TAIWAN AND THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN

- Implementation and Implications of The U.S. CHIPS and Science Act

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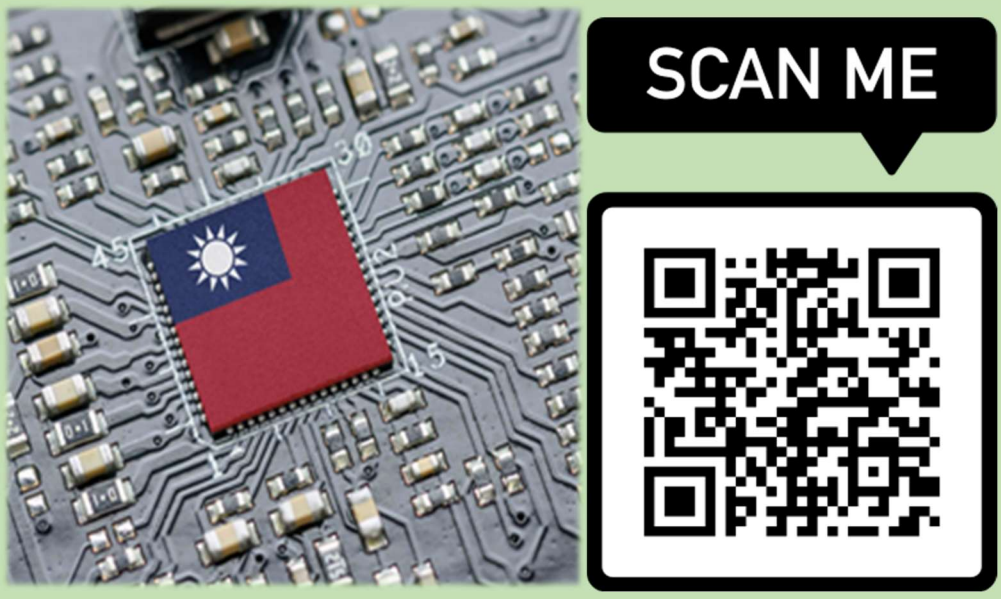

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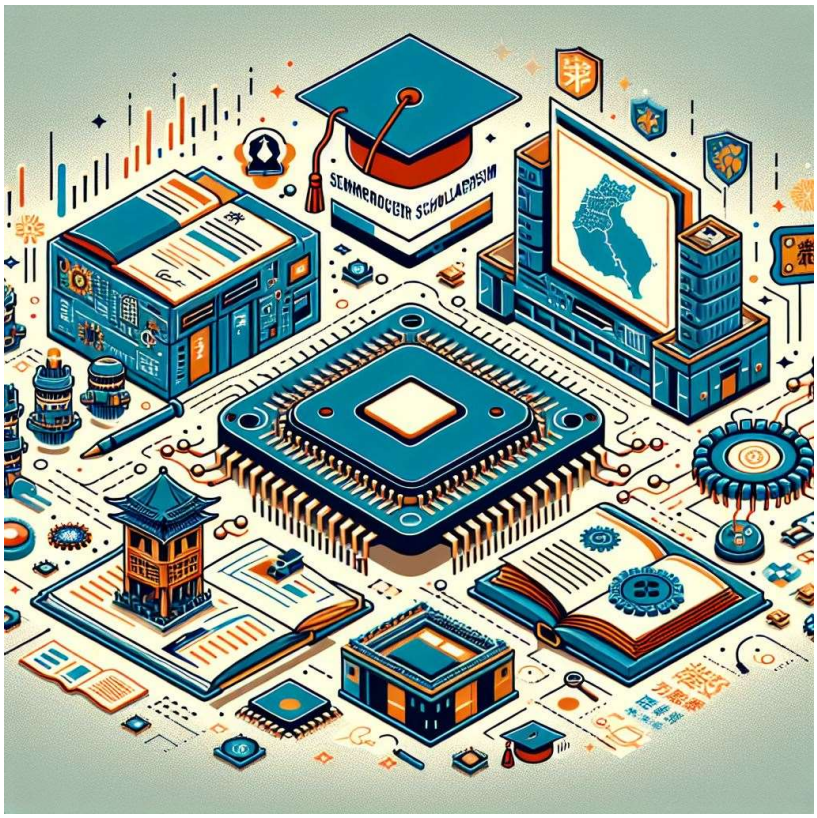

We warmly welcome our Singaporean friends to explore semiconductor studies in Taiwan, a country renowned for its cutting-edge semiconductor technology. Our semiconductor companies like the Taiwan Semiconductor Manufacturing Company (TSMC), United Microelectronics Corporation (UMC), MediaTek and ASE Technology are global leaders in the semiconductor industry.

Semiconductors play a critical role in various electronic devices, including smartphones, computers, and automobiles. The semiconductor industry has been instrumental in fostering bilateral trade and investment between Taiwan and Singapore. To enhance collaboration further—particularly in talent development—the Taipei Representative Office in Singapore proudly presents the latest guidebook titled 'Study Semiconductor in Taiwan.' This comprehensive resource covers application details for scholarships at nine Taiwanese universities. Download the full text of "Study Semiconductor in Taiwan" https://shorturl.at/jNd5E

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IN THE SPOTLIGHT

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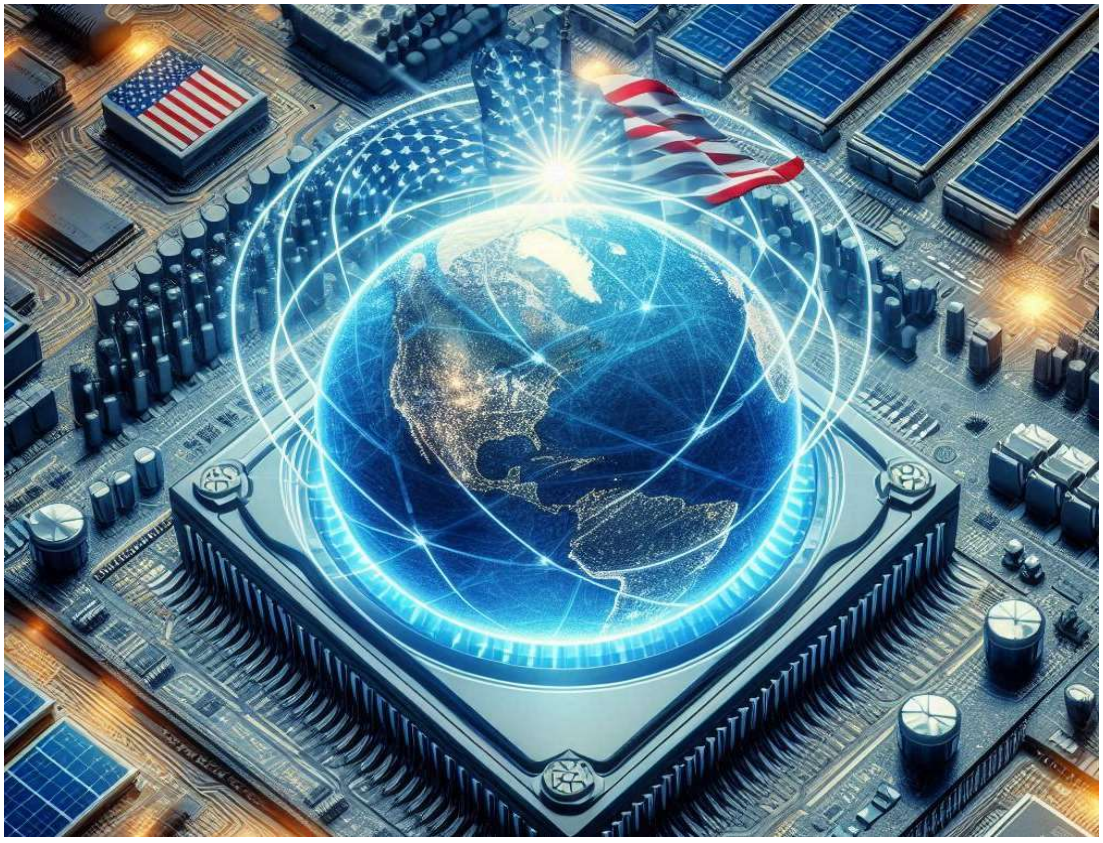
- **The share of semiconductor manufacturing capacity located in the U.S.A has declined from 37% in 1990 to 10% of the world's supply in 2022. In addition, the U.S.A. has zero production of the most advanced chips in 2022, and relies on Taiwan and South Korea for ≤7nm chips.**
- **The CHIPS Act provides US$ 52.7 billion in federal funding and is accompanied by export control restrictions and national security guardrails.**
- **Boston Consulting Group Report (May 2024): With the U.S. CHIPS Act, the U.S. share of the world's chip manufacturing capacity will hit 14% by 2032, up from 10% in 2022.**
- **TrendForce Report (Nov 2024): The U.S. is projected to become the second-largest producer of advanced chips by 2027, with TSMC a key contributor to this growth.**



Source: Created by Microsoft Copilot

THE U.S. SEMICONDUCTOR INDUSTRY

Semiconductors, or "chips," are the brains behind a variety of modern technology applications, from medical devices and clean energy to transportation and defense. With the global semiconductor industry expected to become a trillion-dollar industry by 2030, chips have become a cornerstone in modern geopolitics and global trade.[1]

The semiconductor industry is highly globalized and intensely competitive. Six major players – the U.S.A., Taiwan, South Korea, Japan, Europe and China – play pivotal roles in the global semiconductor supply chain. The U.S.A., which played a foundational role in the invention and early development of semiconductors, continues to lead the world in chip technology.[2] As major players vie for control over this critical technology and emerging players jostle to enter the arena, the U.S.A. is actively working to strengthen its position and control in chip production.

U.S.A. in the Global Semiconductor Value Chain

The United States plays a crucial role in various segments of the semiconductor value chain, from research and development (R&D), electronic design automation (EDA), core intellectual property (IP), and design to manufacturing equipment.

According to a Boston Consulting Group (BCG) report in May 2024, semiconductor design is the most significant contributor, accounting for 56% of the global semiconductor added value. Wafer manufacturing comes in second at 19%. Other value-add activities include semiconductor equipment (12%), packaging and testing (6%), semiconductor materials (5%), and EDA and Core IP (3%) (see Figure 1).

[1] Ondrej Burkacky, Julia Dragon, and Nikolaus Lehmann, “The semiconductor decade: A trillion-dollar industry,” McKinsey & Company, April 1, 2022.
[2] "Semiconductors,” National Institute of Standards and Technology (NIST), https://www.nist.gov/semiconductors, Accessed on October 29, 2024.

Figure 1: Semiconductor industry value-added by activity and region: 2022 (%)

Precompetitive Research		Segment value-added		USA	EU	Japan	S. Korea	Taiwan	China	RoW
EDA	**Design**	EDA & Core IP	3%	68%	25%	<1%	<1%	3%	<1%	3%
Core IP	• Logic	Design-Logic	30%	65%	9%	4%	3%	11%	5%	4%
	• DAO	Design-DAO	17%	41%	17%	18%	4%	5%	9%	6%
	• Memory	Design-Memory	9%	25%	<1%	7%	60%	4%	3%	<1%
Equipment	**Manufacturing**	Mfg equipment	12%	47%	18%	25%	3%	<1%	3%	2%
Materials	• Wafer fabrication	Materials	5%	9%	6%	12%	18%	28%	18%	10%
		Wafer fabrication	19%	10%	8%	17%	17%	18%	24%	7%
	• Assembly, test and packaging	ATP	6%	3%	3%	6%	9%	28%	30%	20%
		Overall value chain	100%	38%	11%	12%	12%	11%	11%	5%

Notes on regional breakdown:

- EDA, design, manufacturing equipment, and raw materials based on company revenues and company headquarters location.
- Wafer fabrication and assembly & testing based on installed capacity and geographic location of the facilities.
- RoW includes Singapore, Israel, India and the rest of the world.

Source: Raj Varadarajan, Iacob Koch-Weser, Chris Richard, Joseph Fitzgerald, Jaskaran Singh, Mary Thornton, Robert Casanova and David Isaacs, “Emerging Resilience in The Semiconductor Supply Chain,” Boston Consulting Group, May 2024, p. 10.

Just as different activities contribute differently to the overall value chain, distinct regions excel in specific segments of the semiconductor industry. For instance, companies based in the U.S.A. lead in research and development, chip design, core IP, and EDA. The U.S.A., Japan and the European Union collectively dominate in equipment manufacturing. Companies headquartered in Taiwan, South Korea, China and Japan are leaders in materials. Taiwanese and South Korean companies are at the forefront of advanced node fabrication, particularly for leading-edge semiconductors with process nodes of 7 nanometers (nm) and below. Additionally, assembly, testing, and packaging (ATP) operations are primarily concentrated in China and Taiwan.

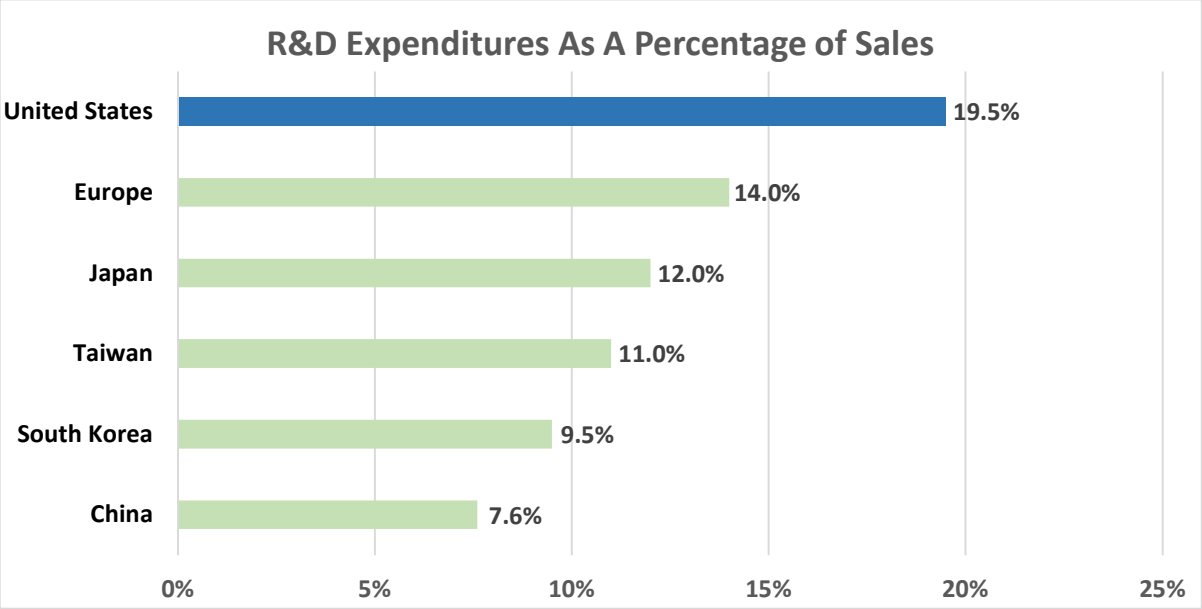
Research and Development

Governments often play a crucial role in advancing basic semiconductor research. Many major breakthroughs in semiconductor technology have emerged from federally funded research programs by the U.S. government. The foundation for extreme ultraviolet (EUV) photolithography technology, indispensable for manufacturing leading-edge semiconductors at 10nm or lower process nodes, for example, was laid by the U.S. Department of Energy's National Extreme Ultraviolet Lithography Program (NEUVLP) in the 1990s. Additionally, the gallium arsenide (GaAs) transistor, a critical technology underlying smartphone chips, was developed in the Microwave and Millimeter Wave Integrated Circuit (MIMIC) program by the U.S. Department of Defense in the late 1980s.[3]

According to the Semiconductor Industry Association, U.S. semiconductor companies invested 19.5% of the total sales in R&D in 2022, putting it ahead of its counterparts in other countries. The European semiconductor companies (14.0%), followed by semiconductor companies in Japan (12.0%), Taiwan (11.0%), South Korea (9.5%) and China (7.6%) (see Figure 2).

[3] Henry Wai-chung Yeung, Shaopeng Huang, and Yuqing Xing, "From Fabless to Fabs Everywhere? Semiconductor Global Value Chains in Transition," Global Value Chain (GVC) Development Report 2023: Resilient and Sustainable GVCs in Turbulent Times, World Trade Organization, 2023.

Figure 2: Semiconductor Industry R&D Spending Across Regions: 2022



Source: Semiconductor Industry Association, SIA 2024 Factbook, May 14, 2024, p. 18.

The United States' dominance in semiconductor R&D is largely due to the fact that most of the world's fabless companies are U.S.-based. Fabless companies devote on average 20% of their revenues to R&D. By focusing heavily on innovation and design, fabless companies can stay competitive and push the boundaries of semiconductor technology. According to the U.S. Bureau of Industry and Security, U.S.-based companies account for 73% of the world's fabless companies and 78% of global R&D carried out by fabless companies.[4]

According to the 2023 EU Industrial R&D Investment Scoreboard, U.S. companies have shown remarkable dedication to research and development in the semiconductor industry. In 2022, U.S.'s Cadence Design Systems had an impressive R&D intensity of 35.1%, meaning it invested 35.1% of its sales revenue back into research and development. Intel Corporation had a R&D intensity of 27.8% while other U.S. companies, such as NVIDIA, Advanced Micro Devices Inc. (AMD) and Qualcomm, also demonstrated strong commitments to R&D, with intensities of 27.2%, 21.2% and 18.5%, respectively (see Table 1).

[4] U.S. Department of Commerce, Bureau of Industry and Security, Office of Technology Evaluation, "Assessment of the Status of The Microelectronics Industrial Base In The United States," December 2023

Table 1: R&D Intensity of Leading U.S. Semiconductor: 2022

Company	Headquarters	R&D Investment (Billions, US$)	R&D Intensity
Cadence Design Systems	United States	$ 12.3	35.1%
Synopsys	United States	$ 16.6	33.1%
Intel	United States	$ 17.3	27.8%
NVIDIA	United States	$7.2	27.2%
AMD	United States	$4.9	21.2%
Western Digital	United States	$ 2.3	18.9%
Qualcomm	United States	$ 8.1	18.5%
Broadcom	United States	$ 4.8	14.8%
Analog Devices	United States	$ 1.7	14.2%
KLA	United States	$ 1.3	12.1%
Applied Materials	United States	$ 2.7	10.7%
Micron Technology	United States	$ 3.1	10.1%
Texas Instruments	United States	$ 1.6	8.3%

R&D intensity is defined as the ratio of a company's R&D expenditure to its total sales revenue.
Based on the average exchange rate for 2022, which was US$ 1 = € 0.9513.
Source: Nindl, E., Confraria, H., Rentocchini, F., Napolitano, L., Georgakaki, A., Ince, E., Fako, P., Hernández Guevara, H., Gavigan, J., Tübke, A., Pinero-Mira, P., Rueda-Cantuche, J.M., Banacloche-Sánchez, S., de Prato, G., and Calza, E., Report: "2023 EU Industrial R&D Investment Scoreboard," December 14, 2023, https://iri.jrc.ec.europa.eu/scoreboard/2023-eu-industrial-rd-investment-scoreboard, Accessed on November 15, 2024.

EDA and Core IP

EDA is a market segment consisting of software, hardware, and services with the collective goal of assisting in the definition, planning, design, implementation, verification, and subsequent manufacturing of semiconductor devices, or chips.[5] The tool provides a simulated environment where circuits and designs are conceived and analyzed before being realized in the physical world. EDA tools are, therefore, widely used in the design of almost all types of chips and have become indispensable as chip designs get complicated. Additionally, EDA tools are also used by chip manufacturers to verify that a design is feasible before production.[6]

An IP core, on the other hand, is a reusable unit of logic or integrated circuit (IC) layout design.[7] IP cores are essential for chip design and functionality. They provide pre-designed and pre-verified blocks of logic that can be integrated into semiconductor devices, significantly speeding up the design process and ensuring reliability. This also allows companies that choose not to build fully customizable chip designs from scratch to focus on innovation and differentiation in other areas of their chip.

Even though the EDA and Core IP segment contributed only 3% to the value-add in the semiconductor value chain in 2022, it is indispensable to the success of semiconductor design and manufacturing. By ensuring that chips meet performance, power, and area requirements, EDA software and IP cores are crucial for enabling the creation of highly complex and efficient chips.[8] To keep up with the semiconductor industry's extremely short innovation cycles, EDA software vendors have the highest R&D spending in the entire

[5] "What is EDA," Synopsys, https://www.synopsys.com/glossary/what-is-electronic-design-automation.html, Accessed on November 11, 2024.

[6] Zeyi Yang, "Inside the software that will become the next battle front in US-China chip war," MIT Technology Review, August 18, 2022.

[7] Rahul Awati, "What is an intellectual property core (IP core)?" TechTarget, https://www.techtarget.com/whatis/definition/IP-core-intellectual-property-core#, Accessed on November 11, 2024.

[8] Ramiro Palma, Raj Varadarajan, Jimmy Goodrich, Thomas Lopez, and Aniket Patil, "The Growing Challenge of Semiconductor Design Leadership," Boston Consulting Group and Semiconductor Industry Association, November 2022.

semiconductor value chain.[9] In 2022, U.S.-based Cadence Design Systems had an R&D expenditure of 35.2% of its sales revenue (see Table 1).[10]

In 2022, the U.S.A. led the EDA and Core IP market, capturing a 68% share with companies like Cadence, Synopsys and Mentor Graphics (a Siemens business) providing essential tools and IP for IDM (Integrated Device Manufacturer), fabless and foundry customers in advanced chip design and manufacturing. These companies have established strong reputations and extensive portfolios, making it difficult for new entrants to compete. Moreover, developing EDA tools requires significant investment in research and development, as well as deep expertise in semiconductor design and manufacturing processes, making the barriers to entry to the EDA and Core IP segment even higher. In 2023, Synopsys topped the IP license revenue charts with a 32% market share, while Cadence held the third position with a 6.7% market share.[11]

In November 2023, the U.S. Commerce Department's United States Patent and Trademark Office (USPTO) announced a new Semiconductor Technology Pilot Program to support the CHIPS for America program.[12] This pilot program is designed to accelerate improvements in the semiconductor industry by expediting examination of patent applications for certain semiconductor manufacturing innovations. The program accepts petitions from December 1, 2023 until either December 2, 2024 or the date the USPTO accepts a total of 1,000 grantable petitions, whichever occurs first. This initiative is expected to help bring key innovations to market more quickly, strengthening the U.S. semiconductor supply chain and reducing dependence on foreign semiconductor supplies.[13] As of November 4, 2024, 227 patent applications have been filed and 121 granted by the USPTO.[14]

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[9] Nenni, Daniel and McLellan, Paul (2019), Fabless: The Transformation of the Semiconductor Industry, SemiWiki.com Project.

[10] Macrotrends, "Cadence Design Systems Research and Development Expenses." Available at: https://www.macrotrends.net/stocks/charts/CDNS/cadence-design-systems/research-development-expenses, Accessed on November 13, 2024.

[11] David Manners, "Design IP revenues have 10.8% CAGR 2016-23 to $7.04bn," Electronics Weekly, April 21, 2024.

[12] United States Patent and Trademark Office, Press Release: "US USPTO announces Semiconductor Technology Pilot Program in support of CHIPS for America Program," November 30, 2023.

[13] Ibid.

[14] "Semiconductor Technology Pilot Program," United States Patent and Trademark Office, https://www.uspto.gov/patents/initiatives/patent-application-initiatives/semiconductor-technology-pilot-program, Accessed on November 11, 2024.

Chip Design

Chip design is a crucial activity that determines the function and value of a semiconductor device.[15] In 2022, chip design contributed 56% value-add to the semiconductor industry.

Semiconductor chips can be broadly classified into three main categories, namely, Logic, Memory, and Discrete, Analog and Other (DAO) chips. Each category of chips performs different functions and requires specialized design and manufacturing processes.[16] Logic chips are crucial for processing and executing instructions in electronic devices; memory chips, such as dynamic random-access memory (DRAM) and Not And (NAND) flash memory, are essential for storing and retrieving data in devices; while DAO chips are used in the design and optimization of semiconductor manufacturing processes.

Chip design is carried out by fabless companies and IDMs.[17] Fabless companies focus on designing semiconductor chips and partner with other companies (foundries) for the manufacturing phase while IDMs design and manufacture their own chips in their own fabs.[18]

In 2022, the U.S.A. led with a 65% share in the design of logic chips. Fabless companies such as U.S.'s NVIDIA Corporation, Qualcomm Incorporated, Broadcom Inc., AMD, Apple and Tesla have consistently been at the forefront of chip design. In both 2022 and 2023, NVIDIA, Qualcomm, Broadcom and AMD were the top four global chip design houses in terms of revenue.[19] Apple and Tesla are both giants in their respective industries, and

[15] "Strengthening U.S. Leadership In Chip Design," Semiconductor Industry Association, https://www.semiconductors.org/wp-content/uploads/2023/07/Chip-Design-Leadership-One-pager_062623.pdf, Accessed on November 11, 2024.
[16] Congressional Research Service, CRS Report: "Semiconductors and the Semiconductor Industry," April 19, 2023.
[17] "Strengthening U.S. Leadership In Chip Design," Semiconductor Industry Association, https://www.semiconductors.org/wp-content/uploads/2023/07/Chip-Design-Leadership-One-pager_062623.pdf, Accessed on November 11, 2024.
[18] Ibid.
[19] TrendForce, Press Release: "Top 10 IC Design Houses' Combined Revenue Grows 12% in 2023, NVIDIA Takes Lead for the First Time, Says TrendForce," May 9, 2024.

their in-house chips play a significant role in their success. Intel, renowned for its microprocessors, is a prominent IDM that designs logic chips.[20]

In the design of memory chips, the U.S.A. ranked second with a share of 25%, behind South Korea's share of 60% in 2022. U.S. companies such as Intel and Micron Technology are key players in memory chip design. South Korea, the leader in the memory chip industry, is home to companies like Samsung Electronics and SK Hynix that are at the forefront of memory chip design and manufacturing globally.[21]

The U.S.A. accounted for a majority share of 45% in the design of DAO chips in 2022. The U.S.A. is home to leading design houses for DAO chips including Texas Instruments and Analog Devices.

The U.S.'s leadership in semiconductor design, the highest value-added activity within the semiconductor industry, significantly boosted its share of value and profitability ahead of all other major players in 2022 (see Figure 1).

Semiconductor Equipment Manufacturing

Semiconductor equipment manufacturing, the third highest value-added activity within the semiconductor value chain, accounted for 12% value-add to the semiconductor value chain in 2022. In a market dominated by a handful of key players, the U.S.A. is a clear leader in semiconductor equipment manufacturing. Three of the five leading equipment companies—Applied Materials, Lam Research, and KLA—are based in Silicon Valley and are thriving.[22] Applied Materials, for example, led the pack with a 19.8% market share in 2022.[23]

[20] "Integrated Device Manufacturer (IDM)," Semiconductor Engineering, https://semiengineering.com/knowledge_centers/manufacturing/integrated-device-manufacturer-idm/, Accessed on November 11, 2024.

[21] Christian Davies and Song Jung-a, "SK Hynix and Samsung's early bet on AI memory chips pays off," Financial Times, July 29, 2023.

[22] Richard Elkus Jr., "A Strategy for The United States to Regain its Position in Semiconductor Manufacturing," February 13, 2024.

[23] "The Global Semiconductor Equipment: Markets, Market Shares, Market Forecasts," The Information Network, April 11, 2023.

Semiconductor Materials

The materials segment of the semiconductor value chain accounted for only 5% value-add in 2022. The U.S.A. accounted for only 9% of the global semiconductor materials market. This highlights the significant role other regions such as Taiwan (28%), South Korea (18%), China (18%) and Japan (12%) play in the production of essential materials used in semiconductor manufacturing (see Figure 1).

Semiconductor Assembly, Test and Packaging

The semiconductor Assembly, Test and Packaging (ATP) segment contributed 6% to the overall value chain. ATP, especially traditional ATP, generally involves fewer complex processes and tools than other portions of manufacturing and is correspondingly more labor-intensive. The ATP footprint is concentrated in China, and Taiwan, which hold 30% and 28% of the market share, respectively (see Figure 1).

Semiconductor Manufacturing

Semiconductor manufacturing requires high capital expenditure, and many highly specialized inputs and skilled workers.[24] Although wafer manufacturing is the second highest value-add segment in the semiconductor value chain, the U.S. share of semiconductor manufacturing capacity is low relative to the rest of the semiconductor value chain. In fact, the U.S.A. accounted for only 10% of value-added to the semiconductor industry, behind China (24%), Taiwan (18%), Japan (17%) and South Korea (17%) in 2022 (see Figure 1).

U.S.A. in the Overall Semiconductor Value Chain

By excelling across various segments of the semiconductor value chain, including R&D, EDA software, IP core, chip design and manufacturing equipment, the U.S. continues to lead the global semiconductor industry, driving innovation, maintaining high profitability, and contributing significantly to the global supply chain.

[24] Antonio Varas, Raj Varadarajan, Jimmy Goodrich and Falan Yinug, "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era," Semiconductor Industry Association, April 1, 2021.

According to BCG estimates, the United States accounted for 38% of the total added value of the global semiconductor industry in 2022. The U.S. semiconductor industry's share of total added value far exceeded that of its nearest rival by more than three times in 2022. This dominance highlights the U.S.'s leadership in the areas of chip design, EDA design software and core IP and semiconductor equipment manufacturing as well as its profitability in the semiconductor industry (see Figure 1).

U.S. Semiconductor Production Capacity

Over the years, the U.S.A.'s global share of semiconductor manufacturing capacity located on its shore has declined. The U.S.A., Japan and Europe used to virtually dominate the entire global semiconductor production in 1990. Europe led with 44%, the U.S.A. followed with 37%, and Japan accounted for 19% of the global fabrication capacity.[25] The U.S. share of global semiconductor manufacturing capacity, however, slipped to 12% in 2020, and fell further to about 10% in 2022 (see Table 2).[26]

Table 2: U.S. Share and CAGR of Production Capacity

Year	U.S. Share of Global Capacity	Compound Annual Growth Rate	
		U.S.	World
1990	37.0%	N.A.	N.A.
2000	19.0%	12.8%	20.2%
2010	13.0%	5.0%	9.6%
2020	12.0%	4.0%	4.9%
2022	10.0%		

Source: Douglas Thomas, "Annual Report on the U.S. Manufacturing Economy: 2023," NIST Advanced Manufacturing Series, National Institute of Standards and Technology (NIST), https://nvlpubs.nist.gov/nistpubs/ams/NIST.AMS.600-13-upd1.pdf.

The Compound Annual Growth Rate (CAGR) of the semiconductor industry represents the annualized average rate of revenue growth over a specific period, assuming the growth happens at an exponentially compounded

[25] Florian Zandt, "Where Can the Most Chips Be Manufactured?" Statista, December 5, 2023.
[26] Semiconductor Industry Association, Press Release: "SIA America Projected to Triple Semiconductor Manufacturing Capacity by 2032, the Largest Rate of Growth in the World," May 08, 2024.

rate.[27] When U.S.'s share of global capacity dropped from 37.0% in 1990 to 19.0% in 2000, its CAGR stood at 12.8%, while the world's CAGR was 20.2% in 2000. In 2010, as the U.S. share of global capacity further decreased to 13.0%, its CAGR stood at 5.0%, compared to the global CAGR of 9.6%. In 2020, the U.S. share slightly declined to 12.0%, and its CAGR was reduced to 4.0%, with the global rate at 4.9%. The U.S. CAGR has thus been lower than the global CAGR in semiconductor production from 2000 to 2020 (see Table 2). This indicates that other regions have significantly ramped up their semiconductor manufacturing capabilities more quickly than the U.S.A. Northeast Asian countries like Taiwan, China, Japan, and South Korea, for example, were heavily investing in their semiconductor industries through aggressive government incentives. By 2022, the combined production share of the U.S., Europe and Japan had fallen to 35% while the combined production share of Northeast Asian region rose to 59% (see Figure 1).

Additionally, according to a report by the BCG and SIA, the U.S. share of global semiconductor production capacity would slip further to 8% by 2032 if there were no government intervention.[28]

Some members of the U.S. Congress have voiced their concerns about the concentration of semiconductor manufacturing in East Asia, highlighting the vulnerability of supply chains to trade disputes, military conflicts, and other disruptions.[29] These concerns have led to initiatives such as the U.S. CHIPS and Science Act.

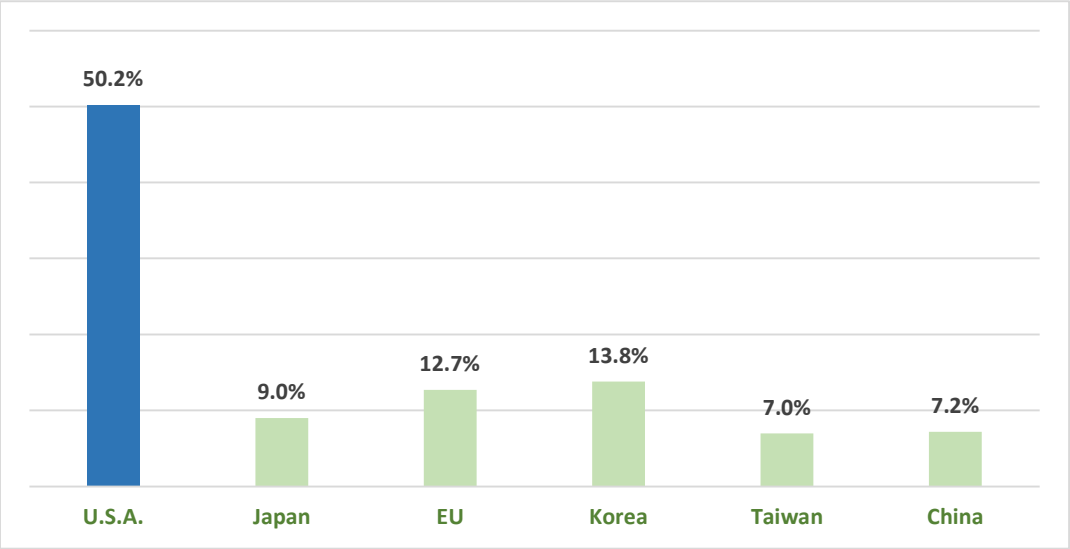
U.S. Semiconductor Revenue

Since the late 1990s, the United States has dominated the global sales market share for chips.[30] According to World Semiconductor Trade Statistics (WSTS) and the Semiconductor Industry Association (SIA), as global semiconductor sales increased from US$ 139.0 billion in 2001 to US$ 526.9 billion in 2023, the revenue of U.S.-based semiconductor companies also

[27] Gartner Glossary, Gartner, https://www.gartner.com/en/information-technology/glossary/cagr-compound-annual-growth-rate, Accessed on November 24, 2024.
[28] Raj Varadarajan, et al., "Emerging Resilience in the Semiconductor Supply Chain," Boston Consulting Group and Semiconductor Industry Association, May 2024.
[29] "Semiconductors and the CHIPS Act: The Global Context," Congressional Research Service, May 18, 2023.
[30] State of the U.S. Semiconductor Industry Report 2024, Semiconductor Industry Association, September 9, 2024.

increased in tandem, from US$ 71.1 billion in 2001 to US$ 264.6 billion in 2023.[31] The U.S. semiconductor firms, therefore, remains the semiconductor industry leader with a 50.2% share (see Figure 3).[32]

Figure 3: Share of Semiconductor Revenue by Region: 2023



Source: SIA 2024 Factbook, Semiconductor Industry Association, May 14, 2024.

In contrast, the semiconductor industry of other countries has between 7.0% and 13.8% global market share, a distribution expected to remain stable in the foreseeable future. The U.S. semiconductor industry, with its leading position in the market, is able to heavily invest in R&D, keeping it at the forefront of global tech advancements and reinforcing its sales leadership (see Figure 3).

A report from the U.S. Department of Commerce (DOC)'s Bureau of Industry and Security (BIS) in December 2023 highlighted the strength of U.S. companies in chip design and IDMs. U.S.- based companies are particularly strong in design processes, accounting for 72% of all fabless revenue, 42% of IDM revenue among companies that do both design and manufacturing, and 53% of global semiconductor revenue in 2022.[33] However, the U.S.A. has a relatively lower share in the foundry segment (6%) and the outsourced semiconductor assembly and test segment (OSAT) (15%) (see Table 3).

[31] SIA 2024 Factbook, Semiconductor Industry Association, May 14, 2024.
[32] Ibid.
[33] Office of Technology Evaluation, Bureau of Industry and Security, U.S. Department of Commerce, "Assessment of the Status of the Microelectronics Industrial Base in the United States," December 2023.

Table 3: Market Share of Process Roles by Location of Company Headquarters: 2022

	Fabless	IDM	Total Semiconductor Providers	Foundry	OSAT	Total Outsourced Manufacturing
Total (US$ billion)	**248**	**412**	**660***	**139**	**50**	**190**
United States	72%	42%	53%	6%	15%	8%
Taiwan	14%	2%	6%	65%	58%	63%
South Korea	1%	22%	14%	16%	1%	12%
Japan	1%	17%	11%	1%	0%	0%
China	12%	2%	6%	9%	20%	12%
Germany	0%	5%	3%	1%	0%	0%
Switzerland	0%	4%	3%	0%	0%	0%
Netherlands	0%	4%	2%	0%	0%	0%

BIS's data is based on publicly reported sales and estimates of the revenues of major non-public companies

* The BIS estimates may exceed those of the Semiconductor Industry Association (US$ 574 billion, via SIA 2023 Factbook) and Gartner (US$ 600 billion, April 26 2023 press release) in part because it is revenue focused, and thus may not have fully accounted for non-semiconductor revenue or integration of semiconductors into other semiconductor devices. Foundry and ATP revenue are not part of these vendor-specific reports.

Source: Office of Technology Evaluation, Bureau of Industry and Security, U.S. Department of Commerce, "Assessment of the Status of the Microelectronics Industrial Base in the United States," December 2023.

Wafer manufacturing, which encompasses production by both wafer foundries and IDMs, is a crucial part of the semiconductor supply chain. In 2022, the output value of the IDM segment was valued at US$ 412 billion. This figure is almost 3 times higher than the output value of the foundry segment, which was valued at US$ 139 billion. The United States, with IDMs like Intel and Texas Instruments, was the global leader in integrated device manufacturing, accounting for 42% of global IDM output value in 2022. Combining the total market share of total U.S. semiconductor companies (US$ 349.8 billion) and total outsourced manufacturing (US$ 15.2 billion), the U.S. market revenue totaled US$ 365 billion or 42.9% share of the global market (see Table 3).

Meanwhile, Taiwan, led by Taiwan Semiconductor Manufacturing Company (TSMC), was the leader in the wafer foundry segment, accounting for 65% of global foundry output value in 2022 (see Table 3).

Table 4 lists the world's 30 largest semiconductor companies in 2022 as per a U.S. Bureau of Industry and Security (BIS) report. These 30 largest

semiconductor companies accounted for approximately US$ 684.5 billion or 75 % of global semiconductor revenue in 2022. Sixteen U.S. semiconductor companies, including fabless, IDMs and foundries were among the top 30 ranks, accounting for a share of 51.2% of the world's 30 largest semiconductor companies, or US$ 350.4 billion in total revenue in 2022. This places the total output value of the U.S. semiconductor industry far ahead of all other major players. Second-place Taiwan had a total output value of US$ 125.7 billion in 2022, which was about one-third of the output value of the United States.

Table 4: World's 30 Largest Semiconductor Companies by Revenue: 2022

Company	Primary Segment	Process Role	Country of Headquarters	Revenue (US$ billions)
Samsung*	Memory	IDM	South Korea	$76.2
TSMC	Foundry	Foundry	Taiwan	$75.9
Intel	Micro	IDM	U.S.A.	$63.1
Qualcomm	Logic	Fabless	U.S.A.	$43.0
Apple**	Logic	Fabless	U.S.A.	$40.0
SK Hynix	Memory	IDM	South Korea	$34.0
Broadcom	Logic	Fabless	U.S.A.	$33.2
NVIDIA	Logic	Fabless	U.S.A.	$29.6
Micron Technology	Memory	IDM	U.S.A.	$27.2
Advanced Micro Devices	Micro	Fabless	U.S.A.	$23.6
Advanced Semiconductor Engineering	AT&P	AT&P	Taiwan	$22.2
Texas Instruments	Analog	IDM	U.S.A.	$19.6
MediaTek	Logic	Fabless	Taiwan	$18.4
Western Digital	Memory	IDM	U.S.A.	$16.4
STMicroelectronics	Analog	IDM	Switzerland	$16.1
Infineon	Discretes	IDM	Germany	$15.8
Murata	Sensors	IDM	Japan	$14.0
NXP Semiconductors***	Micro	IDM	Netherlands	$13.2
Analog Devices	Analog	IDM	U.S.A.	$12.0
Kioxia	Memory	IDM	Japan	$11.7
Renesas	Analog	IDM	Japan	$11.3
United Microelectronics Corporation	Foundry	Foundry	Taiwan	$9.2
Sony-Imaging and Sensing Solutions****	Optoelectronics	IDM	Japan	$9.1
onsemi	Discretes	IDM	U.S.A.	$8.3
GlobalFoundries	Foundry	Foundry	U.S.A.	$8.1
Microchip Technology Incorporated	Micro	IDM	U.S.A.	$8.1
Semiconductor Manufacturing International Corporation (SMIC)	Foundry	Foundry	China	$7.2
Amkor Technology	AT&P	AT&P	U.S.A.	$7.1
Marvell Semiconductor, Inc.	Logic	Fabless	U.S.A.	$5.8
Skyworks Solutions	Analog	IDM	U.S.A.	$5.3
U.S.A. Total				**$350.4**
U.S.A. Share (%)				**51.2%**
Top 30 Total				**$684.5**

Data is based on annual and quarterly financial filings via company websites and U.S. Securities and Exchange Commission.
*Data is for Samsung's Semiconductor (DS) segment.
**Estimated value of Apple's semiconductor production based on publicly reported share of TSMC's revenue.

***NXP Semiconductors is spun off from Philips in 2006. Philips Semiconductors became NXP Semiconductors, a separate, stand-alone company.[34]
****Data is for Sony's Imaging and Sensing Solutions segment.

Source: Office of Technology Evaluation, Bureau of Industry and Security, U.S. Department of Commerce, "Assessment of the Status of the Microelectronics Industrial Base in the United States," December 2023, p. 15.

Semiconductors significantly boost the U.S. economy. In 2023, U.S. exports of semiconductors were worth US$ 52.7 billion, making semiconductors the sixth highest among U.S. exports. The industry also directly employs 338,000 Americans and indirectly accounts for 1.9 million additional jobs.[35]

Zero Production of Most Advanced Logic Chips

While the United States holds a leading position in various segments of the semiconductor industry, it plays a smaller role in the actual manufacturing of semiconductors, particularly advanced chips.

Today, chips are fabricated in a wide variety of nodes, the smallest currently in production are 3nm chips produced by Taiwan's TSMC and South Korea-based Samsung.[36] In 2022, the U.S.A. did not produce any advanced logic chips manufactured on sub-10nm technologies.[37] Advanced logic capacity (≤7nm) was 100% concentrated in Taiwan and South Korea in 2022 (see Figure 4).

For logic chips of 10 to 22nm, the U.S.A. accounted for 28% share of global fabrication capacity in 2022. Taiwan held the largest share of 40% in this category. For logic chips of 28nm and above, the U.S.A.'s share of global wafer fabrication capacity in 2022 was 8%, behind China (33%), Taiwan (30%), and Japan (10%).

In the case of memory chips, the U.S.A. held 3% global share of both DRAM and NAND chip fabrication capacity in 2022. South Korea, with 52%

[34] NXP Semiconductors, Annual Report 2006, NXP Semiconductors, 2006.
[35] Ibid.
[36] "3nm Technology," TSMC, https://www.tsmc.com/english/dedicatedFoundry/technology/logic/l_3nm, Accessed on November 24, 2024; Samsung, Press Release: "Samsung Begins Chip Production Using 3nm Process Technology With GAA Architecture," June 30, 2022.
[37] National Institute of Standards and Technology, U.S. Department of Commerce, "Vision for Success: Commercial Fabrication Facilities", February 28, 2023.

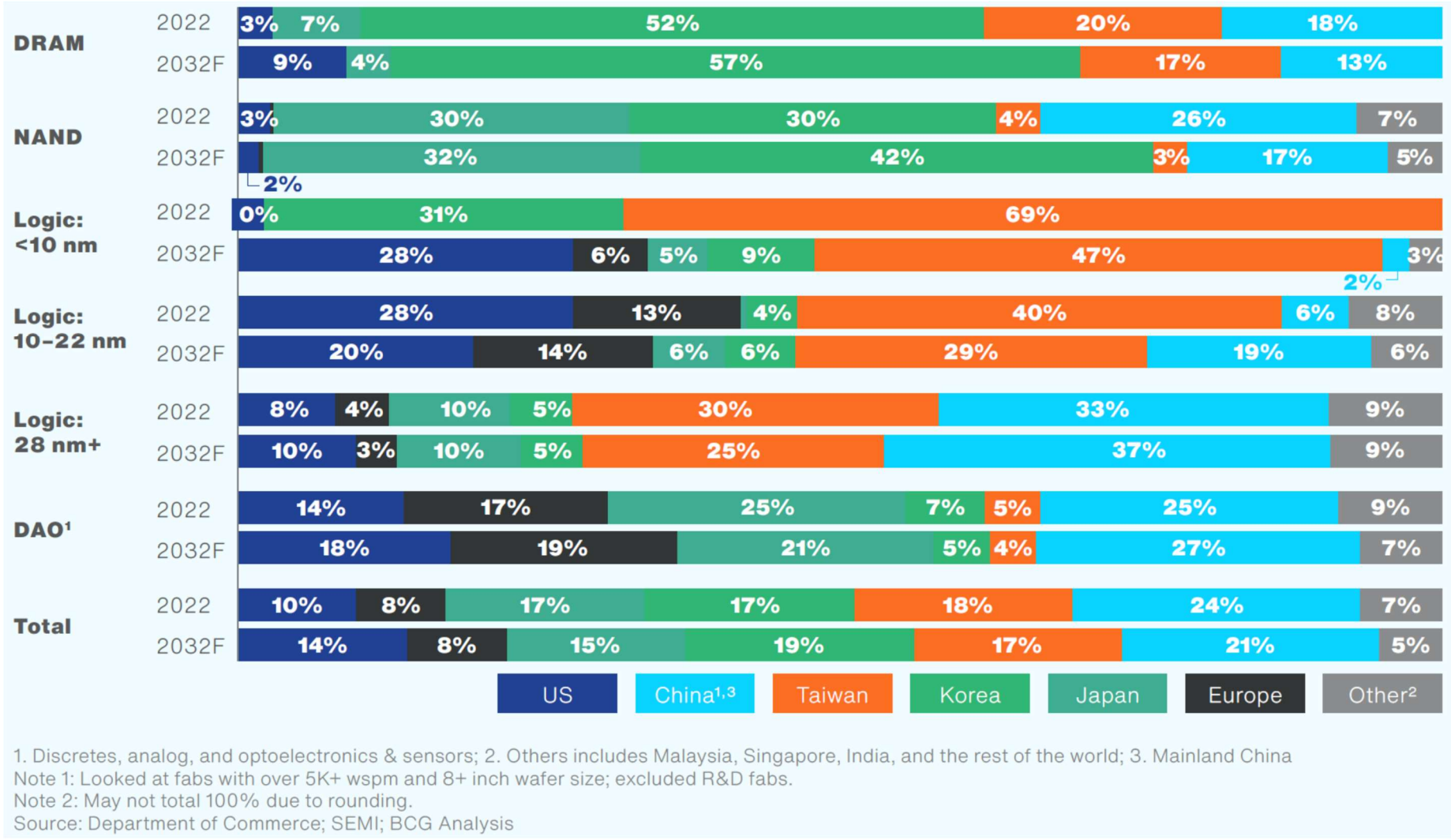
share was the market leader in DRAM chip production. Both Japan and South Korea led in the fabrication capacity of NAND chips with a market share of 30% each.

For DAO chips, the U.S.A. accounted for 14% of global fabrication capacity in 2022. Its share fell behind that of China (25%), South Korea (25%) and Europe (17%) (see Figure 4).

Leading-edge logic chips are needed to power artificial intelligence (AI) and other fast-growing industries like high-performance computing, consumer electronics, automotive, and Internet of Things. The U.S. government emphasizes that advanced logic chips produced on its shores is foundational to its technological and economic leadership in the 21st century.[38] The U.S., therefore, saw a need to increase U.S. semiconductor production capacity by providing incentives and funding for building new fabs and advancing manufacturing technologies.

[38] U.S. Department of Commerce, Press Release: "Biden-Harris Administration Announces CHIPS Incentives Award with TSMC Arizona to Secure U.S. Leadership in Advanced Semiconductor Technology," November 15, 2024.

Figure 4: Global Wafer Fabrication Capacity by Technology Category by Region: 2022 and 2032 Forecast



1. Discretes, analog, and optoelectronics & sensors; 2. Others includes Malaysia, Singapore, India, and the rest of the world; 3. Mainland China
Note 1: Looked at fabs with over 5K+ wspm and 8+ inch wafer size; excluded R&D fabs.
Note 2: May not total 100% due to rounding.
Source: Department of Commerce; SEMI; BCG Analysis

Source: Raj Varadarajan, Iacob Koch-Weser, Chris Richard, Joseph Fitzgerald, Jaskaran Singh, Mary Thornton, Robert Casanova and David Isaacs, "Emerging Resilience in The Semiconductor Supply Chain," Boston Consulting Group, May 2024, p. 14.

POLICY MEASURES

To strengthen its semiconductor supply chain as well as maintain its economic and technological leadership in the world, the U.S.A. has formulated policies, including incentives, guardrails, export controls, and also forged various alliances with like-minded allies.

U.S. Chips and Science Act

On August 9, 2022, U.S. President Biden signed the bipartisan Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act (hereinafter "the CHIPS Act") into law.[39] The CHIPS Act, a cornerstone of the CHIPS for America initiative, aims to reestablish the United States' leadership in semiconductor manufacturing, bolster global supply chains, and enhance both national and economic security.[40]

The four strategic goals for the CHIPS for America Fund as spelt out by the DOC are as follows:

(1) Invest in U.S. production of strategically important semiconductor chips, focusing on leading-edge technologies.
(2) Assure a sufficient, sustainable, and secure supply of older and current generation chips for national security purposes and for critical manufacturing industries.
(3) Strengthen U.S. semiconductor R&D leadership to catalyze and capture the next set of critical technologies, applications, and industries.
(4) Grow a diverse semiconductor workforce and build strong communities that participate in the prosperity of the semiconductor industry.[41]

Correspondingly, DOC aims to reach the following goals by 2030 in order to advance U.S. economic and national security:

(1) make the U.S.A. home to at least two, new large-scale clusters of leading-edge logic chip fabs,

[39] For the full text of the CHIPS and Science Act, see H.R.4346 - 117th Congress (2021-2022).
[40] The White House, Fact Sheet: "Two Years after the CHIPS and Science Act, Biden-Harris Administration Celebrates Historic Achievements in Bringing Semiconductor Supply Chains Home, Creating Jobs, Supporting Innovation, and Protecting National Security," August 9, 2024.
[41] The U.S. Department of Commerce, Press Release: "A Strategy for the Chips for America Fund", September 6, 2022.

(2) make the U.S.A. home to multiple, high-volume advanced packaging facilities,
(3) produce high-volume leading-edge memory chips, and
(4) increase production capacity for current-generation and mature-node chips, especially for critical domestic industries.[42]

Financial Incentives

The CHIPS Act provides US$ 52.7 billion over five years (2022 to 2027) for American semiconductor research, development, manufacturing, and workforce development.[43] This includes US$ 39 billion in manufacturing incentives, US$ 11 billion for R&D, and US$ 2.7 billion for defense, technology security and workforce development (see Figure 5).

Figure 5: CHIPS and Science Act Provides US$ 52.7 Billion for U.S. Semiconductor Research, Development, and Manufacturing

Semiconductor Manufacturing and Research & Development
US$ 39 Billion Manufacturing Incentives: • Build, expand, or modernize domestic facilities and equipment for semiconductor fabrication, assembly, testing, advanced packaging, or research and development, including US$ 2 billion specifically for mature semiconductors.

US$ 11 Billion for Research and Development (R&D):
• **DOC National Semiconductor Technology Center (NSTC):**
  ○ A public-private partnership to conduct advanced semiconductor manufacturing R&D and prototyping; invest in new technologies; and expand workforce training and development opportunities.
• **DOC National Advanced Packaging Manufacturing Program:**
  ○ A Federal R&D program to strengthen advanced assembly, test, and packaging (ATP) capabilities, in coordination with the NSTC.
• **DOC Manufacturing USA Semiconductor Institute:**
  ○ A partnership between government, industry, and academia to research virtualization of semiconductor machinery, develop ATP capabilities, and design and disseminate training.
• **DOC Microelectronics Metrology R&D:**
  ○ A National Institute of Standards and Technology (NIST) research program to advance measurement science, standards, material characterization, instrumentation, testing, and manufacturing capabilities.

[42] The U.S. Department of Commerce, Press Release: "Biden-Harris Administration Launches First CHIPS for America Funding Opportunity", February 28, 2023.
[43] U.S. Department of Commerce, "CHIPS for America Fact Sheet," March 18, 2024.

- **DOC Economic Development Administration (EDA)'s Tech Hub Program**
  - Designation of Tech Hubs in regions across the country to drive regional innovation and job creation.
  - Award of Strategy Development Grants (SDG) to help communities significantly increase local coordination and planning activities.

Defense, Technology Security and Workforce Development

- **CHIPS for America Defense Fund:**
  - US$ 2 billion for the DOD to implement the Microelectronics Commons, a national network for onshore, university-based prototyping, lab-to-fab transition of semiconductor technologies—including DOD-unique applications—and semiconductor workforce training.
- **CHIPS for America International Technology Security and Innovation Fund:**
  - US$ 500 million for the Department of State, in coordination with the U.S. Agency for International Development, the Export-Import Bank, and the U.S. International Development Finance Corporation, to support international information and communications technology security and semiconductor supply chain activities, including supporting the development and adoption of secure and trusted telecommunications technologies, semiconductors, and other emerging technologies.
- **CHIPS for America Workforce and Education Fund:**
  - US$ 200 million to kick start development of the domestic semiconductor workforce, which faces near-term labor shortages, by leveraging activities of the National Science Foundation.

Source: U.S. Department of Commerce, CHIPS and Science Act of 2022: Division A Summary - CHIPS and ORAN Investment, July 2022, and U.S. Economic Development Administration's Press Release: "Biden-Harris Administration Designates 31 Tech Hubs Across America", October 23, 2023.

The CHIPS Program Office, responsible for manufacturing incentives, and the CHIPS Research and Development Office, responsible for the R&D programs, both sit within the National Institute of Standards and Technology (NIST) at the DOC.[44] The CHIPS Program Office gives preference to applicants that commit to making long-term investments in the United States.[45] By providing substantial financial incentives and supporting cutting-edge research and development through programs administered by the NIST, the CHIPS Act aims to restore the United States as a leader in semiconductor technology and innovation.

[44] U.S. Department of Commerce, "Biden-Harris Administration Launches First CHIPS for America Funding Opportunity," February 28, 2023.

[45] National Institute of Standards and Technology, U.S. Department of Commerce, "Vision for Success: Commercial Fabrication Facilities CHIPS Incentives Program", February 28, 2023.

The CHIPS Act also provides a 25% investment tax credit for capital expenses for manufacturing of semiconductors and related equipment.[46] The tax credit is available for projects that start construction between January 1, 2023, and December 31, 2026.[47] Semiconductor firms that build new plants or extend existing plants, including foreign-owned firms such as TSMC and Samsung, can claim a tax credit equal to 25% of the cost for plant and equipment placed in service after December 31, 2022 or for which construction starts before January 1, 2027.[48]

The U.S. Congressional Budget Office originally estimated in 2022 that investment tax credit for capital expenses for manufacturing of semiconductors and related equipment would cost US$ 24.3 billion in forgone revenue.[49] However, according to a June 2024 report by the Peterson Institute for International Economics that used "very conservative assumptions based on the current investment trends," the true cost could be more than US$ 85 billion.[50]

In fact, tax credits are expected to account for the greatest share of CHIPS Act incentives going to any one company. Micron Technology Inc., for example, expects to get around US$ 11.3 billion in tax credits for two chip factories in New York, compared to the sums of US$ 6.1 billion in grants and US$ 7.5 billion in loans that it is receiving to support those two facilities and another plant in Idaho.[51] Texas Instruments Inc. anticipates US$ 6 billion to US$ 8 billion in tax credits — as much as five times the size of its Chips Act grant.[52]

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[46] The White House, Fact Sheet: "CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China," August 9, 2022.

[47] The White House, Fact Sheet: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China, August 9, 2021.

[48] Gary Clyde Hufbauer and Megan Hogan, Policy Brief 22-13 "CHIPS Act Will Spur US Production but Not Foreclose China", Peterson Institute for International Economics, October 2022.

[49] Congressional Budget Office, Cost Estimates: Table 2. Estimated Budgetary Effects of Divisions A and B of H.R. 4346, as Amended by the Senate and as Posted by the Senate Committee on Commerce, Science, & Transportation on July 20, 2022, https://www.cbo.gov/system/files/2022-07/hr4346_chip.pdf, Accessed on October 30, 2024.

[50] Martin Chorzempa, "The US and Korean CHIPS Acts are spurring investment but at a high cost," Peterson Institute for International Economics, June 10, 2024.

[51] US Department of Commerce, Press Release: "Biden-Harris Administration Announces Preliminary Terms with Micron to Onshore Leading-Edge Memory Chip Production in U.S. for First Time in Decades," April 25, 2024.

[52] Martin Chorzempa, "The US and Korean CHIPS Acts are spurring investment but at a high cost," Peterson Institute for International Economics, June 10, 2024.

Tax credits could also go to the many companies that were not awarded CHIPS grant money — like Applied Materials — but are still building factories for chips, equipment or wafers. Businesses can get refunds for construction that starts by the end of 2026 and is continuous after that point.[53]

Guardrails

The DOC highlighted that the funds under the CHIPS Act come with strong guardrails "to ensure technology and innovation funded by the CHIPS and Science Act is not used for malign purposes by adversarial countries against the United States or its allies and partners" and also "to prevent CHIPS funds from being used to directly or indirectly benefit foreign countries of concern".[54]

The Guardrails Rule applies only to covered entities who have a CHIPS agreement with the DOC. According to the CHIPS Act, a covered entity is defined as "a nonprofit entity, a private entity, a consortium of private entities, or a consortium of nonprofit, public, and private entities with a demonstrated ability to substantially finance, construct, expand, or modernize a facility relating to fabrication, assembly, testing, advanced packaging, production, or research and development of semiconductors, materials used to manufacture semiconductors, or semiconductor manufacturing equipment."[55]

The CHIPS Act identifies a "foreign country of concern" as one that falls under 10 U.S.C. § 4872(d) and any other country that the Secretary of Commerce, in consultation with other key government officials, determines poses a threat to U.S. national security or foreign policy.[56]

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[53] Ibid.

[54] The U.S. Department of Commerce, Press Release: "Commerce Department Outlines Proposed National Security Guardrails for CHIPS for America Incentives Program", March 21, 2023; "Frequently Asked Questions: Preventing the Improper Use of CHIPS Act Funding," NIST, https://www.nist.gov/chips/frequently-asked-questions-preventing-improper-use-chips-act-funding?form=MG0AV3; Accessed on November 19, 2024.

[55] Frequently Asked Questions: Preventing the Improper Use of CHIPS Act Funding, NIST, https://www.nist.gov/chips/frequently-asked-questions-preventing-improper-use-chips-act-funding?form=MG0AV3; Accessed on November 19, 2024.

[56] 10 U.S.C. § 4872(d) defines the terms used in Section 4872, which pertains to the acquisition of sensitive materials from non-allied foreign nations. Specifically, it includes definitions for "covered material" and "covered nation" (North Korea, China, Russia and Iran).

A "foreign entity of concern" under the CHIPS Act includes:

a) Entities designated as foreign terrorist organizations.
b) Entities on the specially designated nationals and blocked persons list by the U.S. Department of the Treasury.
c) Entities controlled by governments listed in 10 U.S.C. § 4872(d).
d) Entities convicted of certain illegal activities, such as espionage or violations of export control laws.
e) Entities determined by the Secretary of Commerce to be engaged in detrimental conduct to U.S. national security or foreign policy.
f) Entities on the Bureau of Industry and Security's Entity List.
g) Entities on the Department of the Treasury's list of Non-SDN Chinese Military-Industrial Complex Companies (NS–CMIC List).

A person is considered under the jurisdiction or direction of a government of concern if:

- They are a citizen, national, or resident of a listed country and are located there.
- Their organization is based in a listed country.
- The government of a listed country directly or indirectly holds 25% or more of their outstanding voting interest, board seats, or equity interest.
- Any combination of persons fitting these criteria holds 25% or more of their voting interest, board seats, or equity interest.

The CHIPS Act establishes two separate guardrails, namely the expansion guardrail and the technology guardrail, and includes clawbacks to prevent the beneficiaries of CHIPS funds from supporting the semiconductor manufacturing and technology development of foreign countries of concern. Both guardrails permit the U.S. DOC to recover the entire award if violated (See Figure 6).[57]

[57] National Institute of Standards and Technology, "Preventing the Improper Use of CHIPS Act Funding," Federal Register, September 25, 2023.

Figure 6: Chips Act Guardrails

Expansion Guardrail:
• Companies receiving CHIPS funding, as well as members of their affiliated group, may not build new facilities or expand existing facilities in foreign countries of concern for 10 years.   ○ They may upgrade manufacturing capacity by 5% for the purpose of allowing existing facilities to continue ordinary operations (such as tool upgrades and replacements). • Existing facilities manufacturing legacy semiconductors are excepted; however, such a facility may not increase capacity by 10% or more. • Existing facilities may upgrade their technology, but export controls may still apply. • The exception for new legacy facilities that predominantly serve the country of concern requires that 85% of the final products containing the chips be used or consumed in that country.
Technology Guardrail:
• Companies may not generally engage in joint research or technology licensing related to technology or products that raise national security concerns (i.e., certain export-controlled semiconductors or semiconductors critical to national security as determined by the Secretary) with foreign entities of concern.   ○ The Technology Guardrail does not apply to joint research or technology licensing that was ongoing prior to the issuance of the final rule on September 22, 2023.

Source: National Institute of Standards and Technology, US Department of Commerce, CHIPS for America: Preventing the Improper Use of CHIPS Act Funding, September 22, 2023.

The CHIPS Act classifies semiconductors as critical to national security and places limits on the expansion and new construction of legacy facilities in foreign countries of concern. Under the rules, "legacy semiconductor" means (1) a digital or analog chip of the 28nm generation or older; (2) a DRAM memory device with a half-pitch greater than 18nm or a NAND flash memory device that is less than 128 layers and does not use emerging memory technologies; or (3) any other device designated by DOC. Only semiconductors utilizing advanced 3D integration packaging such as by directly attaching one or more die or wafer, through silicon vias (TSV), or through mold vias (TMV) are not considered to be legacy semiconductors and would be subject to the guardrails.[58]

[58] "Preventing the Improper Use of CHIPS Act Funding," Federal Register, September 25, 2023, https://www.govinfo.gov/content/pkg/FR-2023-09-25/pdf/2023-20471.pdf, Accessed on November 20, 2024; Sujai Shivakumar, Charles Wessner, and Thomas Howell, "Guardrails" on CHIPS Act Funding to Restrict Investments in China May Restrict Participation in CHIPS Act Incentives, Center for Strategic and International Studies, November 7, 2023.

The rules do provide two exceptions to the prohibition for legacy semiconductors. The first applies to a recipient's existing facilities or equipment for manufacturing "legacy semiconductors" that exist on the date of the award so long as the facility does not undergo a "significant renovation" (capacity is increased by 10% or more). The second applies to new facilities so long as at least 85% of its output is incorporated in end products used or consumed in the host country.[59]

The guardrails enhance national security by:

- Prohibiting the material expansion of semiconductor manufacturing capacity ("increase of the semiconductor manufacturing capacity of an existing facility by more than 5% of the capacity memorialized in the required agreement due to the addition of a cleanroom, production line or other physical space, or a series of such additions") for leading-edge and advanced facilities in foreign countries of concern for 10 years from the date of award.
- Restricting the expansion of semiconductor manufacturing capacity for legacy facilities in foreign countries of concern.
- Classifying a list of semiconductors as critical to national security, thereby subjecting them to tighter restrictions. This designation covers chips that have unique properties that are critical to U.S. national security needs, including current-generation and mature-node chips used for quantum computing, in radiation-intensive environments, and for other specialized military capabilities. This list of semiconductor chips was developed in consultation with the Department of Defense and U.S. Intelligence Community.
- Restricting covered entities from engaging in joint research or technology licensing with a foreign entity of concern that relates to a technology or product that raises national security concerns. (This restriction does not apply to several types of engagements which are necessary to existing operations and do not threaten national security, such as activities related to international standards, involving patent

[59] National Institute of Standards and Technology, "CHIPS for America- Preventing the Improper Use of CHIPS Act Funding- Final Rule", September 22, 2023.

licensing, and to enable funding recipients to utilize foundry and packaging services.) [60]

- Restricting the ability of "U.S. persons" — including American citizens or green card holders —to support the development, or production, of semiconductors at certain China-located semiconductor fabrication "facilities" without a license.[61]
- Prohibiting recipients from using CHIPS funding for stock buybacks or dividends.[62]

Violations of these guardrails allow the DOC to take remedial measures, including recovering up to the full amount of the award.[63]

Export Controls

Alongside the provisions in the statute, the DOC's Bureau of Industry and Security (BIS) issued additional Export Administration Regulations (EAR) on the semiconductor industry on October 7, 2022.[64] Critical changes were made to the EAR in two areas to address U.S. national security and foreign policy concerns. First, BIS imposes additional export controls on certain advanced computing semiconductor chips, transactions for supercomputer end-uses, and transactions involving certain entities on the Entity List. Second, BIS adopts additional controls on certain semiconductor manufacturing items and on transactions for certain integrated circuit end use.

[60] U.S. Department of Commerce, Press Release: "Biden-Harris Administration Announces Final National Security Guardrails for CHIPS for America Incentives Program," September 22, 2023; "Frequently Asked Questions: Preventing the Improper Use of CHIPS Act Funding," NIST, https://www.nist.gov/chips/frequently-asked-questions-preventing-improper-use-chips-act-funding?form=MG0AV3, Accessed on November 19, 2024; Jamie Bennet, "NIST CHIPS Program Office Finalizes Material Expansion Scope in CHIPS Act Funding Use Law," ExecutiveGov, January 2, 2024; .

[61] Bureau of Industry and Security, U.S. Department of Commerce, Press Release: "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC), October 7, 2022.

[62] National Institute of Standards and Technology, U.S. Department of Commerce, "Vision for Success: Commercial Fabrication Facilities CHIPS Incentives Program", February 28, 2023.

[63] "Frequently Asked Questions: Preventing the Improper Use of CHIPS Act Funding," NIST, https://www.nist.gov/chips/frequently-asked-questions-preventing-improper-use-chips-act-funding?form=MG0AV3, Accessed on November 19, 2024;

[64] Bureau of Industry and Security, Department of Commerce, "Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification", Federal Register, Vol. 87, No. 197, October 13, 2022.

The export controls by BIS are aimed at restricting the ability of countries of concern, in particular China, to obtain advanced computing chips, develop and maintain supercomputers, and manufacture advanced semiconductors. These technologies are essential for China to produce advanced military systems, and improve military decision-making, planning, logistics, and autonomous military systems. Further, if BIS is prevented by the actions of foreign government from making compliance determinations, it will impact a company's access to U.S. technology through addition to the Entity List.[65]

The heaviest restrictions are centered on the tightening of restrictions on high performance computing chips, semiconductor manufacturing equipment, and supercomputing items. In addition to cutting-edge chips with U.S.-origin technology that meet the compute performance thresholds in a further October 17, 2023, controls, there will also be a gray zone that will be monitored for chips that could still be used for military aims even if they might not meet the thresholds for trade limitations.[66] One of the new rules, for example, prevents the workaround of simply purchasing a larger number of smaller datacenter AI chips which, if combined, would be equally powerful as restricted chips.

In addition, chip exports to companies headquartered in China and 21 other countries for which the U.S. maintains an arms embargo can be restricted to prevent countries of concern from circumventing the controls and providing chips to China. Similarly, controls are imposed on additional types of semiconductor manufacturing equipment, and license requirements for semiconductor manufacturing equipment will apply to additional countries beyond China, to anywhere under a U.S. arms embargo.[67]

[65] Bureau of Industry and Security, U.S. Department of Commerce, Press Release: "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)", October 7, 2022.

[66] Bureau of Industry and Security, U.S. Department of Commerce, Press Release: "Commerce Strengthens Restrictions on Advanced Computing Semiconductors, Semiconductor Manufacturing Equipment, and Supercomputing Items to Countries of Concern", October 17, 2023.

[67] Bureau of Industry and Security, U.S. Department of Commerce, "Frequently Asked Questions (FAQs) for "Export Controls on Semiconductor Manufacturing Items" (SME IFR) and "Implementation of Additional Export Controls: Certain Advanced Computing Items; Supercomputer and Semiconductor End Use; Updates and Corrections" (AC/S IFR)," December 29, 2023.

As of April 11, 2024, the DOC reported that 319 Chinese companies have been added to the Entity List by the Biden administration, compared to the 306 entities added during Donald Trump's time in the White House.[68]
On December 2, 2024, the BIS updated the EAR, adding 140 Chinese semiconductor-related companies to the Entity List.[69] It also announced a package of rules designed to further impair China's capability to produce advanced-node semiconductors that can be used in the next generation of advanced weapon systems and in AI and advanced computing, which have significant military applications. The package includes new controls on China-bound shipments of high bandwidth memory chips, critical for high-end applications like AI training; new curbs on 24 additional chipmaking tools and three software tools; and new export curbs on chipmaking equipment made in countries such as Singapore and Malaysia to prevent circumvention of the U.S. restrictions through third-party countries.[70]

International Coordination with U.S Partners and Allies

During the implementation of the CHIPS Act, the U.S.A. has remained in close contact with its partners and allies to advance shared goals, advance collective security, and strengthen global supply chains through initiatives such as the Chip 4 Alliance, the Indo-Pacific Economic Framework for Prosperity (IPEF), the U.S.A.-Japan-Netherlands Alliance, the European Union-United States Trade and the Technology Council (TTC) and North American Semiconductor Conference (NASC).[71]

Chip 4 Alliance

The Chip 4 Alliance is U.S. led partnership between four key players of the global semiconductor value chain – the United States, Taiwan, South Korea, and Japan.[72] The group's members are home to top IDMs like Intel and

[68] "Biden surpasses Trump's record for blacklisting Chinese entities," Bloomberg News, April 12, 2024.
[69] Bureau Of Industry and Security, U.S. Department of Commerce, Press Release: "Commerce Strengthens Export Controls to Restrict China's Capability to Produce Advanced Semiconductors for Military Applications," December 2, 2024.
[70] Karen Freifeld and David Shepardson, "Latest US clampdown on China's chips hits semiconductor toolmakers," Reuters, December 3, 2024.
[71] U.S. Department of Commerce, Press Release: Biden-Harris Administration Announces Final National Security Guardrails for CHIPS for America Incentives Program," September 22, 2023.
[72] Sarah Wu, "Taiwan says U.S.-led 'Chip 4' group discussed supply chain resilience," Reuters, September 30, 2022.

Micron, the world's largest contract chip maker TSMC, South Korean memory chip giants Samsung Electronics and SK Hynix and key Japanese suppliers of semiconductor materials and equipment.[73]

The U.S.A. has been a key driver in shaping the goals of the Chip 4 Alliance. Through the alliance, the U.S. focus has expanded beyond domestic production to include coordinated production and policy efforts among the world's largest semiconductor producing nations.[74] This initiative reflects U.S. strategic interests in securing the semiconductor supply chain, especially given the geopolitical importance of semiconductors in modern technology. By working closely with Japan, South Korea, and Taiwan, the U.S. aims to bolster the collective technological edge and ensure a resilient supply chain.[75]

At the alliance's first formal meeting of senior officials from its working group on February 16, 2023, the U.S.A.'s suggestion on an early warning system received positive responses from its partners.[76] This system is designed to prevent disruptions by providing timely information about potential issues in the supply chain.[77]

Indo-Pacific Economic Framework for Prosperity

Launched in May 2022, the IPEF is a U.S.-led economic initiative involving 14 countries in the Indo-Pacific region.[78] The U.S. partners include Australia, Brunei Darussalam, Fiji, India, Indonesia, Japan, the Republic of Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand and Vietnam, which together represent 40% of global GDP and 28% of global goods and services trade.

[73] "Taiwan says 'Fab 4' chip group held first senior officials meeting," Reuters, February 26, 2023.
[74] Zachariah Peterson, "An overview of the Chip 4 Alliance and its ramifications," Electronics 360, December 21, 2022.
[75] Ibid.
[76] 'Fab 4' discuss supply chain early warning system," Taipei Times, Feb 27, 2023; "Taiwan says 'Fab 4' chip group held first senior officials meeting," Reuters, February 26, 2023.
[77] Ralph Jennings, "US-led semiconductor alliance setting up 'early warning system' to protect supply chains, Taiwan says," South China Morning Post, February 27, 2023.
[78] "Indo-Pacific Economic Framework for Prosperity," U.S. Department of Commerce, https://www.commerce.gov/ipef, Accessed on November 20, 2024.

The IPEF aims to enhance economic cooperation, promote sustainable and inclusive growth, and strengthen supply chain resilience.[79] The Supply Chain Agreement under IPEF, which came into effect in February 2024, focuses on improving supply chain resilience and connectivity through collective and individual actions.[80]

At the first in-person meetings of the IPEF Agreement's Supply Chain Council on September 12, 2024, semiconductors, critical minerals, batteries, and chemicals have been identified as critical sectors under its supply chain resilience agreement.[81]

U.S.A.-Japan-Netherlands Alliance

The Netherlands and Japan hold the only three companies that supply the world with deep ultraviolet (DUV) lithography systems − the only chip making equipment that China can use since the Netherlands already banned the sale of extreme ultraviolet (EUV) lithography systems to China in 2019.

In January 2023, the Netherlands and Japan agreed to restrict semiconductor equipment exports to China in a deal with the U.S.A. aimed at cutting off China from the most advanced chips that could be used in sophisticated weaponry and machines.[82]

In July 2023, to align with U.S. policy, Japan, home to chip equipment makers Nikon Corp and Tokyo Electron, curbed exports of 23 types of equipment, from machines that deposit films on silicon wafers to devices that etch out the microscopic circuits.[83]

[79] Ibid.
[80] "IPEF: Pillar II – Supply Chains," U.S. Department of Commerce, https://www.commerce.gov/ipef/pillar-ii, Accessed November 20, 2024.
[81] U.S. Department of Commerce, Press Release: "U.S. and IPEF Partners Hold First In-Person Meetings of the IPEF Supply Chain Council and the IPEF Crisis Response Network," September 14, 2024.
[82] Leo Lewis and Kana Inagaki, "Japan to restrict semiconductor equipment exports as China chip war intensifies", Financial Times, March 31, 2023.
[83] Karen Freifeld and Toby Sterling, "US wants Netherlands, Japan to further restrict chipmaking equipment to China," Reuters, June 19, 2024.

Dutch ASML's machines use technologies developed in the U.S.A., making them subject to both U.S. and Dutch export restrictions.[84] On September 1, 2023, the Netherlands Standing Committee on Foreign Trade and Development Cooperation announced it is set to begin curbing its semiconductor technology exports to China. This regulation prevents ASML from exporting advanced chip manufacturing technologies without government-approved licenses.[85]

On October 17, 2023, the BIS published the updated version of the advanced computing and semiconductor manufacturing equipment rule, imposing additional restrictions on export of advanced chip manufacturing technology.[86] After the tightened U.S. rules, ASML is not allowed to sell to fabs that produce semiconductors near the cutting edge to China. China's Semiconductor Manufacturing International Corp (SMIC), a primary customer relying on DUV lithography for its 7nm-class process technology, faces restrictions in acquiring additional machines due to these new export limitations.[87] This export rule was imposed after SMIC reportedly used ASML's DUV lithography and its second-generation 7nm process (referred to as the N+2 processing technology) to make 7nm chips for Huawei.[88]

These coordinated efforts aim to prevent China from advancing its semiconductor manufacturing capabilities.

European Union-United States Trade and Technology Council

The European Union-United States Trade and Technology Council (TTC) is a platform established in June 2021 to deepen transatlantic cooperation on

[84] Alfonso Maruccia, "New export ban to China hits ASML's DUV lithography chip manufacturing tools, TechSpot, January 3, 2024.
[85] Ting-Fang Cheng and Lauly Li, "Netherlands' chip tool export controls take effect: 4 things to know", Nikkei Asia, August 31, 2023.
[86] ASML, Press Release: "Statement regarding US government's export control regulations announcement," October 17, 2023.
[87] Alfonso Maruccia, "New export ban to China hits ASML's DUV lithography chip manufacturing tools, TechSpot, January 3, 2024.
[88] Cagan Koc and Diederik Baazil, "Controversial chip in Huawei phone produced on ASML machine", American Journal of Transportation, October 25, 2023; "HiSilicon Kirin 9000s GFCV120 SMIC 7nm (N+2) FinFET Process Advanced CMOS Essentials Analysis," Tech Insights, https://www.techinsights.com/blog/hisilicon-kirin-9000s-gfcv120-smic-7nm-n2-finfet-process-advanced-cmos-essentials-analysis? Accessed on November 25, 2024.

trade, technology, and security.[89] At their inaugural meeting in 2021, both parties reaffirmed their commitment to rebalance global semiconductor supply chains to enhance security of supply and production capacity, especially for leading-edge semiconductors.[90]

The U.S.A. and EU have been cooperating under two administrative arrangements:

1. A joint early warning mechanism aimed at identifying (potential) supply chain disruptions and enabling early action to address their impacts, which has already proven useful in monitoring developments in the gallium and germanium markets; and
2. A transparency mechanism for reciprocal sharing of information about public support provided to the semiconductor sector.[91]

At the sixth ministerial meeting of the TTC which took place on 4 and 5 April 2024, the U.S.A. and the EU reiterated that they plan to extend the two administrative arrangements for an additional three years to enhance coordination and create synergies between their support for semiconductor sector investments under the EU Chips Act and the U.S. CHIPS Act. Both sides have also deepened their dialogue and cooperation on export controls and investment screening.[92]

North American Semiconductor Conference

The North American Semiconductor Conference (NASC) is a collaborative effort between the United States, Mexico, and Canada aimed at advancing government policies and increasing investment to strengthen regional semiconductor supply chains.[93] The first NASC took place in Washington, D.C., on May 18-19, 2023, with the support of the Semiconductor Industry Association and Arizona State University. The NASC reflects a shared

[89] "U.S.-EU Trade and Technology Council (TTC)," U.S. Department of State, https://www.state.gov/u-s-eu-trade-and-technology-council-ttc/, Accessed on November 20, 2024.
[90] The White House, Press Release: "U.S.-EU Trade and Technology Council Inaugural Joint Statement," September 29, 2021.
[91] The White House, Press Release: "U.S-EU Joint Statement of the Trade and Technology Council," April 5, 2024.
[92] The White House, Press Release: "U.S-EU Joint Statement of the Trade and Technology Council," April 5, 2024.
[93] Semiconductor Industry Association, Press Release: "North America Semiconductor Conference Meets in Washington to Advance Ambitious Plan to Rebalance Supply Chain," May 19, 2023.

commitment by government, industry, and academia to work together to strengthen the resilience of the North American semiconductor supply chain.[94]

At the Semiconductor Conference in May 2023, the governments of the United States, Canada and Mexico committed to grow the following areas of collaboration:

(1) **Information Exchange**: Supporting a robust and innovative North American R&D ecosystem, with the potential for new cross-border partnerships in semiconductor research and development.
(2) **Industry and Academic Partnerships**: Training the semiconductor workforce of the future.
(3) **Investments**: Developing, manufacturing, and packaging semiconductor technologies and related innovations to address supply chain gaps and leverage the strengths of each nation.[95]

DOMESTIC OUTCOMES OF CHIPS ACT

- **Companies have announced nearly US$ 400 billion in investments in semiconductors and electronics and the creation of over 115,000 jobs since President Biden and Vice President Harris took office.**

The CHIPS Act has had a significant impact across several key areas, including chip production, R&D, employment, and talent cultivation.

Chip Production

A BCG-SIA report released in May 2024 projected the United States will see a tripling of its domestic semiconductor manufacturing capacity from 2022—when CHIPS was enacted—to 2032.[96] The report also projected the U.S.A. will capture over one-quarter (28%) of total global capital expenditures (capex) from 2024-2032. In fact, the U.S. share of global semiconductor production capacity is projected to increase from 10% in 2022 to 14% 2032 (see Figure 7).

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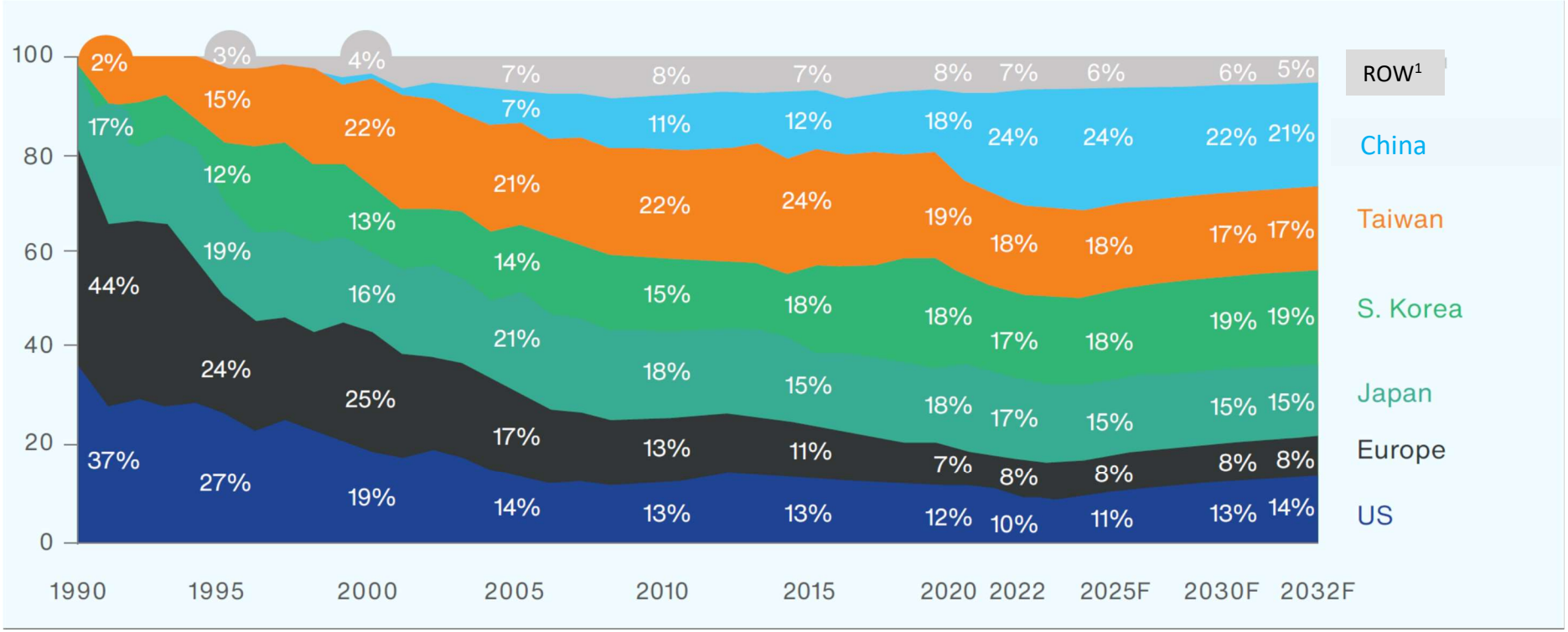
[94] The White House, Press Release: "Joint Statement on the Launch of the North American Semiconductor Conference and North American Ministerial Committee on Economic Competitiveness," May 24, 2023.
[95] Ibid.
[96] "Emerging Resilience in the Semiconductor Supply Chain," was released by the Semiconductor Industry Association (SIA) in partnership with the Boston Consulting Group (BCG) on May 8, 2024

South Korea, too, is expected to see an increase in its share of global semiconductor fab capacity. On the other hand, regions like China, Taiwan, Japan, and the “Rest of the World” (ROW) category are anticipated to experience a decline in their share of global semiconductor fab capacity. These shifts underscore the dynamic nature of the semiconductor industry and the strategic moves by countries to bolster their positions in this critical sector (see Figure 7).

Figure 7: Global 200mm (8-inch equivalent) Commercial Semiconductor Fab Capacity Share by Region: 1990-2032F



1. "ROW" includes Malaysia, Singapore, India, and the rest of the world.

Note: Rounding errors- may not total 100% due to rounding. All values shown in 300 mm (12") equivalents; excludes capacity below 5K wafer starts per month (wspm) or produced on wafer sizes less than 8 inches. WSPM is a measurement of the output of a semiconductor wafer plant. It refers to how many wafers that is put into the front of the line each month. This is determined by the capacity of the bottleneck step, as well as how much time the overall processes take.

Source: Raj Varadarajan, Iacob Koch-Weser, Christopher Richard, Joseph Fitzgerald, Jaskaran Singh, Mary Thornton, and Robert Casanova, "Emerging Resilience In The Semiconductor Supply Chain," Semiconductor Industry Association and Boston Consulting Group, May 8, 2024, p. 15.

As of November 2024, over US$ 36 billion of the US$ 52.7 billion in federal funding provided by the CHIPS Act has been announced.[97]

The CHIPS Program Office within the U.S. DOC is responsible for administering US$ 39 billion in semiconductor incentives through direct funding in the form of grants, loans and loan guarantees. These funds are designated for projects involving the construction, expansion, or modernization of semiconductor manufacturing facilities.[98]

The DOC has signed preliminary agreements with 16 semiconductor fabrication companies, committing US$ 36 billion in direct funding and approximately US$ 25 billion in loans. The DOC aims to allocate all remaining funds to CHIPS grantees by the end of 2024.[99] As of November 27, 2024, Intel, BAE Systems, GlobalFoundries, TSMC, and Polar Semiconductor are among the few semiconductor fabrication companies that have had their awards finalized (see Tables 5 and 6).[100]

Table 5: Finalized CHIPS for America Awards (Semiconductor Fabrication)

Company	Award Amount	Purpose
Intel Corporation **Hillsboro, Oregon; Chandler, Arizona; New Albany, Ohio and Rio Rancho, New Mexico*** * Award for Rio Rancho, New Mexico is for advanced packaging facility	up to US$ 7.9 billion	**Oregon**: Expansion and modernization of technology development facilities that will utilize the world's first High NA EUV (high-numerical aperture extreme ultraviolet) lithography equipment. **Arizona**: Construction of two new leading-edge logic fabs and modernization of one existing fab, significantly increasing leading-edge logic capacity, including high volume domestic production of Intel 18A – the company's most advanced chip design that enables higher performing, leading-edge chips through RibbonFET gate-all-around transistors and PowerVia backside power delivery.

[97] "Funding Updates," NIST, https://www.nist.gov/chips/funding-updates, Accessed on November 21, 2024.

[98] National Institute of Standards and Technology, Department of Commerce, United States, "CHIPS for America Fact Sheet: Federal Programs Supporting the U.S. Semiconductor Supply Chain and Workforce," March 18, 2024.

[99] The White House, Fact Sheet: "Two Years after the CHIPS and Science Act, Biden-Harris Administration Celebrates Historic Achievements in Bringing Semiconductor Supply Chains Home, Creating Jobs, Supporting Innovation, and Protecting National Security," August 9, 2024.

[100] "Funding Updates," NIST, https://www.nist.gov/chips/funding-updates, Accessed on November 21, 2024.

Company	Award Amount	Purpose
		Ohio: Creation of a new regional chipmaking ecosystem, anchored by the construction of two leading-edge logic fabs, expanded leading-edge foundry capacity, and supply chain diversification. **New Mexico**: Modernization of two existing fabs into an advanced packaging facility to close an important gap in the domestic semiconductor supply chain.
BAE Systems, Inc. **Nashua, New Hampshire**	approximately US$ 35 million	Modernization project that will replace aging tools and quadruple the production of chips necessary for critical defense programs, including the US$ 1.7 trillion F-35 fighter jet program.
GlobalFoundries **Burlington, Vermont and Malta, New York** * GlobalFoundries focuses on specialized processes and high-volume manufacturing at the 14nm and 12nm levels, having halted development of sub-7 nm nodes in 2018. Its 12LP+ fabrication process is comparable to 10nm-class nodes of other foundries.	up to US$ 1.5 billion in direct funding	**Vermont**: Revitalization of an existing fabrication facility that is expected to commercialize new 200 mm technologies. This would create the first U.S. facility capable of high-volume manufacturing of next-generation Gallium Nitride on Silicon for use in electric vehicles, power grid, 5G and 6G smartphones, and other critical technologies. **New York**: Construction of a new, large-scale 300 mm fabrication facility that is expected to produce high value technologies not currently available in the U.S. It will also support the expansion of the existing Malta, New York fabrication facility, which includes a strategic agreement with General Motors, that is expected to secure a dedicated supply of essential semiconductor technologies.
TSMC Arizona **Phoenix, Arizona**	US$ 6.6 billion in direct funding	TSMC's planned investment of more than US$ 65 billion in three greenfield leading-edge fabs in Phoenix, Arizona. • **Fab 1**: 4nm and 5nm Fin Field-Effect Transistor (FinFET) process technologies • **Fab 2**: 3nm FinFET process technologies • **Fab 3**: TSMC A16™ technology and TSMC 2nm (N2) process technologies
Polar Semiconductor **Bloomington, Minnesota**	US$ 123 million in direct funding	Expand and modernize the company's manufacturing facility in Bloomington, Minnesota, doubling its U.S. production capacity of sensor and power chips within two years.

Listing is in reverse chronological order. List of investments as of November 27 2024.
Source: "CHIPS for America Awards," NIST, https://www.nist.gov/chips/chips-america-awards?page=0, Accessed on November 27, 2024.

Table 6: Proposed CHIPS for America Awards (Semiconductor Fabrication)

Company	Proposed Award Amount	Purpose
Akash Systems **West Oakland, California**	up to US$ 18.2 million	Construction of a 40,000 square foot cleanroom space within an existing building to transform it into a facility for semiconductor manufacturing with various Diamond Cooling substrates, devices, and systems at scale.
Infinera **San Jose, California**	up to US$ 93 million (split across Bethlehem, PA and San Jose, CA)	Construction of a new, modernized fab and foundry with over 40,000 square feet of cleanroom space, which would increase its Indium Phosphide (InP) Photonic Integrated Circuit (PIC) manufacturing to meet future capacity and capability demands.
Wolfspeed **Marcy, New York and Siler City, North Carolina**	up to US$ 750 million	**New York**: Expansion of its device manufacturing facility which would contribute to the growth of the facility as the world's first fully automated 200mm silicon carbide power device fab. **North Carolina**: Construction of a new silicon carbide wafer manufacturing facility.
HP Inc. **Corvallis, Oregon**	up to US$ 50 million	Expansion and modernization of HP's existing facility in Corvallis, Oregon, which is part of the company's "lab-to-fab" ecosystem in the region that spans from R&D activities to commercial manufacturing operations.
Texas Instruments **Lehi, Utah and Sherman, Texas**	up to US$ 1.6 billion	**Utah:** Construction of one new 300-mm fabrication plant. **Texas**: Construction of two new, large-scale 300-mm fabrication facilities that are expected to produce 65nm – 130nm essential chips.
SK hynix **West Lafayette, Indiana**	up to US$ 450 million	Construction of a memory packaging plant for artificial intelligence (AI) and an advanced packaging R&D facility.
Rogue Valley Microdevices **Palm Bay, Florida**	up to US$ 6.7 million	Construction of RVM's pure play microelectromechanical systems (MEMS) and sensor foundry facility in Palm Bay, Florida.
Micron **Boise, Idaho and Clay, New York**	up to roughly US$ 6.14 billion	**Idaho**: Develop a high-volume manufacturing (HVM) fab, with approximately 600,000 square feet of cleanroom space focused on the production of leading-edge DRAM chips in Idaho. **New York**: Construct the first two fabs of planned four fab "megafab" focused on leading-edge DRAM chip production in New York.

Company	Proposed Award Amount	Purpose
Samsung Electronics **Austin, Texas and Taylor, Texas**	up to US$ 6.4 billion	**Austin, Texas**: Expand the existing facilities to support the production of leading fully depleted silicon-on-insulator (FD-SOI) process technologies. **Taylor, Texas**: Construction of a comprehensive advanced manufacturing ecosystem comprising two leading-edge logic foundry fabs focused on mass production of 4nm and 2nm process technologies, a research and development fab dedicated to development and research on technology generations ahead of nodes currently in production, and an advanced packaging facility producing 3D High Bandwidth Memory and 2.5D packaging.
Microchip Technology **Gresham, Oregon and Colorado Springs, Colorado**	approximately US$ 162 million	**Oregon**: Expand a fabrication facility to increase its U.S. production of microcontroller units and other specialty semiconductors built on mature-nodes. **Colorado**: Modernize and expand a fabrication facility to significantly increase its U.S. production of microcontroller units and other specialty semiconductors built on mature-nodes.

Listing is in reverse chronological order. List of investments as of November 27 2024.
Source: "CHIPS for America Awards," NIST, https://www.nist.gov/chips/proposed-funding-sites?page=0, Accessed on November 27, 2024.

The CHIPS Act award will be finalized only if the semiconductor fabrication company meets key milestones and satisfies DOC's due diligence requirements. The purpose of due diligence is "to validate material facts of the application", "address critical risks", and "uncover any new information that may impact the size, nature, or timing of the proposed award".[101] This process, which applies to all CHIPS Act applicants, has been clear from the outset and aims to ensure that companies receive taxpayer dollars only after they have met their commitments.

[101] NIST, "Due Diligence Process Fact Sheet," July 2024, https://www.nist.gov/system/files/documents/2024/07/15/20240415%20DD%20Fact%20Sheet-508C.pdf, Accessed November 25, 2024.

Advanced Chipmakers of Sub-7nm Chips: TSMC, Samsung and Intel

Currently, only three companies—TSMC, Samsung, and Intel—are capable of providing foundry services below the 7nm process.[102] Of the three, TSMC and Intel have had their CHIPS Act award finalized.

TSMC's CHIPS Act award includes US$ 6.6 billion in grants and up to US$ 5 billion in loans.[103] TSMC has already achieved some of the benchmarks required for CHIPS Act funding and DOC's finalization of TSMC's CHIPS Act funding came after TSMC pledged to produce chips in the U.S.A. using its advanced A16 process.[104] The TSMC A16™ technology is a next-generation nanosheet-based technology featuring an innovative Super Power Rail (SPR).[105] It is an improvement over the TSMC 2nm (N2) technology, with improved logic density and performance, better power delivery and reduced voltage drop. The decision to use TSMC's advanced A16 technology in Arizona guarantees that cutting-edge semiconductor manufacturing will return to the U.S.A., aligning with the U.S. goal of boosting domestic semiconductor manufacturing of advanced chips.[106]

TSMC Arizona will play a vital role in the U.S. government's goal to onshore semiconductor manufacturing and strengthen national economic competitiveness. Its first fab in Arizona, utilizing the 4nm (N4) and 5nm (N5) Fin Field-Effect Transistor (FinFET) process technologies, will begin 4 nm production in December 2024, and start mass production in the first half of 2025.[107] The second fab, utilizing its leading edge 3nm (N3) FinFET process technology, will be operational in 2028. By 2028, the combined monthly

[102] TrendForce, Press Release: "Samsung Reportedly Joins TSMC in Halting 7nm and Below AI Chip Supplies to China," November 12, 2024.
[103] U.S. Department of Commerce, Press Release: "Biden-Harris Administration Announces CHIPS Incentives Award with TSMC Arizona to Secure U.S. Leadership in Advanced Semiconductor Technology," November 15, 2024.
[104] Mackenzie Hawkins and Ian King, "TSMC's Chips Act Award Finalized by US, With Funds Coming This Year," Bloomberg, November 15, 2024; "TSMC's US$6.6bn subsidy linked to 'A16' tech process," Taipei Times, November 19, 2024.
[105] "A16 Technology," TSMC, https://www.tsmc.com/english/dedicatedFoundry/technology/logic/l_A16, Accessed on November 22, 2024.
[106] Mackenzie Hawkins and Ian King, "TSMC's Chips Act Award Finalized by US, With Funds Coming This Year," Bloomberg, November 15, 2024.
[107] "TSMC Arizona," TSMC, https://www.tsmc.com/static/abouttsmcaz/index.htm, Accessed on November 28, 2024; Michael Nakhiengchanh, "Taiwan's TSMC Arizona fab to begin 4 nm production in December," Taiwan News, November 4, 2024.

capacity of these two fabs is projected to reach 60,000 wafers.[108] The recently announced third fab will manufacture chips using TSMC A16™ technology and 2nm (N2) process technologies, with production starting by the end of the decade.[109]

Intel's CHIPS Act award of close to US$ 7.9 billion was finalized on November 26, 2024, down from the US$ 8.5 billion announced in March.[110] It is the biggest recipient of money under the CHIPS Act. The media reported that Intel won a US$ 3 billion contract with the Defense Department in September 2024, after the initial US$ 8.5 billion in grants had been announced. As funding for the Pentagon contract ended up coming from the CHIPS fund rather than the Pentagon's budget, Intel's direct grant award was reduced.[111]

Intel's Fab 52 and Fab 62 in Arizona, which will be manufacturing chips using Intel's next-generation Angstrom-era process technology, including the 18A node, are facing delays due to rising construction costs and labor shortages.[112] Previously scheduled to be completed in 2024, the fabs are now likely to begin operations a year later, in early 2025.[113] In November 2024, Intel announced that it will bring Intel 18A into high-volume manufacturing at Fab 52 in 2025.[114]

Intel's 18A process nodes, however, has received mixed reviews. On one hand, it features advanced technologies like gate-all-around (GAA) transistors and backside power delivery networks (BSPDN), which promise improved performance and efficiency.[115] However, it has faced significant challenges, particularly with yield rates reportedly as low as 10%, making it currently unfit for mass production.[116] Broadcom has voiced its disappointment with Intel's

[108] TrendForce, Press Release: "These Advanced 12-Inch Wafer Fabs Enter a New Stage," December 3, 2024.
[109] Ibid.
[110] David Shepardson, "US finalizes $7.86 billion chips manufacturing award for Intel," Reuters, November 26, 2024.
[111] Ibid.
[112] TrendForce, Press Release: "Uncashed Checks of the Struggling Giant: Intel's Unfulfilled Expansion Plans in a Nutshell," September 10, 2024.
[113] Michelle Adams, "Where Are All The North American Semiconductor Fabs Being Built (2024 Edition)?" Z2Data, October 4, 2024.
[114] Intel, Press Release: "Intel Arizona: The Silicon Desert", revised in November 2024.
[115] TrendForce, Press Release: "The Imminent Arrival of 2-Nanometer Advanced Process," December 3, 2024.
[116] Zo Ahmed, "Intel 18A node reportedly stuck at 10% yields, SRAM density also trails TSMC upcoming 2nm tech," TechSpot, December 6, 2024.

18A node, citing these low yield rates as a major concern. In contrast, Amazon Web Services (AWS), Intel's customer for the 18A process, announced a co-investment in custom chip designs under a multi-year, multi-billion-dollar framework covering product and wafers from Intel.[117]

The construction of Intel's two leading-edge logic fabs in Ohio, too, is facing two-year delays due to market challenges and delays in U.S. subsidies.[118] Ongoing business challenges saw Intel posting its largest loss in the third quarter of 2024 in the company's 56-year history.[119] Originally scheduled to begin chip manufacturing in Ohio in 2025, Intel is now aiming to complete the two fabs in Ohio in 2026–2027, with operations expected to commence around 2027–2028.[120]

Samsung – the only leading-edge semiconductor company that is a leader in both advanced memory and advanced logic technologies– has not had its CHIPS Act award finalized. Samsung's project involves significant investment and expansion in Texas, including the construction of new manufacturing facilities and research and development centers.[121] The scale and complexity of the project require extensive planning and assessment.

Samsung's first fab, known as Fab 2, is currently under construction, with completion targeted for 2026 and advanced sub-5nm processes in development.[122] The start of construction for its second plant, originally expected in 2024, has been postponed.

Samsung Electronics' foundry business is currently facing a challenging period.[123] The company has reported consecutive losses due to low yield rates

[117] Intel, Press Release: "Intel and AWS Expand Strategic Collaboration, Helping Advance U.S.-Based Chip Manufacturing," September 16, 2024.
[118] Dan Robinson, "Intel delays Ohio fab build, blames semiconductor slowdown," The Register, February 2, 2024.
[119] Tripp Mickle and Ana Swanson, "Washington Curtails Intel's Chip Grant After Company Stumbles," The New York Times, November 24, 2024.
[120] TrendForce, Press Release: "Uncashed Checks of the Struggling Giant: Intel's Unfulfilled Expansion Plans in a Nutshell," September 10, 2024.
[121] U.S. Department of Commerce, "Biden-Harris Administration Announces Preliminary Terms with Samsung Electronics to Establish Leading-Edge Semiconductor Ecosystem in Central Texas," April 15, 2024.
[122] TrendForce, Press Release: "Samsung Reportedly Suspends Construction and Contract Plans for Pyeongtaek P4 and Taylor Plant 2," September 26, 2024.
[123] Kim Eun-jin, "Samsung's Foundry Operations Struggle with Unstable Yields and Client Losses," Business Korea, September 30, 2024.

for its advanced process technologies, including its 3nm Gate-All-Around (GAA) process and 2nm process.[124] The success rate, or yield, is a critical measure in the semiconductor industry because it determines whether companies would be able to cover the enormous costs of a chip plant.[125] Although mass production of Samsung's first-generation 3nm process was announced in June 2022, its yields for the 3nm process is still lower than the targeted 70% needed to be competitive.[126] While its yields have improved to between 30-60%, from the initial 20%, Samsung still lags behind TSMC's rumored yield rate of close to 90% for its 3nm (N3E) process.[127] Samsung's technological setback has overshadowed the company's attempts to compete with industry leader TSMC, which dominated the market with a 64.9% share in the second quarter of 2024, far surpassing Samsung's 9.3%.[128]

Samsung is currently focusing on resolving yield issues with their 2nm process technology and finalizing their plans before proceeding with the construction of its second fab in Texas.[129] Meanwhile, the White House is rushing to wrap up negotiations with Samsung, which would provide significant subsidies and support for Samsung's semiconductor manufacturing efforts in the U.S.A.[130]

Overall, the outlook for onshore advanced chip production in the U.S.A. appears positive. TSMC's over US$ 65 billion investment in Arizona and Intel's over US$ 100 billion investment for projects in Arizona, New Mexico, Ohio, and Oregon are expected to provide a major boost to U.S. production of advanced semiconductors.[131]

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[124] Ibid.
[125] Mackenzie Hawkins, "TSMC Arizona fab's yield surpasses Taiwan in Win for U.S.," Bloomberg, October 26, 2024.
[126] Samsung, Press Release: "Samsung Begins Chip Production Using 3nm Process Technology With GAA Architecture," June 30, 2022; Kumar Priyadarshi, "Samsung's 3nm Yield Woes: GAA Gamble Backfires, TSMC Takes the Lead?" Techovedas, June 19, 2024.
[127] Ibid; TrendForce, Press Release: "Samsung May Outsource Exynos Production to TSMC Due to Low 3nm Yield Rate," November 14, 2024.
[128] TrendForce, Press Release: Advanced Processes and Chinese Policies Drive 3Q24 Global Top 10 Foundry Revenue to Record Highs, Says TrendForce," December 5, 2024.
[129] Charlotte Trueman, "Samsung Electronics delays construction at Texas chip fab to consider 2nm foundry process upgrade – report," Data Center Dynamics, June 19, 2024.
[130] Mackenzie Hawkins, "Trump's Win Sets Off Race to Complete Chip Subsidy Deals," Bloomberg, November 8, 2024.
[131] TSMC, Press Release: "TSMC Arizona and U.S. Department of Commerce Announce up to US$6.6 Billion in Proposed CHIPS Act Direct Funding, the Company Plans Third Leading-Edge Fab in Phoenix," April 8, 2024; U.S. Department of Commerce, Press Release: "Biden-Harris Administration Announces CHIPS Incentives

Taiwanese media, citing a research report published on November 22, 2024, by market research firm TrendForce, reported that following significant investments in the U.S. semiconductor industry, particularly TSMC's US$ 65 billion investment in Arizona, the U.S.A. is projected to become No. 2 in advanced semiconductor production in 2027.[132] The White House, too, announced that by 2032, the U.S.A. is expected to supply nearly 30% of the world's advanced chips (≤7nm).[133]

Achieving the projections on advanced chip production as outlined by TrendForce and the White House would heavily rely on the successful allocation of CHIPS Fund to all awardees and ensuring they meet their obligations. Notably, the construction of fabs and ramping up semiconductor production are extremely costly and time-consuming endeavors.[134] Significant expansion typically takes around a year, while building a new facility can take over three years. After the fab is completed, the processes of transporting EUV machines from factory to fab, assembling and testing of the machines and equipment, setting up of the production line for specific products and optimization of the production and quality control processes can take several more months.[135] This makes it challenging to quickly increase semiconductor volumes in the U.S.A.

Among the "Big Three", TSMC is the first to start mass production in early 2025. TSMC has achieved early production yields at its first plant in Arizona that surpass similar factories back home, a significant breakthrough for its U.S. expansion project.[136] Its shares reached a record high in October 2024

Award with Intel to Advance U.S. Leading-Edge Chip Capacity and Create Tens of Thousands of Jobs," November 26, 2024.

[132] TrendForce defines advanced foundry capacity as referring to non-planar (3D) transistor architecture processes including ⩽16/14nm nodes; Chang Chien-chung and Frances Huang, "With TSMC, U.S. forecast to become No. 2 in advanced IC production in 2027," Focus Taiwan, November 23, 2024.

[133] The White House, Fact Sheet:" Two Years after the CHIPS and Science Act, Biden-Harris Administration Celebrates Historic Achievements in Bringing Semiconductor Supply Chains Home, Creating Jobs, Supporting Innovation, and Protecting National Security," August 9, 2024.

[134] Ondrej Burkacky, Marc de Jong and Julia Dragon, "Strategies to lead in the semiconductor world," McKinsey & Company, April 15, 2022.

[135] DHL, Discussion Paper: "Resilience of The Semiconductor Supply Chain," November 17, 2022.

[136] Mackenzie Hawkins, "TSMC Arizona fab's yield surpasses Taiwan in Win for U.S.," Bloomberg, October 26, 2024.

after the chipmaker topped quarterly estimates and raised its target for revenue growth in 2024.[137]

Intel is the second to start mass production using its 18A process technology in 2025. Intel says that the defect density for its 18A process is below 0.4 defects per square centimeter, which is considered healthy.[138] However, some potential clients, like Broadcom, have reported mixed feedback, suggesting that the 18A process might not yet be viable for high-volume production.[139] Additionally, faced with a US$ 7 billion operating loss for the foundry business in 2023, Intel is under severe financial pressure.[140] It has announced it would cut over 15,000 jobs by the end of 2024, aiming to save US$ 10 billion.[141] The layoffs are already impacting 2,000 jobs in California, Oregon, and Arizona, with more expected across other locations.[142] It is also delaying global projects and considering selling assets.[143] In fact, Intel has quietly suspended several of its investment plans in Europe, dealing a setback to Europe's push to produce more semiconductors.[144]

Meanwhile, Samsung, which will only start production of advanced chips in the U.S.A. in 2026, is facing yield issues and operating losses. According to TrendForce, Samsung's foundry business is expected to face operating losses amounting to several trillion Korean won in 2024.[145]

While the investments from TSMC, Intel, and Samsung, coupled with the U.S. government's support through the CHIPS Act, are crucial in growing production of advanced chips in the U.S.A., achieving the production targets

[137] Ibid.
[138] Anton Shilov, "Intel says defect density at 18A is 'healthy,' potential clients are lining up," Tom's Hardware, September 4, 2024.
[139] Max A. Cherney, "Exclusive: Intel manufacturing business suffers setback as Broadcom tests disappoint," Reuters, September 4, 2024.
[140] Ibid.
[141] Barbara Ortutay, "Chipmaker Intel to cut 15,000 jobs as tries to revive its business and compete with rivals," Associated Press, August 2, 2024.
[142] Dylan Martin, "Mass Layoffs at Intel Impact 2,000 Jobs in California, Oregon And Arizona," CRN, October 16, 2024.
[143] Mackenzie Hawkins, "TSMC Arizona fab's yield surpasses Taiwan in Win for U.S.," Bloomberg, October 26, 2024.
[144] Pieter Haeck, "Intel shelves French, Italian chip investments," Politico, July 4, 2024.
[145] TrendForce, Press Release: "Samsung's Foundry Business Reportedly Struggles with Losses behind Soaring Profits in Q2," August 12, 2024.

for advanced chips, especially targets by 2027, would fall largely on TSMC's contribution.

Legacy Chipmakers

The CHIPS Act also recognizes the importance of legacy semiconductors, which typically use older manufacturing processes (often above 7nm). While companies like TSMC, Samsung, and Intel are pushing the boundaries with sub-7nm technologies, GlobalFoundries, the fifth-largest semiconductor foundry in the world by revenue, specializes in legacy semiconductors for essential applications such as automotive, communications, and defense, which do not require the latest technology.[146] BAE Systems, a niche semiconductor player, produces legacy semiconductors in the form of Monolithic Microwave Integrated Circuit (MMIC) chips, which are critical components for advanced military aircraft and commercial satellite systems.[147]

GlobalFoundries' CHIPS Act award was finalized on November 20, 2024. The preliminary agreement was already in place since February 2024, and the company met the necessary milestones and due diligence requirements efficiently. The company's projects, including the expansion of its existing fab in Malta, New York, and the modernization of its facility in Vermont, are both Trusted Foundry accredited and were well-aligned with the goals of the CHIPS Act.[148] Additionally, the scale and scope of GlobalFoundries' projects, which are expected to triple the existing capacity of its Malta campus over the next decade, likely demonstrated a strong commitment to boosting U.S. domestic semiconductor manufacturing.[149]

BAE Systems' preliminary agreement was signed in December 2023 and upon successfully meeting the necessary milestones and due diligence

[146] U.S. Department of Commerce, "Biden-Harris Administration Announces Preliminary Terms with GlobalFoundries to Strengthen Domestic Legacy Chip Supply for U.S. Auto and Defense Industries," February 19, 2024; TrendForce, Press Release: "Top 10 Global Foundries at 4.3% QoQ Drop in 1Q24 Revenue as SMIC Climbed to 3rd Spot, Says TrendForce," June 12, 2024.
[147] "BAE Systems, Inc. (New Hampshire)," NIST, https://www.nist.gov/chips/bae-systems-inc-new-hampshire-nashua, Accessed on November 26, 2024.
[148] GlobalFoundries, Press Release: "GlobalFoundries and U.S. Department of Commerce Announce Award Agreement on CHIPS Act Funding for Essential Chip Manufacturing," November 20, 2024.
[149] Ibid.

requirements, its CHIPS Act award was finalized on November 25, 2024. BAE Systems' Microelectronics Center in Nashua, New Hampshire, is a Department of Defense (DoD)-accredited Trusted Foundry. Moreover, BAE Systems' chips are critical components for advanced military system and this aligns with U.S. national defense priorities.[150]

The increased production of both advanced and legacy chips within the U.S. helps strengthen supply chain security, reduce reliance on foreign manufacturers, and support a diverse array of technological needs.

Overall Chip Production and the Semiconductor Ecosystem

To create a robust semiconductor ecosystem, the CHIPS Act is also supporting multiple high-volume advanced packaging facilities, and critical supply chain components.[151] According to the White House, dozens of companies have pledged nearly US$ 400 billion towards semiconductor investments across the U.S.A. As more chips are produced in America, the U.S. share of the world's chip manufacturing capacity is expected to increase to 14% by 2032 (see Figure 7).[152] Attaining this milestone, however, is highly dependent on the effective distribution of CHIPS Fund to all recipients and their adherence to the set commitments.

Research and Development

The CHIPS for America Office within the U.S. DOC is responsible for administering US$ 11 billion to advance U.S. leadership in semiconductor R&D through four programs: [153]

[150] NIST, Press Release: "Biden-Harris Administration Announces CHIPS Incentives Awards with BAE Systems, Inc., and Rocket Lab to Expand Production of Chips Critical for U.S. National Security and Space Industry," November 25, 2024

[151] The White House, FACT SHEET: Two Years after the CHIPS and Science Act, Biden-Harris Administration Celebrates Historic Achievements in Bringing Semiconductor Supply Chains Home, Creating Jobs, Supporting Innovation, and Protecting National Security," August 9, 2024.

[152] Ibid.

[153] CHIPS R&D Funding Opportunities, NIST, https://www.nist.gov/chips/chips-rd-funding-opportunities, Accessed on November 25, 2024.

1) The CHIPS National Semiconductor Technology Center (NSTC) Program

This program focuses on fostering innovation and collaboration in semiconductor technology, aiming to drive cutting-edge advancements and create a robust semiconductor ecosystem.

2) The CHIPS National Advanced Packaging Manufacturing Program (NAPMP)

This program emphasizes the development of advanced packaging technologies, which are crucial for integrating different semiconductor components and enhancing their performance and efficiency. Over 100 concept papers were submitted for the first funding opportunity. The upcoming second funding opportunity, amounting to US$ 1.6 billion, scheduled for fall 2024, will further boost efforts in this crucial area.[154]

Advanced packaging technologies are essential for the future of semiconductor manufacturing, ensuring that components are efficiently and effectively combined to meet the growing demands of various applications.

3) The CHIPS Metrology Program

This program aims to develop and implement advanced measurement technologies and standards to ensure the quality and reliability of semiconductor manufacturing processes.

4) The CHIPS Manufacturing USA Program

This program supports the establishment of up to three Manufacturing USA institutes, focusing on semiconductor manufacturing and advanced packaging, promoting collaboration between industry, academia, and government to drive technological progress.[155]

The DOC and the Semiconductor Research Corporation Manufacturing Consortium Corporation (SRC) are entering negotiations for the DOC to

[154] U.S. Department of Commerce, Press Release: "Biden-Harris Administration Opens Funding Competition for Up to $1.6 Billion to Accelerate U.S. Semiconductor Advanced Packaging Technologies," October 18, 2024.
[155] "A Strategy for The Chips for America Fund," The U.S. Department of Commerce, September 6, 2022.

provide SRC US$ 285 million to establish and operate the first Manufacturing USA institute.[156]

The new institute, known as SMART USA (Semiconductor Manufacturing and Advanced Research with Twins USA), will be headquartered in Durham, North Carolina. With combined funding totaling US$ 1 billion, this investment will focus on efforts to develop, validate, and use digital twins to improve domestic semiconductor design, manufacturing, advanced packaging, assembly, and test processes.[157]

SMART USA will join an existing network of seventeen institutes designed to increase U.S. manufacturing competitiveness and promote a robust R&D infrastructure. SRC is an important part of North Carolina's research ecosystem, including decades-long relationships with North Carolina's universities.[158]

Table 7 shows a list of CHIPS Act R&D awardees. The CHIPS for America Awards for semiconductor R&D play a crucial role in fostering innovations and maintaining the U.S.'s leadership in semiconductor technology. By investing in R&D, these awards help catalyze new innovations, improve production processes, and develop cutting-edge semiconductor technologies. This not only boosts the U.S.'s competitive edge but also ensures a robust and resilient semiconductor industry that can meet future technological demands.

[156] U.S. Department of Commerce, Press Release: "CHIPS for America Announces New Proposed $285 Million Award for CHIPS Manufacturing USA Institute for Digital Twins, Headquartered in North Carolina," November 19, 2024.
[157] Ibid.
[158] Ibid.

Table 7: CHIPS for America Awards (R&D)

Company	Award Amount	Purpose
Activate – **Berkeley, CA**	US$ 5,000,000	Establish an Entrepreneurial Fellowship Pilot program that will fund up to 10 early-stage companies ("Fellows") focused on innovations in semiconductor manufacturing technologies.
Photon Spot, Inc. – **Monrovia, CA**	US$ 283,393	Develop an ultra-compact, ultra-low vibration cryogenic system to support time-resolved imaging applications. This project will benefit integrated circuit manufacturers and researchers conducting experiments on quantum technologies.
Sigray Inc. – **Concord, CA**	US$ 289,703	Develop a novel linear accumulation x-ray source to achieve an order of magnitude increase in performance over leading x-ray sources for critical dimension scattering. This project benefits researchers and manufacturers of semiconductor transistors.
PrimeNano Inc. – **Santa Clara, CA**	US$ 259,848	Develop a measurement technology for in-line metrology, which has applications in materials purity, electrical properties, three-dimensional devices, and next generation manufacturing. This project will benefit the U.S. metrology and advanced packaging industries.
Steam Instruments, Inc. – **Madison, WI**	US$ 289,529	Develop a rapid and accurate high-resolution ion microscopy technology for materials characterization particularly focused on challenges for the semiconductor industry. This project will benefit the U.S. semiconductor industry and researchers.
Exigent Solutions – **Frisco, TX**	US$ 289,965	Develop AI-powered software to automate chip design optimization for manufacturability through accelerated lithography simulation. This project will benefit U.S. researchers and industry involve in semiconductor design and manufacturing.
Photothermal Spectroscopy Corporation – **Santa Barbara, CA**	US$ 283,489	Develop a new instrument for high-speed thermal properties analysis and simultaneous chemical characterization with sub-micron spatial resolution. This project will improve thermal management and thermal property characterization for the U.S. semiconductor industry.

Company	Award Amount	Purpose
Laser Thermal Analysis, Inc. – **Charlottesville, VA**	US$ 289,830	Develop hybrid atomic force microscopy instrument that will automatically generate maps of the thermal resistance, thermal boundary interface resistance, and temperature profiles of microprocessors and wide bandgap semiconductor materials and devices. This project will benefit devices with thermal management challenges and materials development needs on length scales smaller than 100 nanometers.
Octave Photonics – **Louisville, CO**	US$ 290,000	Develop a new measurement tool to analyze airborne contaminants and toxic gases inside and outside the fab that lead to semiconductor processing defects and safety infringements. This project will benefits U.S semiconductor fabrication facilities.
HighRI Optics, Inc – **Oakland, CA**	US$ 283,009	Develop cutting-edge technology for calibration of the instrument transfer function of extreme ultraviolet (EUV) lithographic tools. This project will advance EUV lithography technology for the U.S. semiconductor industry.
Tech-X Corporation – **Boulder, CO**	US$ 289,992	Develop a simulation tool for photonic integrated circuits that accounts for manufacturing variations and imperfections. This project will benefit the designers of photonic integrated circuits, who will have faster development times as well as U.S. semiconductor manufacturers and fabrication facilities.

List is updated as of November 26, 2024.
Source: "CHIPS for America Awards," NIST, https://www.nist.gov/chips/chips-america-awards, Accessed on November 26, 2024.

Employment

The CHIPS fund initiatives will create over 115,000 direct jobs in construction and manufacturing, with additional investments in workforce development and training.[159] TSMC's investment in Arizona, for example, is expected to generate over 6,000 direct manufacturing jobs, more than 20,000 unique accumulated construction jobs, and tens of thousands of indirect jobs

[159] The White House, Fact Sheet: "Two Years after the CHIPS and Science Act, Biden-Harris Administration Celebrates Historic Achievements in Bringing Semiconductor Supply Chains Home, Creating Jobs, Supporting Innovation, and Protecting National Security," August 9, 2024.

over the next five years. [160] This highlights the immediate and localized economic benefits of such investments.

Talent cultivation

Under the CHIPS for America Workforce and Education Fund, US$ 200 million is set aside to kick start development of the domestic semiconductor workforce, which faces near-term labor shortages, by leveraging activities of the National Science Foundation (NSF).[161] The NSF launched its Future of Semiconductors (FuSe) initiative, a US$ 45.6 million investment to conduct frontier research and develop the future microelectronics workforce.[162]

The NSTC's Workforce Center of Excellence (WCoE), with a US$ 250 million investment from the DOC, focuses on addressing critical job and skill gaps in the semiconductor industry.[163] It will collaborate with industry, academia, labor unions, the Departments of Labor and Education, the NSF, and local government partners to develop innovative solutions and best practices. According to the NSTC's vision and strategy document, the CHIPS Research and Development Office is expected to release a workforce strategy at a later date.[164]

CONCLUSION

Current Status of U.S. Semiconductor Industry

The U.S.'s share of global semiconductor production has declined from 37% in 1990 to 10% in 2022, with zero capacity for advanced chips (7nm or below). Furthermore, advanced chips were exclusively produced in Taiwan and

[160] NIST, Press Release: "TSMC Arizona Community Impact Report," November 15, 2024.
[161] U.S. National Science Foundation, Press Release: "U.S. National Science Foundation and Department of Commerce announce a new $30M funding opportunity, funded by the CHIPS & Science Act, to prepare talent for semiconductor jobs nationwide," September 27, 2024.
[162] The White House, Fact Sheet: "Two Years after the CHIPS and Science Act, Biden-Harris Administration Celebrates Historic Achievements in Bringing Semiconductor Supply Chains Home, Creating Jobs, Supporting Innovation, and Protecting National Security," August 9, 2024.
[163] "NSTC Workforce Center of Excellence," Natcast, https://natcast.org/workforce, Accessed on November 26, 2024.
[164] "CHIPS for America, A Vision and Strategy for The National Semiconductor Technology Center," CHIPS Research and Development Office, April 25, 2023.

South Korea. To maintain its global economic and technological leadership and strengthen national and economic security, the U.S.A. passed the CHIPS Act in August 2022.

Nevertheless, even without the resources provided by the CHIPS Act, the U.S.A. has always been the strongest country in the global semiconductor industry. Whilst the majority of chip manufacturing is not located within the U.S.A., the country accounted for 38% of the global semiconductor industry's value-added in 2022, significantly ahead of Japan (12%), South Korea (12%), Taiwan (11%), Europe (11%), and China (11%), according to the BCG.

By category, the U.S.A. accounts for 68% of the global semiconductor industry's value-added in electronic design automation and core intellectual property, 65% in logic chip design, 41% in discrete, analog, and optoelectronic (DAO) chip design, 25% in memory chip design, 47% in equipment manufacturing, 9% in materials, 10% in wafer manufacturing, and 3% in packaging and testing.

Based on BIS's semiconductor company headquarters data in 2022, the U.S.A. accounted for 53% of global revenue from chip design and integrated device manufacturers (IDMs), but only 8% of revenue from outsourced manufacturing (foundry and assembly/testing). Including design, manufacturing, and assembly/testing, the U.S.A. accounted for 42.9% of the global semiconductor revenue, similar to BCG's estimates.

The CHIPS Act encompasses four main policies: financial incentives, safeguard mechanisms, export controls, and international alliances. From 2022 to 2027, the Act allocates US$ 39 billion for manufacturing, US$ 11 billion for R&D, and US$ 2.7 billion for defense, technology security, and workforce development—totaling US$ 52.7 billion to subsidize U.S. semiconductor R&D, manufacturing, and workforce development. Additionally, the CHIPS Act offers a 25% investment tax credit for semiconductor equipment expenditures, with estimated costs reaching US$ 85 billion, according to the Peterson Institute for International Economics.

To prevent CHIPS Act-funded technologies and innovations from benefiting U.S. adversaries, guardrails have been included. The expansion guardrail prohibits subsidized companies from building new facilities or expanding existing ones in adversary nations for ten years. Meanwhile, the technology guardrail prohibits subsidized companies from engaging in joint research or technology licensing with adversaries that raise national security concerns. Violations could lead to the U.S. government recovering up to the full amount of the award.

Additionally, export controls aim to limit adversaries, especially China, from acquiring advanced chips, supercomputer technologies, and semiconductor manufacturing capabilities. These restrictions apply to high-performance computing chips, semiconductor manufacturing equipment, high-bandwidth memory chips, and supercomputing projects. Foreign companies that violate U.S. export controls may be blacklisted, losing access to U.S. technologies.

To strengthen the impact of the CHIPS Act, the U.S.A. has formed several international alliances, including the Chip 4 Alliance (U.S., Taiwan, South Korea, Japan), the Indo-Pacific Economic Framework, the U.S.-Japan-Netherlands Alliance, the U.S.-EU Trade and Technology Council, and the North American Semiconductor Conference (U.S., Canada, Mexico). These alliances aim to strengthen semiconductor supply chain resilience, bolster collective technological edge, restrict exports of advanced chips or equipment to China, and promote policy coordination and information sharing.

Progress and Challenges

Two years after its implementation, the U.S.A. has allocated US$ 36 billion of the CHIPS Act's US$ 52.7 billion funding, attracting nearly US$ 400 billion in semiconductor industry investments. Notable subsidies include over US$ 36 billion for 16 semiconductor manufacturers and US$ 25 billion in loans.

The five chip manufacturers confirmed under the current subsidy program are: Intel (US$ 7.9 billion), TSMC (US$ 6.6 billion), GlobalFoundries

(US$ 1.5 billion), Polar Semiconductor (US$ 120 million) and BAE Systems (US$ 35 million).

Currently, only three companies worldwide are capable of producing chips with process technology below 7 nanometers: TSMC, Intel, and Samsung.

TSMC's Role

TSMC plans to invest US$ 65 billion in three factories in Arizona:

- First factory (4nm and 5nm): Trial production achieved higher yields than similar plants in Taiwan, with mass production expected in the first half of 2025.
- Second factory (3nm): Operations planned for 2028.
- Third factory (2nm and 1.6nm): Expected to be operational before 2030.

Intel and Samsung Challenges

Intel has recently secured US$ 7.9 billion in CHIPS Act subsidies. The company is investing over US$ 32 billion in two plants in Arizona, utilizing 1.8nm process technology. However, the operations are delayed by one year and are now expected to begin in 2025. Additionally, its US$ 20 billion investment in two plants in Ohio has been postponed by two years, pushing production from the originally planned 2025 timeline to 2027-2028.

According to a Reuters report in early September, Broadcom has raised concerns about the yield rates of Intel's 1.8nm process technology, deeming it unsuitable for mass production. Furthermore, Intel reported a US$ 7 billion operating loss for the foundry business, wider than the US$ 5.2 billion in losses the year earlier. These challenges add uncertainty to Intel's ability to achieve mass production of 1.8nm wafers in 2025.

Meanwhile, Samsung's US$ 6.4 billion subsidy proposal under the CHIPS Act has yet to be approved by the U.S. government. Samsung's first wafer fab expansion in Texas, intended to utilize 4nm and 2nm process technologies, is

scheduled for completion in 2026. Construction of a second fab, initially planned to begin in 2024, has been delayed due to ongoing challenges with its 2nm process technology. Consequently, Samsung's ability to produce advanced chips in the U.S. before 2027 also remains uncertain.

Outlook

Due to the benefits of the CHIPS Act, market research firm TrendForce projected in November 2024 that the U.S.'s global share of advanced chip production will increase from the current 9% to 21% by 2027, making it the second-largest producer of advanced chips worldwide. Furthermore, the White House even predicted in August 2024 that the U.S.'s share of the global advanced chip market would reach 30% by 2032. However, given the uncertainties surrounding yield issues faced by Intel and Samsung, TSMC is poised to play a pivotal role in advanced chip production in the U.S. over the next three years.

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SEMICONDUCTOR STATISTICS AT A GLANCE

Global Foundry Revenue Increased by $2.9 Billion in Q3; TSMC Contributed 93.2%, Setting a New Market Share Record at 64.9%

According to TrendForce's latest data, global semiconductor foundry revenue reached US$ 34.87 billion in Q3 2024, breaking the previous pandemic-era record. This represents a US$ 2.91 billion increase (up 9.1%) compared to Q2 2024, driven primarily by surging demand for high-priced 3nm chips. Of the US$ 2.91 billion growth, TSMC contributed US$ 2.71 billion, accounting for an impressive 93.2%.

Top 10 Foundries Control 96.2% of Global Market Share

The top 10 global foundries maintained a combined market share of 96.2% in Q3. Rankings remained unchanged from Q2, with notable changes in revenue and market share observed primarily at TSMC and Samsung, while other players saw little fluctuation.

TSMC continued to dominate, posting revenue of US$ 23.53 billion, a US$ 2.71 billion (13.0%) increase from Q2. Its global market share surged by 2.6 percentage points to a record-breaking 64.9%, leaving competitors far behind.

In contrast, Samsung, ranked second, saw its revenue drop to US$ 3.4 billion—a sharp decline of US$ 480 million (down 12.4%) from Q2. Samsung's market share also fell significantly, from 11.5% in Q2 to 9.3% in Q3, a decrease of 2.2 percentage points.

Annual Trends: TSMC's Market Share on the Rise

On an annual basis, TSMC's market share has consistently increased. It rose from 55.4% in 2022 to 58.9% in 2023, and further to 63.0% for the first three quarters of 2024—a gain of 7.6 percentage points. The only other foundry with a growing market share is SMIC, which increased from 5.3% in 2022 to 5.8% in 2024, a modest 0.5 percentage point rise.

Declining Market Shares Among Other Foundries

Samsung experienced the steepest decline, with its market share dropping from 16.0% in 2022 to 12.0% in 2023, and further to 10.6% for the first three quarters of 2024—a total decrease of 5.4 percentage points.

Other notable declines include:

- **UMC**: From 6.8% in 2022 to 5.4% (-1.4 percentage points)
- **GlobalFoundries**: From 6.0% in 2022 to 4.9% (-1.1 percentage points)
- **Hua Hong Group**: From 3.1% in 2022 to 2.2% (-0.9 percentage points)
- **PSMC**: From 1.7% in 2022 to 1.1% (-0.6 percentage points)

Minor Declines in Smaller Foundries

For smaller players, the declines were less pronounced:

- **Tower Semiconductor**: From 1.3% in 2022 to 1.1% (-0.2 percentage points)
- **VIS**: From 1.3% in 2022 to 1.0% (-0.3 percentage points)
- **Nexchip**: From 1.3% in 2022 to 0.9% (-0.4 percentage points)

TSMC's overwhelming dominance and growing market share continue to define the global foundry industry, leaving competitors struggling to keep up.

Table 8: Ranking and Market Share of Global Top 10 Foundries by Revenue: 2022Q1-2024Q3

Ranking	Company	Market Share										
		2024Q3	2024Q2	2024Q1	2023Q4	2023Q3	2023Q2	2023Q1	2022Q4	2022Q3	2022Q2	2022Q1
1	TSMC (TW)	64.9%	62.3%	61.7%	61.2%	57.9%	56.4%	60.1%	58.5%	56.1%	53.4%	53.6%
2	Samsung (KR)	9.3%	11.5%	11.0%	11.3%	12.4%	11.7%	12.4%	15.8%	15.5%	16.4%	16.3%
3	SMIC (CN)	6.0%	5.7%	5.7%	5.2%	5.4%	5.6%	5.3%	4.7%	5.3%	5.6%	5.6%
4	UMC (TW)	5.2%	5.3%	5.7%	5.4%	6.0%	6.6%	6.4%	6.3%	6.9%	7.2%	6.9%
5	GlobalFoundries (USA)	4.8%	4.9%	5.1%	5.8%	6.2%	6.7%	6.6%	6.2%	5.8%	5.9%	5.9%
6	Huahong Group (CN)	2.2%	2.1%	2.2%	2.0%	2.6%	3.0%	3.0%	2.6%	3.3%	3.1%	3.2%
7	Tower (IL)	1.0%	1.1%	1.1%	1.1%	1.2%	1.3%	1.3%	1.2%	1.2%	1.3%	1.3%
8	VIS (TW)	1.0%	1.0%	1.0%	1.0%	1.1%	1.2%	1.0%	0.9%	1.2%	1.5%	1.5%
9	PSMC (TW)	0.9%	1.0%	1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.6%	1.9%	2.0%
10	Nexchip (CN)	0.9%	0.9%	1.0%	1.0%	1.0%	n.a.	n.a.	n.a.	1.0%	1.4%	1.4%
Total of Top 10		96.2%	96.0%	96.0%	95.0%	95.0%	94.0%	98.0%	98.0%	97.0%	98.0%	98.0%

Table 9: Ranking and Market Share of Global Top 10 Foundries by Revenue: 2022-2024

Ranking	Company	Market Share		
		2024-3Qs	2023	2022
1	TSMC (TW)	63.0%	58.9%	55.4%
2	Samsung (KR)	10.6%	12.0%	16.0%
3	SMIC (CN)	5.8%	5.4%	5.3%
4	UMC (TW)	5.4%	6.1%	6.8%
5	GlobalFoundries (USA)	4.9%	6.3%	6.0%
6	Huahong Group (CN)	2.2%	2.7%	3.1%
7	Tower (IL)	1.1%	1.2%	1.3%
8	VIS (TW)	1.0%	1.1%	1.3%
9	PSMC (TW)	1.0%	1.1%	1.7%
10	Nexchip (CN)	0.9%	1.0%	1.3%

Table 10: Top Global Foundries Revenue: 2024Q2-Q3

Unit: million USD

Ranking	Company	2024Q3	2024Q2	Difference	QoQ	Contribution
1	TSMC	23,527	20,819	2,708	13.0%	93.2%
2	Samsung	3,357	3,833	-476	-12.4%	-16.4%
3	SMIC	2,171	1,901	270	14.2%	9.3%
4	UMC	1,873	1,756	117	6.7%	4.0%
5	GlobalFoundries	1,739	1,632	107	6.6%	3.7%
6	Huahong Group	799	708	91	12.8%	3.1%
7	Tower	371	351	20	5.6%	0.7%
8	VIS	366	342	24	6.9%	0.8%
9	PSMC	336	320	16	4.9%	0.6%
10	Nexchip	332	300	32	10.7%	1.1%
Total of Top 10		34,869	31,962	2,907	9.1%	100.0%

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Taiwan Talks

Can TSMC Continue To Dominate the Global Chip Supply?

The construction of TSMC's Arizona fab is nearing completion. Amid recent reports that U.S. President Joe Biden and President-elect Donald Trump had planned to attend the fab's completion ceremony, TSMC founder Morris Chang has announced that a completion ceremony will not be held. How might the incoming Trump administration impact TSMC and Taiwan's industry? In this episode of "Taiwan Talks," we discuss how Trump may alter the U.S. CHIPS Act, how his proposed tariffs may impact Taiwan's chip industry, and how TSMC is managing Trump's demands for the company's U.S. fabs. Furthermore, we examine TSMC's global expansion strategy, as well as how Japanese and Korean subsidies and competitors such as Intel may affect global chip competition.

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