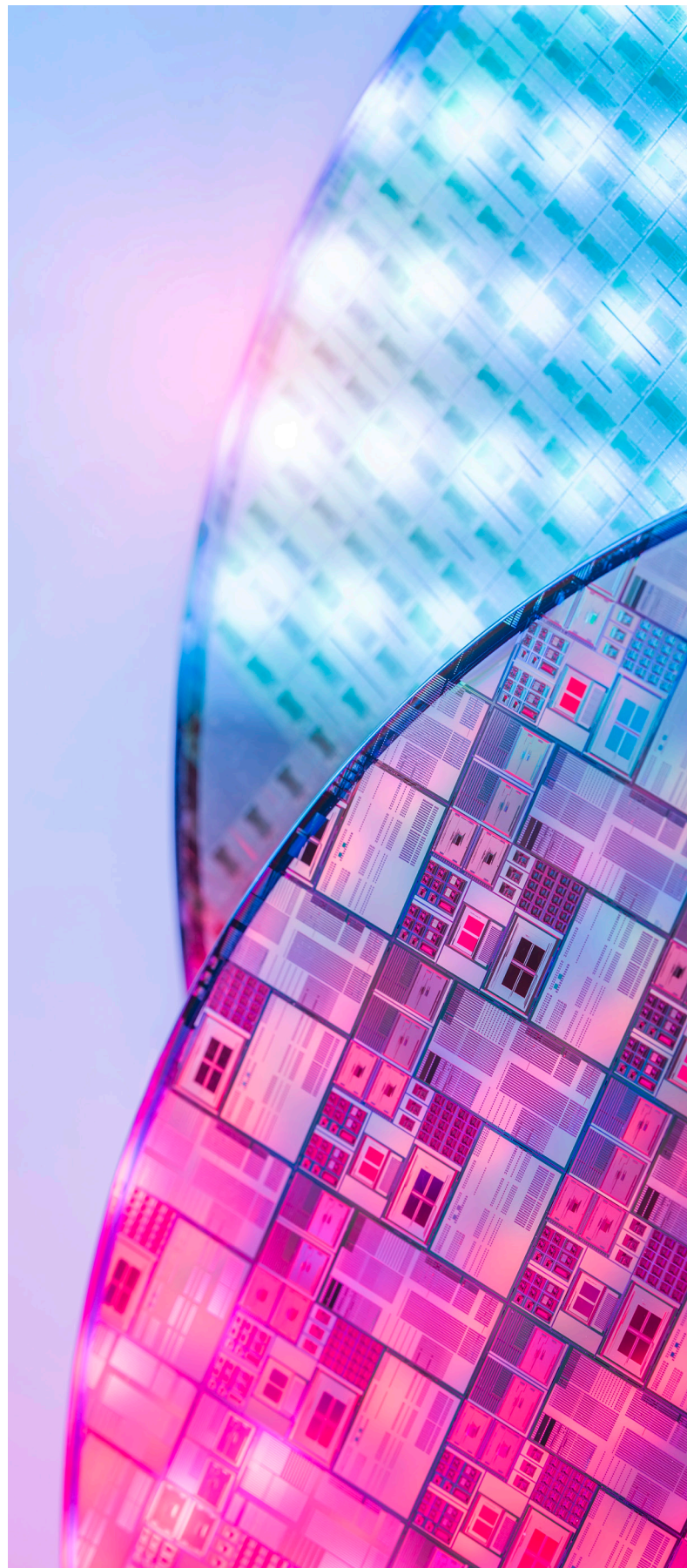
– UBS' Timothy Arcuri

"There are 20, 30 emerging new [PRC chip] players" in early-stage investment.¹¹

– Evercore ISI's Christopher Muse

"China is showing good progress in making chips based on mature technology."¹²

– Needham & Company's Charles Shi



WHY SHOULD THE U.S. NOT DEPEND ON CHINA FOR ACCESS TO LEGACY CHIPS?

Dependence on Chinese Legacy Chips Threatens American Military Superiority

“A single compromised chip in the right place can provide our adversaries with unfettered access to critical platforms.”¹³

– former National Security Advisor Robert O'Brien

Legacy chips play vital roles in virtually every modern military system, including fighter jets, ships, land-based vehicles, handheld missile launchers, radar systems, and other tools. The U.S. should endeavor to avoid dependence on China for these chips. Chinese dominance in any sector of the legacy chip market will force the U.S. to face very uncomfortable choices between government funding of U.S. chipmakers on a much larger scale than last year's CHIPS Act, or accepting China as a source for vital components. A reliance on China for chips for our military could have catastrophic implications for weapons stocks, information security, and protection against sabotage and espionage.

Unfortunately, in their drive to cut costs, top tier American defense contractors have already turned to Chinese suppliers for vital components. A 2020 study done by supply chain intelligence firm Govini concluded, “From 2010–2019, the number of Chinese suppliers in the [Defense] Department's supplier base in the sample Govini assessed increased by a total of 420%, to 655, across numerous critical industries.” With regard to semiconductors specifically, the number of China-based companies participating in the Pentagon's supply chain increased 364% (65 companies).¹⁴ The U.S. defense supply chain should not be potentially compromised by Chinese inputs. Self-policing isn't working. A much higher standard of integrity and an enforcement mechanism are required.

Despite inaction, the U.S. government does have authority to compel vendors to review and report back on their supply chain vulnerabilities. CTT examined this problem in a [report](#) entitled *No Weak Links*, written with former International Trade Administration Assistant Secretary for Industry and Analysis Nazak Nikakhtar.¹⁵ There we outlined a recommended solution for ensuring clean supply chains: The U.S. government can use existing authorities under the Defense Production Act to compel vendors to audit their supply chains and report their findings to the U.S. government.

Dependence on Chinese Legacy Chips Threatens American Jobs

“The Chinese government has thrown hundreds of billions of dollars at domestic chipmakers. Because each of the American trio [Applied Materials, KLA, Lam Research] is dominant at a different step of the process, the unavoidable conclusion is that America's most advanced technology is furthering China's economic goals.”¹⁶

– *The Economist*

China has heavily subsidized many industries to gain dominance as a global supplier, beginning with steel and aluminum in the 1990s, followed by computers, networking equipment, television sets, and solar panels in more recent years. Huawei is perhaps the poster child for Chinese industrial strategy, having used a combination of government subsidies and brazen IP theft to become the world's largest supplier of networking gear for global telecom networks.

Now China is doing the same with legacy chips: In 2022, China gave out \$1.75 billion in subsidies to its chip companies, including \$282.1 million to its largest legacy chip maker, SMIC.¹⁷ This does not include the billions invested in Chinese chipmakers by Chinese venture funds, which are themselves funded largely by the Chinese government.



Chinese dominance in mainstream chip manufacturing threatens the thriving American chip design industry, centered primarily in California. Furthermore, legacy and advanced chip design and manufacturing are closely related. Proficiency in design of legacy chips leads naturally to developing design skills in more advanced chips. Right now, the momentum of the industry continues to move towards China and away from the U.S. and its allies. The U.S. has an opportunity to halt and ideally reverse that flow by ceasing all efforts to furnish the Chinese chip industry with equipment and knowledge.

Dependence on Chinese Legacy Chips Threatens American Economic Security

“If China were to capture a major share of the world's market for mature process chips, it would also gain a ‘bargaining position’: If the U.S. were to block 20 percent of advanced process products, we would reciprocate by blocking 80 percent of mature process products.”¹⁸

– Peking University Professor quoted in *Foreign Policy*

The Chinese government has already used economic coercion to advance its political interests, such as when it cut off supplies of critical minerals to Japan in 2010 and many goods from Australia in 2020. The U.S. should not depend on China for semiconductors, the lifeblood of the digital economy. In the words of Ben Noon, writing in *Foreign Policy*, “Washington would have to worry at every turn about angering Beijing to avoid a ‘surprise’ semiconductor supply crunch for tablets, automotive parts, or smartphones.”¹⁹ Additionally, American consumers should not be at the mercy of the Chinese government for its chip needs in the event of a geopolitical crisis over Taiwan or another pandemic. COVID-19 exposed the perils of such dependence. Ford Motor Company said the pandemic-related chip shortage cost them 1.3 million vehicles in lost production, and CEO Jim Farley commented in November 2022 that “one thing that keeps me up at night is legacy nodes.”²⁰

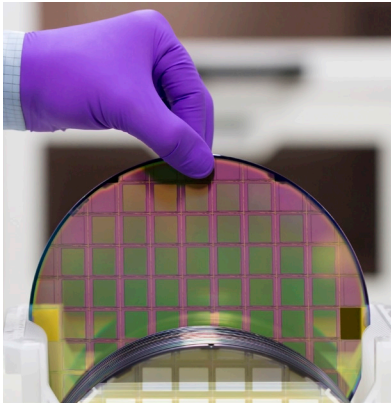
“China is, in fact, on track to become a major producer of legacy chips. If its behavior in other industry sectors is a model for its actions in legacy semiconductors, the world should expect massive overcapacity of these older chips, which would collapse the price for every other producer.”²¹

– Robert Daly and Matthew Turpin, “Mitigating the Impact of China's Nonmarket Behavior in Semiconductors”

EVIDENCE INDICATES THAT CHINESE LEGACY CHIPS ARE NOT A U.S. GOVERNMENT PRIORITY

“A world in which Chinese companies dominate the production of mature chips — driven directly by American policy — hardly looks like a victorious outcome for the United States.”²²

— *Technology analyst Dan Wang, quoted in the New York Times*



In light of the above scenarios, it would be logical to think that the U.S. government would be moving quickly to stop China from dominating the legacy market. Instead, the federal agency with the power to stop this disastrous outcome – the Department of Commerce, and specifically the Bureau of Industry and Security (BIS) – has been exclusively focused on advanced chips. In February, BIS Director Alan Estevez told Congress that legacy chips are “ubiquitous.”²³ This stance, which suggests that Estevez is not eager to confront the legacy chips problem, is all the more regrettable given Estevez’s background as focusing on technology issues at the Department of Defense. Recent comments from Secretary Raimondo and media reports suggest the Administration is finally starting to recognize the importance of legacy chips, but it remains unseen if they will act quickly and forcefully enough.²⁴

U.S. GOVERNMENT EXPORT CONTROLS ARE FAILING TO PREVENT CHINESE ACQUISITION OF CONTROLLED AMERICAN TECHNOLOGIES

Instead of restricting key technologies, U.S. export control policies are permitting U.S. companies to supply the People’s Liberation Army (PLA) with the very capabilities that could be deployed against the United States in a future conflict. Chinese assurances that American technologies licensed for civilian uses inside China will be confined to those purposes are worthless considering the Chinese government’s serial dishonesty and state-led Military-Civil Fusion (MCF) strategy. According to a 2021 comment filed to the Federal Communications Commission (FCC), China Tech Threat and BluePath Labs noted, “MCFS seeks to acquire, exploit and weaponize American-made technologies and, ultimately, usurp the United States’ economic and military leadership.”²⁵ Additionally, the U.S. government has only two export control officers dedicated to verifying the end-uses of all controlled technology shipped to China. Former Pentagon Chinese tech advisor Steve Coonen [says](#) U.S. end-use checks are “practically useless” in China, noting that “it is impossible for U.S. export control officers (ECOs) to verify the ultimate destinations or end-uses of U.S. technology.”²⁶ Ultimately, BIS’ willful blindness to Chinese MCF activities empowers America’s greatest adversary in the most critical area of technological inputs: semiconductors.

The White House’s 2021 supply chain report notes that Chinese chipmakers are primarily reliant on five large toolmakers throughout the world. Three of them are American: Lam Research, KLA Corp, and Applied Materials.²⁷ The U.S. Commerce Department, which in general rubber stamps applications to export controlled technologies at the behest of industry voices, has done little to stop the export of these toolmakers’ products. For example, from November 9th, 2020 to April 20th, 2021, the Department of Commerce either approved or returned without action 99.5% of all applications for the export of technologies to SMIC.²⁸ This is despite SMIC being placed on the Entity List in 2020 for its documented cooperation with the PLA.

BIS is also evidently heavily influenced by U.S. toolmakers' powerful lobbying operation. *The Economist* has described the toolmakers, which have raked in hundreds of billions of dollars from China, as advocating for fewer restrictions on "less advanced pieces of equipment." Fewer restrictions would "allow the toolmakers to retain some portion of their Chinese revenues."²⁹ In early 2023, KLA CEO Rick Wallace was confident enough to speculate, "So I think the expectation is the controls will remain on the leading edge, and they'll [Chinese chipmakers] be able to continue to develop some of these mature technologies."³⁰

This lobbying effort has undoubtedly been aided by a "revolving door" culture between BIS and the private sector. For example, in 2020, Assistant Secretary of Commerce for Export Administration Richard Ashooh resigned from his post to become the Vice President of Global Government Affairs for Lam Research, one of the companies most invested in selling its equipment to Chinese chipmakers.³¹

Other chipmakers Intel, Qualcomm, and NVIDIA have also lobbied the Biden Administration against additional restrictions affecting the semiconductor industry. In July 2023, in an attempt to justify his plans to continue to sell advanced chips to China, Intel CEO Pat Gelsinger complained, "Today, we have over 1,000 companies on the entities list, many of which have nothing to do with national security and nothing to do with security concerns in China."³² This assessment is patently inaccurate. Either the companies listed have known national security implications for the U.S., or they are front companies for the Chinese military and intelligence apparatus.

DID BIS GUIDANCE KEEP THE DOOR OPEN FOR CHINA TO KEEP ACQUIRING ADVANCED CHIPMAKING TECHNOLOGY?

Three weeks after BIS issued its controls for advanced chipmaking technology on October 7, 2022, it promulgated additional [guidance](#) to clarify any ambiguities in the new rules. SEMs apparently were curious whether they were precluded from shipping equipment to any Chinese facility that produced both advanced chips (covered under the new controls) and legacy chips (not covered under the new controls). In response, BIS suggested that "If an entity has multiple buildings located on the same campus with the same address and/or are part of the same legal entity, parties should exercise sufficient due diligence to ensure their item or activity is only for an unrestricted fabrication."³³ This guidance prompts several questions:

- Are American SEMs shipping technologies to Chinese fabs making both advanced and legacy chips?
- If so, are American SEMs relying only on promises from Chinese entities as their "due diligence" to ensure that their equipment will not be used to make advanced chips?
- Is BIS able to conduct end-use checks to ensure that Chinese fabs are not secretly, illegally repurposing equipment exported for legacy chipmaking for advanced chipmaking?
- In light of China's national objectives in the semiconductor space, as well as the Chinese Communist Party's serial history of lying, is it reasonable to believe that Chinese fabs will not leverage toolmaking equipment for advanced chip manufacturing?

Either way, each of the U.S. SEMs, in subsequent quarterly financial calls, expressed that the BIS guidance would allow them to "ship certain products [to Chinese semiconductor manufacturers] we had originally excluded," in the words of Lam Research President and CEO Tim Archer.³⁴ This clarification has allowed each to generate hundreds of millions in additional revenue.



SEMICONDUCTOR EQUIPMENT MANUFACTURERS ARE CASHING IN ON U.S. GOVERNMENT INACTION

Whether because of BIS' inadequate comprehension of the problem, or the success of the toolmakers' lobbying efforts, as of August 2023, top toolmakers – three of which are American companies – have made billions of dollars selling to China. A CTT/CPA analysis of the four largest SEMs (Dutch lithography giant ASML and three American companies: Applied Materials, Lam Research, and KLA Corporation) shows that despite all the talk since 2018 of rebuilding the U.S. semiconductor industry and withdrawing support from the Chinese industry, the share of equipment going to China has actually risen, from 21.5% to 24.7%. In contrast, the U.S. share of sales in these four years has fallen from 11.4% to 9.8%. In dollar terms, the value of equipment delivered to China from the four SEMs has risen an astonishing 89%, from \$9.7 billion in 2018 to \$18.4 billion last year.

SEMICONDUCTOR EQUIPMENT INDUSTRY REVENUE BY REGION, 2018-2022

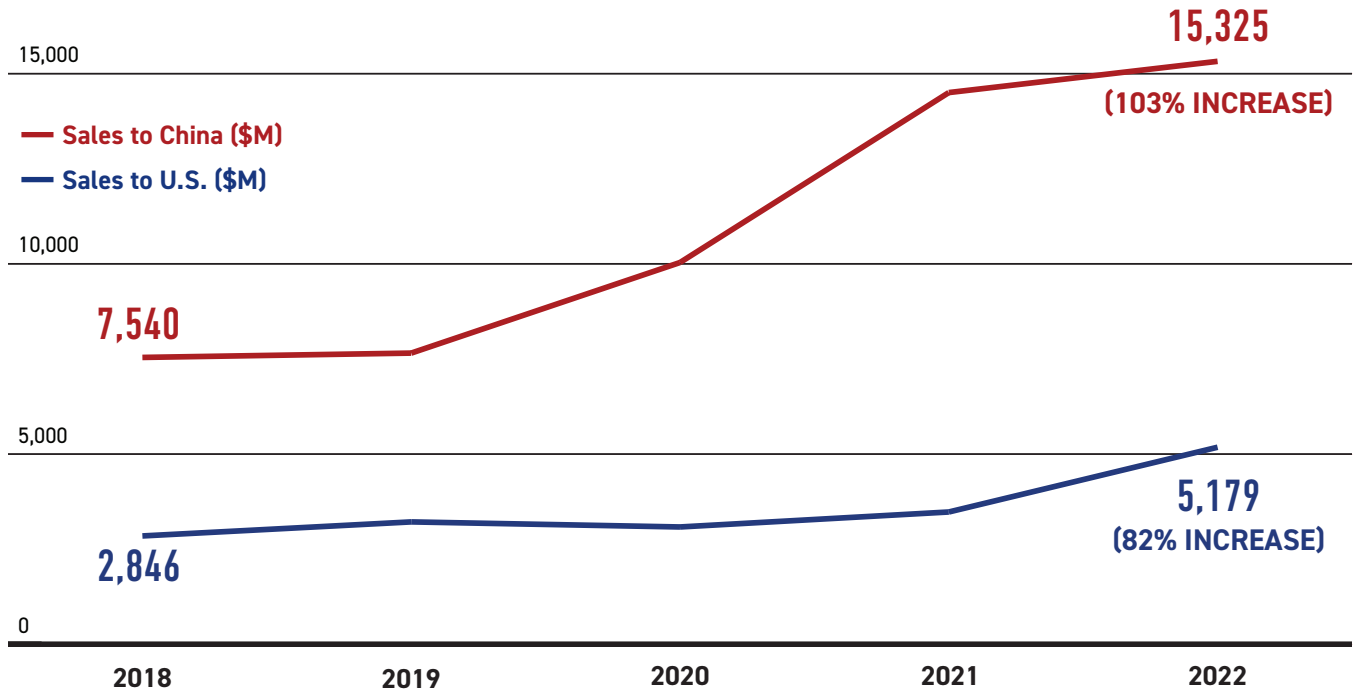
(Applied Materials, ASML, KLA, Lam Research)

| | FY 2022 | FY 2021 | FY 2020 | FY 2019 | FY 2018 | % Increase 2018-2022 |
|------------------------------------|----------|----------|----------|----------|----------|----------------------|
| Total Revenue (\$M) | \$74,456 | \$66,569 | \$50,102 | \$43,306 | \$45,281 | 64.4% |
| Sales to U.S. (\$M) | \$7,270 | \$5,345 | \$4,972 | \$5,434 | \$5,162 | 40.9% |
| Sales to U.S. (% of total) | 9.8% | 8.0% | 9.9% | 12.5% | 11.4% | -1.60% |
| Sales to China (\$M) | \$18,388 | \$17,738 | \$12,686 | \$9,152 | \$9,715 | 89.3% |
| Sales to China (% of total) | 24.7% | 26.6% | 25.3% | 21.1% | 21.5% | 3.20% |

Source: SEC filings, authors' calculations

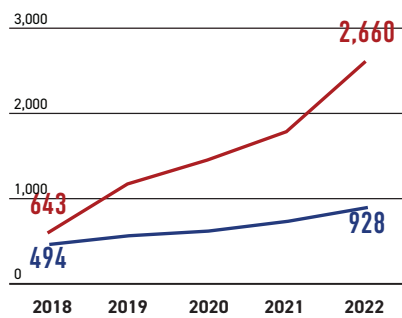
To examine just one company, sales of Lam Research into China alone have tripled since 2018, to reach \$5.4 billion last year. Lam has enjoyed booming sales to China because Lam's equipment is primarily used for memory chips. The Chinese strategy is to achieve a strong position in memory chips, which are relatively easier to manufacture and sell, and then use that position to drive other competitors out of the memory market. IT would then use strength in memory chips to provide more funding and leverage to get into so-called "legacy" logic and advanced logic chips.

THREE U.S. EQUIPMENT MANUFACTURERS SALES GROWTH: U.S. VS. CHINA



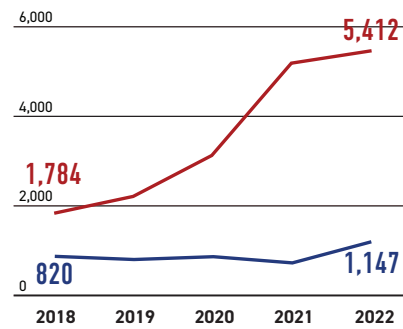
With the U.S. government evidently taking no actions to arrest the growth of the growing Chinese legacy chip sector, the three U.S. toolmakers are planning to generate billions more in revenue from it:

Applied Materials



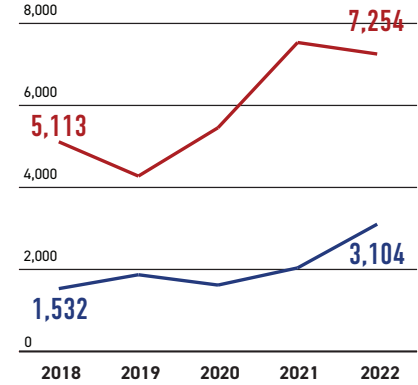
"We have factories that we will be able to ship to in the second half [of 2023]. And at least for Q3, that's in our guide."³⁵ – Applied Materials SVP and CFO Brice Hill, May 18, 2023

KLA



"New infrastructure is being added in China to support legacy activity, and that's probably a driver of an incremental couple of hundred million or so of revenue for us."³⁶ – KLA CFO Bren Higgins, January 26, 2023

Lam Research



"[Our] investment in China still remains pretty robust. And I see it showing up more in trailing edge foundry for the most part...lagging specialty node, devices that go into power devices, RF, image sensors and things like that."³⁷ – Lam Research EVP and CFO Doug Bettinger, March 7, 2023



WHAT CAN POLICYMAKERS DO TO STOP CHINA FROM DOMINATING THE LEGACY CHIP MARKET?

Policymakers have multiple options for ensuring that Beijing cannot grow to control global supplies of mature-node chips:

1. Restrict U.S. Toolmakers from Selling to Any Chinese Chip Manufacturers

Chinese chip firms depend on the tools supplied by American toolmakers. The U.S. government should broaden restrictions, which are currently focused on advanced semiconductors, to prevent the toolmakers from exporting any technologies used in the fabrication of legacy and larger semiconductors to Chinese companies.

2. Deny Additional 2023 Export Licenses

In March, Lam Research CFO Doug Bettinger, referring to business lost as a result of the October 7, 2022 export controls, remarked, “We’re potentially working on licenses that may bring some of it back.”³⁸ BIS should deny these applications, as well as those seeking authorization for additional shipments of chipmaking equipment in 2023.

3. Tighten Export Controls Across the Board

The U.S. and its allies Japan and the Netherlands (home to other top toolmaking companies) must impose a presumption of denial standard for the export of all controlled technologies destined for China. U.S. Senators Marco Rubio (R-FL) and Roger Wicker (R-MS) have introduced a bill to require BIS to adopt a presumption of denial for any end user from China, and to notify Congress before approving a license to that country.³⁹ Lawmakers should not worry about damaging the U.S. economy by instituting a presumption of denial standard: According to BIS, the value of controlled technologies shipped to China in 2021 constituted \$1.5 billion, only 1% of total U.S. exports to China.⁴⁰

4. Expand EDA Restrictions

In August 2022, the Commerce Department implemented export controls on electronic design automation (EDA) software used for designing leading-edge chips.⁴¹ To the extent the Commerce Department is permitting the export of EDA software to Chinese entities used in the design of legacy chips such as that made by Cadence, Mentor, and Synopsys, it should stop.

LEVERAGING THE CHIPS ACT TO REVITALIZE AMERICAN SEMICONDUCTOR MANUFACTURING

If tougher export controls are the defensive element for ensuring American dominance in the chip space, the U.S. must also play offense in catalyzing a domestically sourced supply of legacy-node chips and other products in the semiconductor supply chain.

1. Expand Domestic Production of Legacy Chips

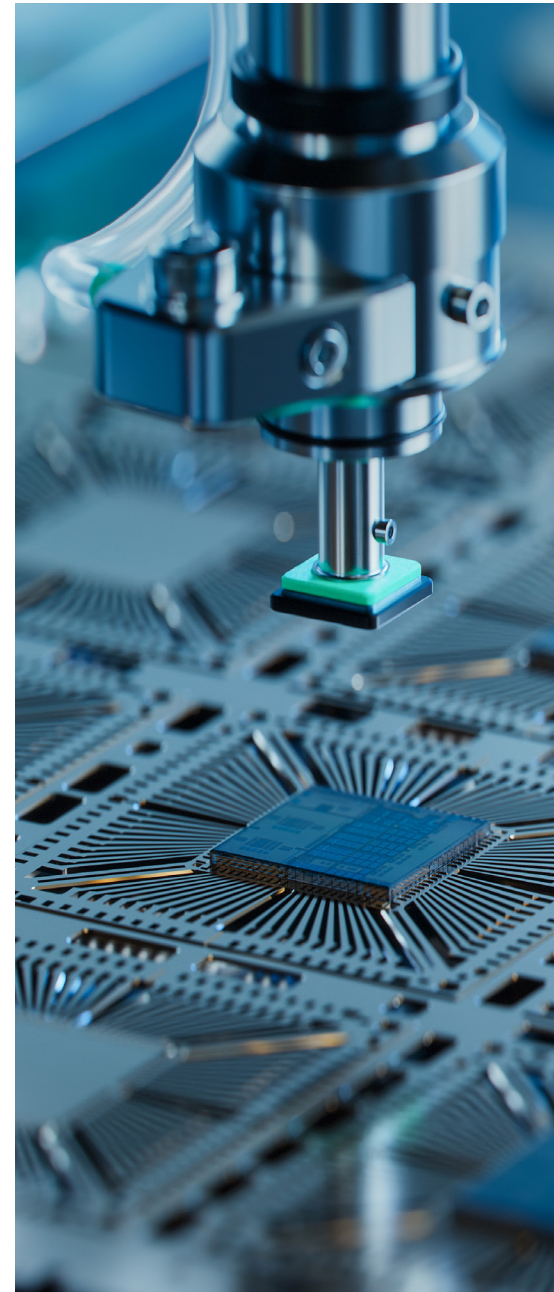
Secretary of Commerce Gina Raimondo has said that one goal of the CHIPS Act is to increase production of “current-generation *and* mature-node chips most critical to our economic and national security.”⁴² In July 2023, at a panel at the American Enterprise Institute, Raimondo also said, “The amount of money that China is pouring into subsidizing what will be an excess capacity of mature chips and legacy chips — that’s a problem that we need to be thinking about and working with our allies to get ahead of.”⁴³ Congress must ensure her Department follows through on a proper disbursement of CHIPS Act funding for legacy chip production. Money allocated to manufacturers under the CHIPS Act should also be strategically apportioned to creating legacy-node production capacity inside the U.S.

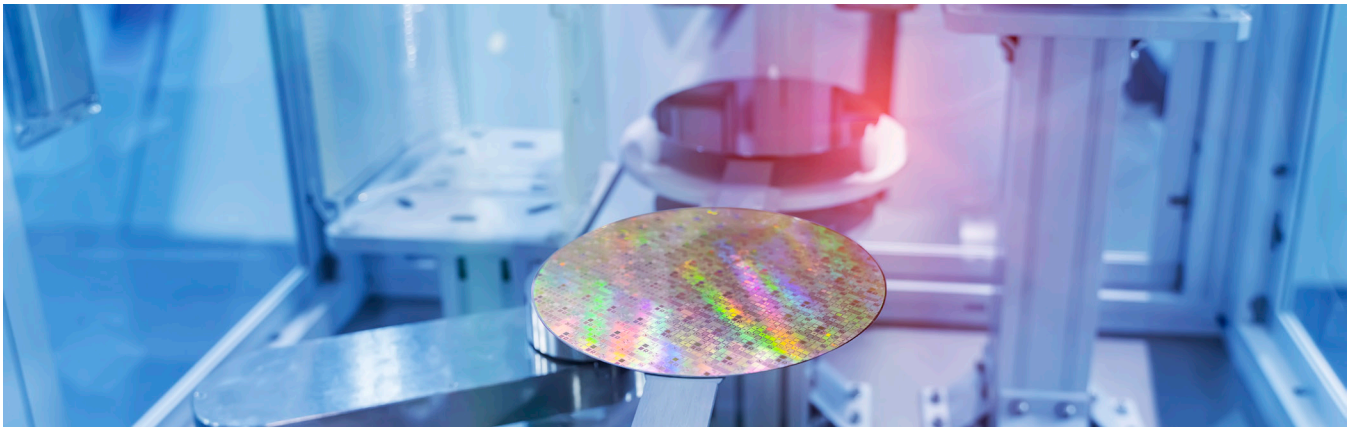
2. Expand Domestic Production of All Elements in the Semiconductor Supply Chain

As part of an overall rejuvenation of the U.S. manufacturing base to produce high-tech materials, the U.S. must also use CHIPS Act funds to support the domestic production of other elements in the semiconductor supply chain. While a complete reshoring of semiconductor supply chains will not be achieved in the short-term, it is a long-term effort worth doing in light of China’s own long-term plan for concentrating all elements of technology production inside its borders. Additionally, domestic production of chips to create independence from China is of little utility if the U.S. remains dependent on China (or other nations) for other technologies in the semiconductor ecosystem such as circuit boards and computers.

3. Create Metrics for Success

The CHIPS Act seeks to galvanize domestic production of both advanced and legacy chips. But how will that progress be measured? Congress should mandate that the Commerce Department collect and publish yearly the percentage of total chips manufactured inside the U.S. versus the rest of the world. The metrics could be broken down into the relevant categories. These metrics should be monitored and managed over time to demonstrate that the CHIPS Act is on track to achieve its stated goals including restoring American preeminence in chip manufacturing.





CONCLUSION

“When you think about electrification of mobility, think about the energy transition, the IoT in the industrial space, the roll-out of the telecommunication infrastructure, battery technology – that’s the sweet spot of mid-critical and mature semiconductor...And that’s where China without any exception is leading.”⁴⁴

– ASML CEO Peter Winnick

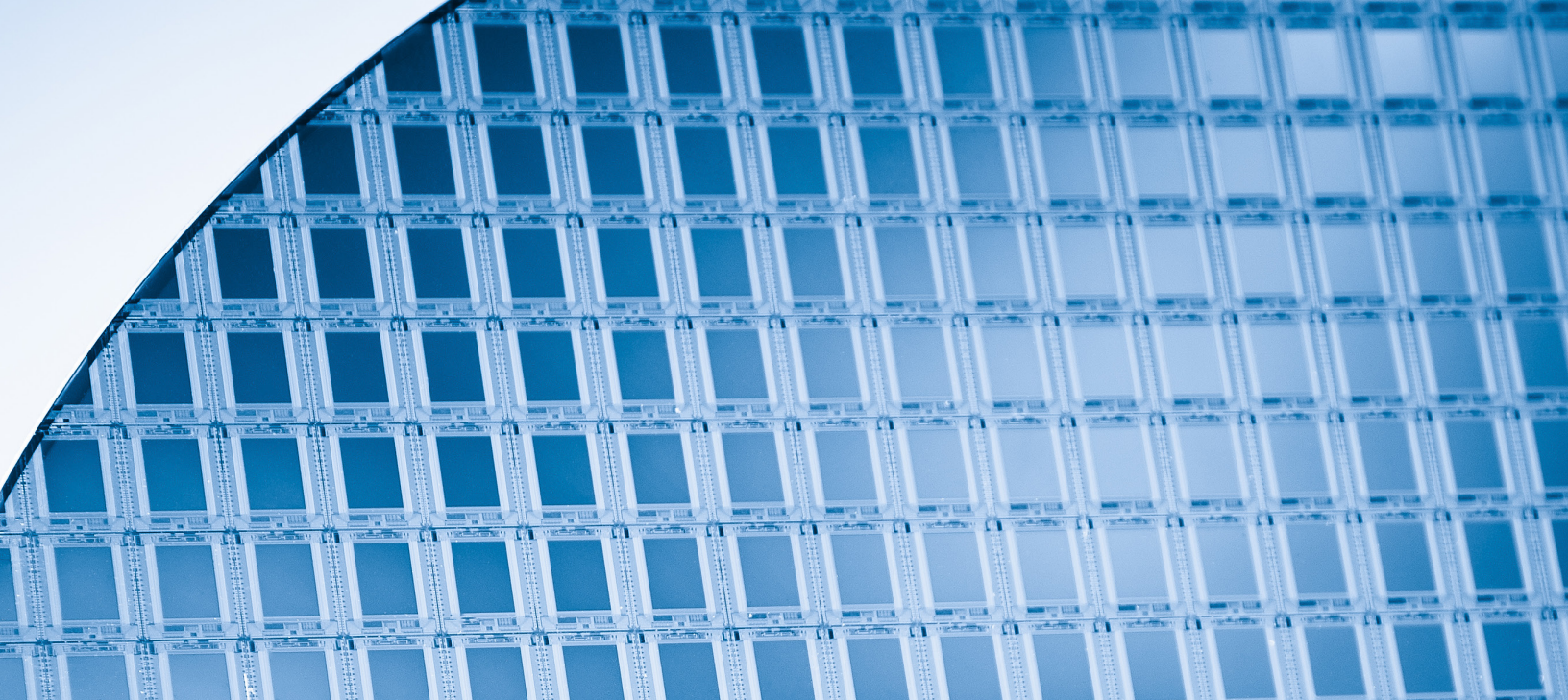
China’s demonstrated drive to dominate the legacy chip market has negative consequences for American national security, economic security, and jobs. The U.S. government, and in particular the Department of Commerce’s Bureau of Industry and Security, must implement export controls designed to restrict Chinese manufacturers’ ability to produce legacy-node chips. Additionally, CHIPS Act funds must be apportioned to boost the production of legacy-node chips inside the United States. Absent both defense and offensive measures, the U.S. and the world can only expect to become more dependent on China for the world’s most ubiquitous chips.

ENDNOTES

- 1 "Every Chip Matters - Why the U.S. Must Fight Back against a Looming Chinese Monopoly in the Legacy Semiconductor Sector" (China Tech Threat, April 2023), <https://chinatechthreat.com/wp-content/uploads/2023/05/CTT-EveryChipMatters-Final-Paper.pdf>.
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