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Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation

April 25, 2023

Congressional Research Service

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R47523



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Semiconductors are a uniquely important enabling technology, fundamental to nearly all modern industrial and national security activities, as well as essential building blocks of other emerging technologies, such as artificial intelligence, autonomous systems, and quantum computing. The federal government and U.S. companies pioneered semiconductor development throughout the 1960s and 1970s, and the United States led the world in semiconductor manufacturing. A variety of factors subsequently led to a concentration of semiconductor manufacturing in East Asia. These factors included other nations subsidizing the construction and operation of semiconductor fabrication facilities (fabs); lower operating costs abroad; outsourcing of manufacturing by fabless semiconductor design firms that previously manufactured their own chips; and a preference for being physically proximate to electronics business clusters in the region.

The U.S. share of global semiconductor fabrication capacity fell from about 36% in 1990 to about 10% in 2020. Policymakers became increasingly concerned about the potential implications of this trend for economic and national security reasons, and noted the risks associated with ensuring an adequate supply of semiconductors resulting from potential disruption of East Asian manufacturing and shipping due to trade disputes, natural hazards, or armed conflict. The COVID-19 pandemic and consequent interruption of semiconductor supplies to the United States—and the subsequent effects on U.S.-based industries—bolstered these concerns. U.S. overreliance on semiconductor production in East Asia and its vulnerability to disruption has been an ongoing source of concern for many Members of Congress.

The National Defense Authorization Act for Fiscal Year 2021 (2021 NDAA, P.L. 116-283) authorized an incentive program for building and equipping semiconductor fabs in the United States, as well as research and development (R&D) activities to support U.S. leadership in semiconductor technology. In July 2022, Congress enacted the CHIPS and Science Act (P.L. 117-167), which President Biden signed into law in August 2022. The CHIPS Act of 2022 (Division A of P.L. 117-167) establishes and appropriates \$39.0 billion to a CHIPS for America Fund to bolster semiconductor manufacturing capacity in the United States by providing financial incentives for building, expanding, and equipping domestic fabrication facilities and companies in the semiconductor supply chain. The fund also provides \$11.0 billion for semiconductor R&D activities at the National Institute of Standards and Technology and in partnership with U.S. industry through a National Semiconductor Technology Center, a National Advanced Packaging Manufacturing Program, and the establishment of up to three Manufacturing USA institutes. P.L. 117-167 also provided appropriations for three additional funds that seek to bolster U.S. semiconductor capabilities for national defense, workforce development, and international cooperation.

Congress may wish to exercise its oversight authority with respect to implementation of the programs and policies in the act and their effectiveness in addressing U.S. economic and national security concerns. Among other potential oversight issues: the allocation of incentive funding among various types of chip manufacturing (e.g., logic chips and memory chips, mature chips and leading-edge chips); the adequacy of funding to meet the act's objectives; and the effectiveness of guardrails established in the act to prevent the use of incentive funding from enabling further investments in countries of concern or from being used for stock buybacks or dividends.

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Introduction

In July 2022, Congress enacted the Creating Helpful Incentives to Produce Semiconductors (CHIPS) Act of 2022 (Division A of P.L. 117-167), which was signed into law by President Joe Biden on August 9, 2022. The act appropriates funding for the CHIPS for America provisions enacted in Title XCIX of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (2021 NDAA, P.L. 116-283).¹ It also revised the 2021 NDAA CHIPS provisions and established three additional funds to support efforts that seek to address semiconductor-related challenges in defense, workforce and education, and international technology security and innovation. In total, the act appropriates \$52.7 billion for semiconductor manufacturing, research and development (R&D), workforce training and education, and collaboration and coordination with allied and other friendly countries for FY2022-FY2027.

This report provides an overview of issues shaping the development of Title XCIX of the 2021 NDAA and the CHIPS Act of 2022, as well as the acts' provisions and implementation to-date. The **Appendix** provides an overview of key concepts in semiconductors, including a discussion of the types of chips, process/technology nodes, semiconductor fabrication capacity by location, stages of semiconductor production, and an explanation of the integrated device manufacturer and fabless business models used in the semiconductor industry.²

Congress may opt to exercise oversight of the management of these funds, to monitor the effectiveness of the programs, to consider the intellectual property treatment of research funded under the CHIPS program, and to consider additional benchmarks and reporting requirements. This report identifies topics and questions that Congress may seek to explore in its oversight of these acts.

Foundations of CHIPS for America

What policy challenges inspired CHIPS?

A variety of policy concerns led to enactment of the CHIPS for America program in the 2021 NDAA and the CHIPS Act of 2022. Among them:

¹ This report refers to the semiconductor provisions of the 2021 NDAA and the CHIPS Act of 2022 collectively as CHIPS or the CHIPS program.

² A fabless company is one that only design chips and outsources its chip manufacturing to a foundry or to an integrated device manufacturer (IDM) acting as a foundry. An IDM is a semiconductor company that designs, manufactures, and sells chips. A pure-play foundry does not design chips but only produces chips from others' designs. Some IDMs, such as Samsung, both manufacture their own designs as well as offer foundry services for others.

Key Legislation

William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (2021 NDAA, P.L. 116-283)

Signed into law January 1, 2021.

Established and authorized Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America.

CHIPS Act of 2022 (Division A of P.L. 117-167, widely known as the CHIPS and Science Act)

Signed into law August 9, 2022.

Title XCIX established the CHIPS for America Fund (which, among other things, appropriated funding for the CHIPS for America provisions in the 2021 NDAA), the CHIPS for America Defense Fund, the CHIPS for America International Technology Security and Innovation Fund, and the CHIPS for America Workforce and Education Fund.

Concerns about a decline in the U.S. position in semiconductor manufacturing and technology and potential rise of China's industrial and technological competitiveness

Some Members of Congress and other U.S. policymakers have expressed concerns about the economic and military implications of a loss of leadership of U.S. firms in the semiconductor sector. These concerns relate to the extent to which U.S. industry has fallen behind industry in Taiwan and South Korea in advanced chip manufacturing capabilities, due in part to a movement of U.S. semiconductor firms to a fabless business model and the outsourcing of chip production to overseas foundries (known as fabrication facilities or fabs). (For further information on the evolution of the fabless business model, see the **Appendix**.) These concerns were also informed by a series of acquisitions by Chinese companies of semiconductor firms in the United States and in allied countries since 2014 that appeared to give China strategic capabilities.³ State-led efforts by the government of the People's Republic of China (PRC, also referred to in this report as China) to develop a native, vertically-integrated semiconductor industry are unprecedented in scope and scale. Many policymakers are concerned that these efforts, if successful, could significantly shift global semiconductor production and related design and research capabilities to China, undermining U.S. and other foreign firms' leading positions.

Although China's current share of the global industry is still relatively small (15% by sales⁴) and its companies produce mostly commodity-grade, generic chips, China's industrial policies aim to establish global dominance in semiconductor design and production by 2030.⁵ Moreover, Chinese semiconductor competencies could support a range of technology advancements, including military applications.

China's emerging semiconductor industry is supported through a state-led effort to achieve global leadership across the supply chain by 2030. Although China's domestic semiconductor fabrication is at least a generation behind the global industry in technology, it appears to be catching up largely through foreign technology acquisition, collaboration, and transfer. This includes the use of joint ventures, licensing agreements, U.S.-led open source technology platforms for chip design, the hiring of foreign talent, and the purchase of U.S. equipment and software tools. In addition, China's government outlays (approximately \$150 billion to date and an additional \$145 billion reported to be under consideration)⁶ and the country's role as a central

³ Executive Office of the President, President's Council of Advisors on Science and Technology, "Report to the President: Ensuring Long-Term U.S. Leadership in Semiconductors," January 2017.

⁴ This figure excludes Taiwan. Center for Security and Emerging Technology, *The Semiconductor Supply Chain: Assessing National Competitiveness*, January 2021, p. 20, at <https://cset.georgetown.edu/wp-content/uploads/The-Semiconductor-Supply-Chain-Issue-Brief.pdf>.

⁵ For more information, see CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*, by Karen M. Sutter.

⁶ Christopher Thomas, *A New World Under Construction: China and Semiconductors*, McKinsey & Company, November 2015, at <https://www.mckinsey.com/featured-insights/asia-pacific/a-new-world-under-construction-china-and-semiconductors>; Yoko Kubota, "China Sets up New \$29 Billion Semiconductor Fund," *Wall Street Journal*, October 25, 2019, at <https://www.wsj.com/articles/china-sets-up-new-29-billion-semiconductor-fund-11572034480>; Tianlei Huang, "Government-Guided Funds in China: Financing Vehicles for State Industrial Policy," China Economic Watch, Peterson Institute for International Economics, June 17, 2019, at https://www.piie.com/blogs/china-economic-watch/government-guided-funds-china-financing-vehicles-state-industrial-policy#_ftn2; OECD, Trade and Agricultural Directorate, "Measuring Distortions in International Markets: The Semiconductor Value Chain," November 21, 2019, pp. 94-95; and Julie Zhu, "China Readying \$143 Billion Package for Its Chip Firms in Face of U.S. Curbs," *Reuters*, December 13, 2022; "Battered by Covid, China Hits Pause on Giant Chip Spending Aimed at Rivaling US," *Bloomberg*, January 4, 2023; Monica Chen and Jessie Shen, "Chinese Foundries Are Quietly Making

production point for global consumer electronics are generating strong incentives and pressures on U.S. and foreign firms to focus on China. China views access to foreign capabilities in the near term as a key pathway to accelerating domestic development. Of concern to policymakers and other stakeholders are China's state-led efforts to acquire companies and access semiconductor technology through both licit and illicit means; targeted intellectual property theft; and technology-transfer pressures.⁷

Inadequate domestic manufacturing capability to meet U.S. national security and economic needs

Some Members of Congress and other U.S. policymakers have expressed concerns about the economic and military implications of a loss of U.S. manufacturing and technological leadership in semiconductors. Only a small share of global chip manufacturing capacity is currently located in the United States (about 10% in 2020, down from 36% in 1990).⁸ In addition, none of the most advanced chip manufacturing capacity is located in the United States.⁹

This shift occurred as manufacturing capacity in the East Asian region grew; U.S.-headquartered semiconductor companies built fabs outside the United States; and a number of U.S.-headquartered semiconductor companies abandoned manufacturing in favor of fabless models, offshoring production to overseas foundries (primarily in East Asia).

U.S. national defense systems are highly reliant on semiconductors—including state-of-the-art chips used in leading edge applications such as fighter jets, artificial intelligence based systems, and military-grade devices that introduce specific military features such as higher level of heat or radiation tolerance.¹⁰ U.S. defense systems also depend on legacy or mature chips for a wide range of applications. Through its Trusted Foundry program,¹¹ the Department of Defense has, for over a decade, relied on a single U.S.-based foundry to supply secure, leading-edge semiconductors. Concerns about the sustainability and adequacy of this approach has generated interest in alternatives, including access to a broader range of commercial, state-of-the-art design and fabrication capabilities.

Equipment Purchases,” DigiTimes, February 3, 2023.

⁷ For examples of such efforts, see Department of Defense, Defense Innovation Unit-Experimental, Michael Brown and Pavneet Singh, *China's Technology Transfer Strategy: How Chinese Investments in Emerging Technologies Enable a Strategic Competitor to Access the Crown Jewels of U.S. Innovation*, January 2018, at <http://nationalsecurity.gmu.edu/wp-content/uploads/2020/02/DIUX-China-Tech-Transfer-Study-Selected-Readings.pdf>; U.S.-China Economic Security and Review Commission, Sean O'Connor, *How Chinese Companies Facilitate Technology Transfer from the United States*, May 6, 2019, at <https://www.uscc.gov/sites/default/files/Research/How%20Chinese%20Companies%20Facilitate%20Tech%20Transfer%20from%20the%20US.pdf>; and National Counterintelligence and Security Center, *Protecting Critical and Emerging U.S. Technologies from Emerging Threats*, October 2021, at https://www.dni.gov/files/NCSC/documents/SafeguardingOurFuture/FINAL_NCSC_Emerging%20Technologies_Factsheet_10_22_2021.pdf.

⁸ SEMI, *World Fab Forecast*, November 2020; Semiconductor Industry Association, *2021 State of the U.S. Semiconductor Industry*, September 2021, at <https://www.semiconductors.org/wp-content/uploads/2021/09/2021-SIA-State-of-the-Industry-Report.pdf>.

⁹ Only South Korea-based Samsung and Taiwan-based Taiwan Semiconductor Manufacturing Company (TSMC) manufacture the most advanced logic chips—currently 5 nanometers (nm).

¹⁰ Eric Lee, “How Taiwan Underwrites the US Defense Industrial Complex,” *The Diplomat*, November 9, 2021.

¹¹ Department of Defense, Defense Microelectronics Activity, “DMEA Trusted IC Program,” at <https://www.dmea.osd.mil/TrustedIC.aspx>.

U.S. reliance on global supply chains and production concentrated in East Asia

Some Members of Congress have expressed concern about the concentration of semiconductor production in East Asia and the related vulnerability of semiconductor supply chains in the event of a trade dispute, military conflict, or other potential disruption, in addition to concerns about product tampering and intellectual property theft. In recent years, China has increased its military investments and intensified its rhetoric with regard to its ambitions to re-unify Taiwan, including by the use of force if necessary, bolstering these concerns.

Geographic concentration in East Asia may leave supply chains susceptible to disruption from local extreme weather events and water shortages. A globally-distributed semiconductor manufacturing capability could help to ameliorate these risks (e.g., a tropical cyclone—often referred to as a typhoon or hurricane—is unlikely to affect multiple regions).

Supply chains disruptions due to the Coronavirus Disease 2019 (COVID-19) pandemic

Disruptions to the semiconductor supply chain during the COVID-19 pandemic—shifting industrial and consumer demands, production declines, and the interruption of transportation/logistics services—exacerbated policymakers’ concerns about the domestic availability of semiconductors for important industrial sectors. At the beginning of the pandemic, some manufacturers that rely on chips as a key component of their products cut their semiconductor orders in anticipation of a decline in demand for their products; this was particularly pronounced in the automobile industry.¹² When these companies later sought to reinstate or increase their semiconductor purchases, they found that companies in industries that accelerated during the pandemic, notably consumer electronics (which were paying a premium for the chips), had taken up the slack in semiconductor manufacturing capacity. The order cancellations and the lack of capacity to fulfill new orders created a shortage of chips that resulted in some industries (e.g., automotive, medical equipment) having to scale back production, leading to economic losses and reduced availability of their products.

Sustaining the ability of the industry to improve semiconductor performance while decreasing cost through technological innovation

Because semiconductors are integral components in almost all industrial activity and fundamental to several emerging technologies, their performance and price affect multiple sectors and the broader U.S. economy.

Retaining and growing high-skilled and high-paying semiconductor industry jobs in the United States

Jobs in the semiconductor and related device manufacturing industry are among the highest compensated in U.S. manufacturing. In March 2022, the states with the highest annual wages in this industry were California (\$370,864), Georgia (\$268,944), South Carolina (\$214,604), Texas (\$208,260), and Oregon (\$206,908).¹³

¹² For more information, see CRS In Focus IF12000, *Semiconductor Shortage Constrains Vehicle Production*, by Manpreet Singh.

¹³ U.S. Department of Labor, Bureau of Labor Statistics, “Quarterly Census of Employment and Wages,” March 2022. CRS calculated the average annual wage by multiplying the average weekly wage by 52.

What issues did Congress consider during the development of the CHIPS Act of 2022?

Congress' decision to appropriate and authorize \$52.7 billion in support of the U.S. semiconductor industry and related R&D reflected over two years of debate and deliberation. One issue that Congress considered was the appropriate role of the federal government in assisting U.S. industry to boost and sustain U.S. leadership and competitiveness in the global semiconductor industry. Other questions that informed the development of the CHIPS Act of 2022 included:

- What activities should be supported and in what manner?
- How much funding should Congress provide for each proposed activity?
- How should federal activities be coordinated among agencies and aligned with initiatives of the U.S. semiconductor and related industries?
- How should China's industrial plans, trade practices, and the role of U.S. firms in China's emerging semiconductor market be addressed?

Additional questions that informed Congress' consideration of specific legislative options included:

- What types and forms of support should be offered? Would direct grants, loans, loan guarantees, or tax deductions be most effective? Should a combination of these approaches be employed?
- How might Congress encourage matching funds from industry, including semiconductor firms, end-user corporate customers, or the U.S. financial sector? How could federal government support best ensure follow-on activity beyond what the act supports?
- Should certain parts of the supply chain be targeted for support?
- Should certain types of semiconductor chips (e.g., logic, memory, or analog; mature or leading-edge) be prioritized?
- Should there be a focus on established players or newer firms or should the programs remain neutral in this regard?
- Should incentives be focused on the implementation and expansion of existing technologies and approaches or on fostering innovation and advanced semiconductor technology, new materials, and novel processes or approaches?
- Given China's investments in its industries, how should Congress structure the incentives to ensure U.S. investments best achieve their objectives?
- What types of guardrails and restrictions would be necessary to prevent the diversion of these resources (e.g., using fungible funds to build capabilities in countries of concern or to bolster dividends or stock buy-backs)?
- What can be done to reduce U.S. and foreign companies' willingness to help advance China's capabilities in exchange for market access?

The CHIPS Act of 2022 includes programs, policies, and funding to address a number of these issues, but not all of them, as discussed in the next section.

Semiconductor Provisions in the 2021 NDAA and the CHIPS Act of 2022

The CHIPS Act of 2022 provides, among other things, appropriations to implement the semiconductor provisions included in Creating Helpful Incentives to Produce Semiconductors for America (CHIPS for America) (Title XCIX of the 2021 NDAA, P.L. 116-283).

What are the CHIPS for America provisions in the 2021 NDAA and CHIPS Act of 2022?

Several bills introduced in the 116th Congress sought to expand U.S. semiconductor fabrication capacity. Certain provisions from these bills were incorporated into CHIPS for America. In the 117th Congress, the 2021 NDAA provisions *authorized* a number of programs and activities, and the CHIPS Act of 2022 *appropriated* funding for them.

2021 NDAA provisions

Section 9902 of the 2021 NDAA (as amended by the CHIPS Act of 2022) authorizes the Secretary of Commerce to provide financial assistance to “covered entities” to incentivize investment in facilities and equipment in the United States for semiconductor fabrication, assembly, testing, advanced packaging, or research and development of semiconductors. Covered entities include

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.¹⁴

The Department of Commerce is authorized to provide funding in various forms, including grants, cooperative agreements, loans, and loan guarantees, in exercising its Section 9902 authorities.¹⁵ Subject to availability of funds and considerations specified in the act, the Secretary may determine the appropriate amount and funding type for each award made to a covered entity, up to \$3 billion. Awards in excess of \$3 billion may be made if the Secretary, in consultation with the Secretary of Defense and the Director of National Intelligence, recommends such an award to the President, and the President certifies and reports to the appropriate committees of Congress, that a larger investment is necessary to significantly increase the proportion of reliable domestic supply of semiconductors relevant for national security and economic competitiveness.

Section 9903(b) of the 2021 NDAA authorizes the Secretary of Defense to establish a National Network for Microelectronics Research and Development “to enable the laboratory to fabrication transition of microelectronics innovations in the United States; and to expand the global leadership in microelectronics of the United States.” The network is intended to enable cost effective exploration of new materials, devices, and architectures, and prototyping in domestic facilities to safeguard domestic intellectual property; accelerate the transition of new technologies to domestic microelectronics manufacturers; and conduct other relevant activities deemed

¹⁴ 15 U.S.C. §4651(2).

¹⁵ NIST, *CHIPS for America: A Strategy for the CHIPS for America Fund*, September 6, 2022, at <https://www.nist.gov/system/files/documents/2022/09/13/CHIPS-for-America-Strategy%20%28Sept%20%2C%202022%29.pdf>.

necessary by the Secretary of Defense. In the CHIPS Act of 2022, this network is referred to as the Microelectronics Commons.

Section 9906(c) of the 2021 NDAA directs the Secretary of Commerce, in collaboration with the Secretary of Defense, to establish a National Semiconductor Technology Center (NSTC)¹⁶ to conduct research and prototyping of advanced semiconductor technology to strengthen the economic competitiveness and security of the domestic supply chain. The center is to operate as a consortium, with participation by the private sector, the Department of Energy, and the National Science Foundation (NSF). The center’s work is to emphasize advanced test, assembly, and packaging capabilities in the domestic semiconductor ecosystem; materials characterization, instrumentation, and testing for next-generation microelectronics; virtualization and automation of maintenance of semiconductor machinery; and metrology¹⁷ research for security and supply chain verification. For further information, see “What is the role of the National Semiconductor Technology Center (NSTC)?” and “What is the implementation status of the NSTC?” (below).

Section 9906(d) of the 2021 NDAA directs the Secretary of Commerce to establish a National Advanced Packaging Manufacturing Program (NAPMP), led by the Director of the National Institute of Standards and Technology (NIST), to strengthen semiconductor advanced test, assembly, and packaging capability in the United States, and to coordinate its efforts with the National Semiconductor Technology Center, authorized by Section 9906(c), and the Manufacturing USA institute, authorized by Section 9906(f) (discussed below). For further information, see “What is the role of the National Advanced Packaging Manufacturing Program?” and “What is the implementation status of the NAPMP and what are the views and priorities of stakeholders?” (below).

Section 9906(e) of the 2021 NDAA authorizes the Director of NIST to conduct an R&D program to enable advances and breakthroughs in measurement science, standards, material characterization, instrumentation, testing, and manufacturing capabilities for next-generation microelectronics metrology, and to ensure U.S. competitiveness and leadership in microelectronics.

Section 9906(f) of the 2021 NDAA authorizes the establishment of a Manufacturing USA institute¹⁸ to pursue research in support of the virtualization and automation of maintenance of semiconductor machinery; the development of new advanced testing, assembly, and packaging capabilities; and the development and deployment of educational and skills training curricula needed to support the industry sector and to ensure the United States can build and maintain a trusted and predictable talent pipeline. The CHIPS Act of 2022 modifies this provision by authorizing up to three Manufacturing USA institutes, rather than a single institute.

CHIPS Act of 2022 provisions and appropriations for each fund and activity

The CHIPS Act of 2022 appropriates \$52.7 billion in emergency supplemental appropriations for semiconductor-related programs and activities for FY2023 through FY2027. These appropriations are provided through four funds: the CHIPS for America Fund, the CHIPS for America Defense Fund, the CHIPS for America International Technology Security and Innovation Fund, and the

¹⁶ The initialism “NSTC” is also used to describe the President’s National Science and Technology Council, which also has a role in the CHIPS for America program.

¹⁷ Metrology is the science of measurement.

¹⁸ For more information on the Manufacturing USA program, see CRS Report R46703, *Manufacturing USA: Advanced Manufacturing Institutes and Network*, by John F. Sargent Jr.

CHIPS for America Workforce and Education Fund. CHIPS Act of 2022 appropriations by fund and by the provisions of the 2021 NDAA are described below and summarized in **Table 1**.

For the **CHIPS for America Fund**, the act appropriates \$50.0 billion for FY2023-FY2027 to the Department of Commerce for semiconductor incentives intended to develop domestic manufacturing capabilities as well as for R&D and workforce development.

- \$39 billion (including \$19 billion in FY2022 and \$5 billion each year from FY2023 through FY2026, each to remain available until expended) for implementation of the incentives program specified in Section 9902 of the 2021 NDAA. The funding available for FY2022 includes \$2 billion specified for the production of mature semiconductor technologies and up to \$6 billion for the cost of direct loans and loan guarantees (not to exceed \$75 billion) for implementation of the provisions of Section 9902;
- \$11 billion for FY2023 through FY2026 for R&D and workforce development programs, including for the National Semiconductor Technology Center (as specified in Section 9906(c) of the 2021 NDAA), the National Advanced Packaging Manufacturing Program (NAPMP) as specified in Section 9906(d)), NIST microelectronics-related research (as specified in Section 9906(e)), and establishment of up to three semiconductor manufacturing technology-focused Manufacturing USA institutes (as specified in Section 9906(f) of the 2021 NDAA and modified by P.L. 117-167). This funding includes:
 - for FY2022, \$2 billion for the NSTC; \$2.5 billion for the advanced packaging program; and \$500 million for the Manufacturing USA institute(s) and other related R&D programs; and
 - the following amounts, collectively, for the NSTC, NAPMP, Manufacturing USA institute(s), and other related R&D programs: \$2 billion in FY2023, \$1.3 billion in FY2024, \$1.1 billion in FY2025, and \$1.6 billion in FY2026; and
- Up to 2% of the funds provided for implementation of Sections 9902 and 9906 may be used for salaries and expenses, administration, and oversight, of which \$5 million is to be made available each year to the inspector general.

In addition, the CHIPS Act of 2022 establishes and provides appropriations for three other funds.

- The **CHIPS for America Defense Fund** provides \$2 billion for the Department of Defense (\$400 million per year for FY2023-FY2027) to carry out the provisions of Section 9903(b) (Advanced Microelectronics Research and Development) of the 2021 NDAA. These funds are to be used for “establishing and operating a Microelectronics Commons, a national network for onshore, university-based prototyping, lab-to-fab transition of semiconductor technologies—including Department of Defense-unique applications—and semiconductor workforce training.”¹⁹
- The **CHIPS for America International Technology Security and Innovation Fund** provides \$500 million (\$100 million per year for FY2023-FY2027), to the Department of State for the purposes of coordinating with foreign government partners to support international information and communications technology

¹⁹ U.S. Senate, Committee on Commerce, Science, and Transportation, *CHIPS and Science Act of 2022, Section-by-Section Summary*, July 29, 2022, at <https://www.commerce.senate.gov/services/files/1201E1CA-73CB-44BB-ADEB-E69634DA9BB9>.

security and semiconductor supply chain activities, including supporting the development and adoption of secure and trusted telecommunications technologies, semiconductors, and other emerging technologies. The Department of State is to conduct this work in coordination with the U.S. Agency for International Development, the Export-Import Bank of the United States, and the U.S. International Development Finance Corporation.

- The **CHIPS for America Workforce and Education Fund** provides \$200 million for the FY2023-FY2027 period to the NSF to promote growth of the semiconductor workforce through microelectronics workforce development activities to meet the requirements under Section 9906 of the 2021 NDAA. Of these funds, the act provides \$25 million for FY2023, \$25 million for FY2024, and \$50 million in each fiscal year 2025-2027.

The act also includes separate provisions that seek to address congressional concerns related to U.S. competitiveness in telecommunications technologies. The act establishes a Public Wireless Supply Chain Innovation Fund and appropriates \$1.5 billion to remain available until expended.

Table I. Appropriations by Fund/Activities in the CHIPS Act of 2022
(total appropriated for FY2022-FY2027)

| Program/Activity Description | 2021 NDAA Section | Appropriation |
|--|-------------------|--|
| CHIPS for America Fund (Department of Commerce) | | |
| Semiconductor manufacturing (fabrication) incentives | 9902 | \$39.0 billion |
| Incentives for legacy chip production | 9902 | \$2.0 billion (of the \$39.0 billion) |
| Cost of direct loans and loan guarantees | 9902 | Up to \$6.0 billion (of the \$39.0 billion) to support up to \$75 billion in loans and loan guarantees |
| Investment tax credit for capital expenses for manufacturing of semiconductors and related equipment | n/a | 25% of qualified investment |

| Program/Activity Description | 2021 NDAA Section | Appropriation |
|--|---------------------------------------|----------------|
| <ul style="list-style-type: none"> Establishment and operation of a National Semiconductor Technology Center to conduct research and prototyping of advanced semiconductor technology to strengthen the economic competitiveness and security of the domestic supply chain | 9906(c) | \$11.0 billion |
| <ul style="list-style-type: none"> Establishment of a National Advanced Packaging Manufacturing Program to strengthen semiconductor advanced test, assembly, and packaging capabilities in the United States | 9906(d) | |
| <ul style="list-style-type: none"> Research and development at the National Institute of Standards and Technology to enable advances and breakthroughs in measurement science, standards, material characterization, instrumentation, testing, and manufacturing capabilities for next-generation microelectronics metrology, and to ensure U.S. competitiveness and leadership in microelectronics | 9906(e) | |
| <ul style="list-style-type: none"> Establishment of up to three Manufacturing USA institutes for <ul style="list-style-type: none"> Research in support of the virtualization and automation of maintenance of semiconductor machinery Development of new advanced test, assembly, and packaging capabilities Development and deployment of educational and skills training curricula needed to support the semiconductor sector and to ensure the United States can build and maintain a trusted and predictable talent pipeline | 9906(f) (as modified by P.L. 117-167) | |
| CHIPS for America Defense Fund (Department of Defense) | | |
| Research, development, test, and evaluation; workforce development; and other requirements unique to the Department of Defense and the intelligence community | 9903(b) | \$2 billion |
| CHIPS for America International Technology Security and Innovation Fund (Department of State) | | |
| International information and communications technology security and semiconductor supply chain activities, among other things | 9905 and 9202(a) | \$500 million |
| CHIPS for America Workforce and Education Fund (National Science Foundation) | | |
| Microelectronics workforce development activities | 9906 | \$200 million |
| Public Wireless Supply Chain Innovation Fund | | |
| Promotion and deployment of wireless technologies that use open and interoperable radio access networks | 9202(a)(1) | \$1.5 billion |

Source: CRS analysis of P.L. 116-283 and P.L. 117-167.

Notes: n/a = not applicable. (These provisions of the CHIPS and Science Act have no corresponding provision in the 2021 NDAA.)

CHIPS Act Implementation by the Department of Commerce

What challenges to domestic semiconductor production does the Department of Commerce's CHIPS strategy seek to address?

In alignment with the provisions of the CHIPS Act of 2022 and the 2021 NDAA, the Department of Commerce's *CHIPS for America: A Strategy for the CHIPS for America Fund* identifies the key challenges the CHIPS program seeks to overcome as:

- the **significant cost gap** between building and operating a manufacturing facility in the United States, and building and operating the same facility elsewhere, resulting from the differences in government subsidies, construction timelines, and ongoing operating costs;
- the **decline in capital investments** in U.S.-based manufacturing capacity and technology upgrades, which makes it harder to master the next learning curve of process innovations and build the next generation of chips;
- the **extremely high cost of building a leading-edge fab**, and the resulting fabless business model that separates the activity of designing a new chip from the process to manufacture it, which has created dependence on a few, very large foundries;
- **a lack of visibility into demand forecasts**, which has long-driven a boom and bust cycle in the global semiconductor manufacturing industry, creating headwinds for domestic investment; and
- **a mismatch and loss of worker skills** in the construction and operation of manufacturing facilities because U.S. construction of large-scale fabs and packaging facilities has been limited in the last decade.²⁰

What administrative structures have been set up to implement the CHIPS Funds and provisions?

The 2021 NDAA, President Biden, and the Department of Commerce have established new offices/institutions to help implement the CHIPS programs:

- Section 9906(a) of the 2021 NDAA established a Subcommittee for Microelectronics Leadership under the President's National Science and Technology Council. The subcommittee is to develop a national strategy on microelectronics research, development, manufacturing, and supply chain security. This strategy is aimed at accelerating the domestic development and production of microelectronics, strengthening the domestic microelectronics workforce, and ensuring that the United States is a global leader in the field of microelectronics research and development. The subcommittee is also charged with coordinating microelectronics related research, development,

²⁰ NIST, *CHIPS for America: A Strategy for the CHIPS for America Fund*, September 6, 2022, at <https://www.nist.gov/system/files/documents/2022/09/13/CHIPS-for-America-Strategy%20%28Sept%206%2C%202022%29.pdf>.

- manufacturing, supply chain security activities, and budgets of federal agencies to ensure these activities are consistent with the strategy.
- President Biden established the CHIPS Implementation Steering Council through Executive Order 14080, “Implementation of the CHIPS Act of 2022.”²¹
 - The Department of Commerce has established two new offices at NIST:
 - CHIPS Program Office (CPO). The CPO is a new operating unit established to implement the Section 9902 semiconductor incentives program and provide policy and stakeholder engagement support across CHIPS programs. The CPO, reporting directly to the Under Secretary of Commerce for Standards and Technology and working closely with the Office of the Secretary, seeks to ensure coordination of all CHIPS-related activities across the Department of Commerce. The CPO is to participate actively in White House-led coordination efforts, including the CHIPS Implementation Steering Council, to ensure a tightly connected implementation of CHIPS throughout the government, including the Departments of Defense, State, Energy, and Homeland Security; the Office of the Director of National Intelligence; the National Science Foundation; and the Office of the United States Trade Representative. The CPO is expected to draw on the technical expertise of these agencies.
 - CHIPS R&D office. The CHIPS R&D office will support the development of the NSTC and manage the Industrial Advisory Committee, Advanced Packaging, Manufacturing USA, and R&D activities, in collaboration with existing NIST laboratories and the NIST Office of Advanced Manufacturing.

The CPO and the CHIPS R&D office will engage with comparable entities in allied and partner economies to advance shared goals on supply chain resiliency and technology protection.²²

What are the overarching initiatives that the Department of Commerce has identified in implementing the CHIPS program?

In *CHIPS for America: A Strategy for the CHIPS for America Fund*, the Department of Commerce has identified three overarching initiatives for the implementation of the CHIPS program, each of which addresses a different set of strategic challenges, has a different time horizon and speed of implementation, and involves a partially overlapping set of stakeholders and incentives:

- **Large-scale investments in leading-edge logic and memory manufacturing clusters.** The Department of Commerce intends to seek proposals for the construction or expansion of manufacturing facilities to fabricate, package, assemble, and test leading-edge logic and memory chips that require the most sophisticated processes available today, focusing on projects that involve multiple high-cost production lines and associated supplier ecosystems. The department expects this initiative to account for approximately three quarters (or approximately \$28 billion) of the CHIPS incentive funding under Section 9902. The Department of Commerce anticipates that this initiative will use grants,

²¹ Available from the Government Printing Office at <https://www.govinfo.gov/content/pkg/DCPD-202200729/pdf/DCPD-202200729.pdf>.

²² NIST, *CHIPS for America: A Strategy for the CHIPS for America Fund*, September 6, 2022.

cooperative agreements, loans, and loan guarantees, and is evaluating the effect of the investment tax credit included in the CHIPS Act of 2022 on this initiative. Department of Commerce’s goal was to begin soliciting applications within six months of enactment of the CHIPS Act of 2022 (enactment occurred on August 9, 2022); the Department of Commerce issued its first notice of funding opportunity on February 28, 2023.²³ The application process includes a preliminary application stage that will enable applicants to get feedback from the CPO before submitting a complete application.

- **Expanding manufacturing capacity for mature and current-generation chips, new and specialty technologies, and suppliers to the industry.** The CHIPS program seeks to increase domestic production of semiconductors across a range of nodes, including chips used in defense and in critical commercial sectors such as automobiles, information and communications technology, and medical devices. Among the types of proposals the Department of Commerce expects to support under this initiative are:
 - construction or expansion of facilities for the fabrication, packaging, assembly, and testing of legacy and current-generation semiconductors, including all types of logic, memory, discrete, analog, and optoelectronic chips;
 - facilities to produce new or specialty technologies such as advanced analog chips, radiation-hardened chips, compound semiconductors, or emerging technologies;
 - facilities that manufacture equipment and materials for semiconductor manufacturing, potentially co-located in regional clusters; and
 - equipment upgrades that provide near-term efficiency improvements in fabs.

The Department of Commerce expects to make dozens of awards under this initiative, with the total value expected to be at least one quarter (approximately \$10 billion) of the CHIPS incentive funding under Section 9902.²⁴

- **Initiatives to strengthen and advance U.S. leadership in R&D.** The CHIPS Act of 2022 includes a number of provisions that seek to ensure future U.S. leadership in semiconductor technology through R&D activities. These include the NSTC, the NAPMP, and the semiconductor focused Manufacturing USA Institutes (each of which was authorized under Section 9906 of the 2021 NDAA), as well as the NIST metrology investments that together received \$11 billion in funding.

²³ NIST, Notice of Funding Opportunity, “CHIPS Incentives Program—Commercial Fabrication Facilities,” February 28, 2023, at https://www.nist.gov/system/files/documents/2023/02/28/CHIPS-Commercial_Fabrication_Facilities_NOFO_0.pdf.

²⁴ NIST, *CHIPS for America: A Strategy for the CHIPS for America Fund*, September 6, 2022.

Promoting Domestic Semiconductor Manufacturing through the CHIPS for America Fund

How does the CHIPS Act of 2022 aim to incentivize the construction of new U.S.-based semiconductor fabs?

The CPO is responsible for administering the \$38.22 billion of direct funding available for semiconductor manufacturing incentives.²⁵ A portion of these funds (up to \$6 billion) will be used to subsidize direct loans or loan guarantees totaling up to \$75 billion.²⁶ The Department expects that the total amount of financial incentives awarded for a project (including grants, loans, and loan guarantees) should account for less than 35% of total capital expenditures. Direct grants should account for 5%-15% of total project costs. Individual projects may not receive more than \$3 billion in federal investments without certification by the President to Congress.²⁷

Additionally, Section 107 of the CHIPS Act of 2022 creates a new tax credit, the advanced manufacturing investment credit (AMIC), to be administered by the Internal Revenue Service. The AMIC is equal to 25% of the value of qualified investments in buildings and other eligible depreciable tangible property for advanced manufacturing facilities that have a primary purpose of manufacturing semiconductors or semiconductor manufacturing equipment. The Department of Commerce expects that the AMIC will serve as an important tool to close the cost gap between investment in fabs in the United States and other countries. The law authorizes AMIC for projects that start construction between January 1, 2023, and December 31, 2026.²⁸ The Congressional Budget Office has estimated that industry claims for this tax credit will decrease federal revenues by \$24.5 billion between FY2023 and FY2027.²⁹

What types of semiconductor chips does the Department of Commerce plan to support?

The semiconductor industry produces a wide variety of chips that perform different functions and that are designed for different applications, including processing, storing, sensing, and transmitting data, as well as power management.³⁰ Generally, separate facilities with unique manufacturing processes are required for producing each type of chip (see the **Appendix** for more information on types of chips). Facilities producing all types of semiconductor chip technologies are eligible to apply for funding to expand domestic manufacturing capacities. The law instructs the Secretary of Commerce to give priority to projects that intend to supply semiconductors for

²⁵ This figure represents the total of the incentives appropriation (\$39.0 billion), minus the 2% (\$780 million) that the law authorizes NIST to use for salaries and expenses, administration, and oversight purposes.

²⁶ 15 U.S.C. §2652(g).

²⁷ For awards exceeding \$3 billion, the President must certify to Congress that larger investments are necessary for increasing the production of particular semiconductors for economic competitiveness and national security (15 U.S.C. §4652(a)(3)(B)).

²⁸ NIST, *CHIPS for America: A Strategy for the CHIPS for America Fund*, September 6, 2022.

²⁹ Congressional Budget Office, "Table 1. Summary. Estimated Budgetary Effects of H.R. 4346, as Amended by the Senate and as Posted by the Senate Committee on Commerce, Science, and Transportation on July 20, 2022," at https://www.cbo.gov/system/files/2022-07/hr4346_chip.pdf.

³⁰ For more information on the types of chips and the functions they perform, see **Table A-1**.

the “national security, manufacturing, critical infrastructure, and technology leadership of the United States.”³¹

Two program objectives outlined by the Department of Commerce are to invest into “leading-edge” facilities producing the most advanced generations of logic and memory chip technologies.³² Metrics used by the Department of Commerce to identify which types of chips may qualify as leading-edge are shown in **Table 2** (for more information on process node and other chip technology metrics, see “Process/Technology Nodes.” Funding applications will first be accepted for leading-edge logic and memory facilities.

Another program objective is to support facilities that produce current and mature generations of all chip technologies. Applicants must explain how expanding domestic production of the particular type of chip will be vital to U.S. economic and national security (e.g., aerospace and defense applications, medical devices). In this objective, the Department of Commerce also encourages applications for certain semiconductor chips made of materials other than silicon, called compound semiconductors, that have increasing applications in defense technologies, electric vehicles, and next-generation communication technologies.³³

Table 2. Semiconductor Chip Technologies and Chip Technology Generation Signifiers

| Chip Type | Function Examples | Application Examples | Chips Technology Generation Signifiers | |
|---------------------|---|---|--|--|
| Memory ^a | 3D NAND | Long term data storage | Store pictures, music, video after a device is powered off | Number of layers. Layers of memory cells are stacked on top of one another. Leading-edge 3D NAND chips typically have more than 200 layers. |
| | DRAM | Short term data storage | Store code for a computer while it is powered on | Half pitch (half of the distance between adjacent memory cells, measured in nanometers (nm)). Leading-edge DRAM chips typically have half pitch lengths of 13 nm or smaller. |
| Logic | Process data for computing | Central processing units (CPUs), graphics processing units (GPUs), microcontrollers | Process node size (abbreviated in nm). Typically the smaller the number, the more advanced the chip. Current leading-edge logic chips are 5 nm or smaller. | |
| Analog | Processes non-digital signals (e.g., sound, electric current) | Power management, data converters | | |
| Radiofrequency (RF) | Wireless communications | Radio frequency identification (RFID) tags, military radio communications | These chips may be labeled by process node size (abbreviated as nm). | |

³¹ 15 U.S.C. §2652(a)(2)(D)(ii).

³² NIST, *Vision for Success: Commercial Fabrication Facilities*, February 28, 2023, at https://www.nist.gov/system/files/documents/2023/02/28/Vision_for_Success-Commercial_Fabrication_Facilities.pdf.

³³ Ibid.

| Chip Type | Function Examples | Application Examples | Chips Technology Generation Signifiers |
|-----------------------------|--|--|--|
| Discrete | Perform single electrical functions | Control electric current in devices | |
| Sensors and Optoelectronics | Process signals such as light and pressure | Image sensors in cameras, laser diodes, pressure sensors | |

Source: CRS.

Notes:

- a. DRAM stands for dynamic random-access memory. NAND is named for the “not-and” logic operation.

Which semiconductor industry firms can apply for financial incentives available through the CHIPS for America Fund program?

The first NIST notice of funding opportunity (NOFO) is reserved for facilities that provide new domestic capacity for front-end fabrication of semiconductor chips as well as back-end production activities (i.e., assembly, testing, and packaging). Additional NOFOs will be released for facilities that produce materials (e.g., chemicals and gases) and manufacturing equipment needed for semiconductor production, as well as those specializing in research and development. The law instructs the Secretary of Commerce to give priority to projects that “address gaps and vulnerabilities in the domestic supply chain.”³⁴

For front-end fabrication facilities, the Department of Commerce has identified program goals to support the production of particular types of semiconductor chips as explained in the next section. Another main program objective for back-end production activities is to increase domestic facilities providing advanced packaging capabilities. This growing segment of the semiconductor supply chain provides innovative strategies such as stacking chips on top of one another in the same package, which can offer enhanced functionalities for chip applications (and thus higher value) that may provide more economic feasibility for reshoring to the United States than traditional, low-value added commodity chip packaging operations.³⁵

Table 3. Semiconductor Supply Chain Segments Eligible for CHIPS Funding

| Supply Chain Segment | Function | Notice of Funding Opportunity (NOFO) Release Schedule |
|-----------------------|--|---|
| Front-end fabrication | Manufacture chips, most often on circular sheets on silicon called wafers, in facilities called “fabs” | First NOFO released 2/28/23 |
| Back-end production | Assembly (cut individual chips from wafers), testing (evaluate chip performance), and packaging (protect from the environment and add connections for integration into the final electronic product) | |

³⁴ 15 U.S.C. §2652(a)(2)(D)(i).

³⁵ John VerWey, *Global Value Chains: Explaining U.S. Bilateral Trade Deficits in Semiconductors*, U.S. International Trade Commission (USITC), Executive Briefing on Trade, p. 2, March 2018.

| Supply Chain Segment | Function | Notice of Funding Opportunity (NOFO) Release Schedule |
|--------------------------|---|---|
| Materials and equipment | Materials, chemicals, gases, and specialized manufacturing equipment needed for front and back-end chip production | Second NOFO expected by late Spring 2023 |
| Research and development | Facilities specializing in activities such as researching innovative semiconductor materials and designs as well as prototyping | Third NOFO expected by fall 2023 |

Source: U.S. Department of Commerce, NIST, Notice of Funding Opportunity, “CHIPS Incentives Program – Commercial Fabrication Facilities,” February 28, 2023, at https://www.nist.gov/system/files/documents/2023/02/28/CHIPS-Commercial_Fabrication_Facilities_NOFO_0.pdf.

When can semiconductor industry firms submit applications for the financial incentives available in the CHIPS for America Fund?

The CHIPS Program Office released the first NOFO and opened the application portal on February 28, 2023.³⁶ The first NOFO is reserved for applicants constructing, expanding, or modernizing facilities to produce semiconductors or provide advanced packaging capabilities. The CHIPS Program Office expects to release additional NOFOs for semiconductor materials and manufacturing equipment facilities in late spring 2023, as well as research and development facilities in the fall of 2023. All potential applicants for the first and future NOFOs (e.g., chip manufacturers, equipment and material suppliers, advanced packaging firms) may submit a required Statement of Interest beginning on February 28, 2023.³⁷ (See **Table 4** for key dates for CHIPS for America funding opportunities.) Other steps in the funding process include an optional pre-application (detailing project description), full application (including technical and financial feasibility of the project), due diligence (validating application information), and award issuance.

Table 4. Key Dates for CHIPS for America Funding Opportunities

| Notice of Funding Opportunity | Semiconductor Facility Type | Applications Accepted | Eligible Facility Examples |
|-------------------------------|-----------------------------|-----------------------|---|
| NOFO #1 | Leading-edge | 3/31/2023 | <ul style="list-style-type: none"> Leading-edge facilities that utilize the most advanced front-end fabrication processes for logic (e.g., extreme ultraviolet (EUV) lithography tools) Advanced memory chip fabs (3D NAND chips with 200 layers or more and DRAM chips at 13 nm and below) |
| | Current-generation | 6/6/2023 | <ul style="list-style-type: none"> Facilities producing logic, analog, radio-frequency, and mixed-signal chips that are non-leading edge up to 28 nm^a |

³⁶ The application portal and program information is available at <http://www.chips.gov>. The first funding opportunity is available at NIST, *CHIPS Incentive Program—Commercial Fabrication Facilities*, February 28, 2023, p. 28, at https://www.nist.gov/system/files/documents/2023/02/28/CHIPS-Commercial_Fabrication_Facilities_NOFO_0.pdf. Hereinafter referred to as “NIST, *NOFO, CHIPS Incentive Program—Commercial Fabrication Facilities*.”

³⁷ The Statement of Interest will be used for administrative purposes and not merit selection and must be submitted at least 21 days prior to any pre-application/full application. Required information includes project description, type of manufacturing facility, end markets for technologies produced, and expected total capital expenditures. NIST, *NOFO CHIPS Incentive Program—Commercial Fabrication Facilities*.

| Notice of Funding Opportunity | Semiconductor Facility Type | Applications Accepted | Eligible Facility Examples |
|-------------------------------|-----------------------------|-----------------------|---|
| | Mature-node | 6/6/2023 | Facilities producing: <ul style="list-style-type: none"> • Logic and analog fabs (above 28 nm) • Discrete semiconductor fabs • Optoelectronics fabs • Sensor fabs |
| | Back-end production | 6/6/2023 | <ul style="list-style-type: none"> • Assembly, test, and packaging (including advanced packaging) facilities |
| NOFO #2 (not released) | Materials and equipment | Late Spring 2023 | TBD |
| NOFO #3 (not released) | Research and development | Fall 2023 | TBD |

Source: NIST, Notice of Funding Opportunity, *CHIPS Incentive Program—Commercial Fabrication Facilities*, February 28, 2023.

Notes:

- a. NIST classifies current generation as semiconductors based on 5 nm to 28 nm processes nodes for logic, analog, and mixed signal devices. NIST, Notice of Funding Opportunity, *CHIPS Incentive Program—Commercial Fabrication Facilities*, February 28, 2023.

What workforce requirements does the first Notice of Funding Opportunity place on applicants for CHIPS incentive funding?

The CHIPS Act of 2022 requires recipients of funding to make significant worker and community investments, including opportunities for small businesses and disadvantaged communities, and requires companies to comply with the Davis-Bacon Act prevailing wage rates for the workers constructing facilities built with CHIPS funding.³⁸

To promote workforce development and equity for facility workers, the Department of Commerce NOFO requires all applicants to secure “sectoral partnerships” with entities including regional educational and training organizations and institutions of higher education to provide workforce training. These strategic partnerships must include programs for training and job placement of economically disadvantaged individuals.³⁹ Examples of such partnerships include those with other businesses, industry associations, government organizations (federal, state, local, and tribal), economic development organizations, faith-based organizations, labor unions, and non-profit organizations. Applicants must also describe how their workforce development plan aligns with the Department of Labor and Department of Commerce’s Good Jobs Principles.⁴⁰

The NOFO states, “Child care is critical to expanding employment opportunity for economically disadvantaged individuals, including economically disadvantaged women.” Accordingly, applicants requesting awards over \$150 million are required to include plans to provide access to

³⁸ For more information on the Bacon-Davis Act, see CRS In Focus IF11927, *Federally Funded Construction and the Payment of Locally Prevailing Wages*, by David H. Bradley and Jon O. Shimabukuro.

³⁹ Sectoral partnerships are defined as those which align key partners to train and place workers into high skilled jobs (15 U.S.C. § 4652(a)(2)(B)(III)).

⁴⁰ For more information on the Department of Labor/Department of Commerce’s Good Jobs Principles, see U.S. Department of Labor, “Department of Commerce and Department of Labor Good Jobs Principles,” at <https://www.dol.gov/general/good-jobs/principles>.

affordable, accessible, reliable child-care for facility and construction workers through measures such as onsite child-care facilities, subsidies, and partnering with off-site providers.

For the construction workforce, applicants must ensure compliance with federal labor laws, including the Davis-Bacon Act and the Occupational Safety and Health Act, and with Executive Order 11246. Applicants must also elect to use project labor agreements or submit workforce continuity plans to ensure timely delivery of the projects.

What requirements and restrictions did Congress require related to the CHIPS for America Fund?

The CHIPS Act of 2022 included a number of provisions meant to protect national security and ensure that funds appropriated to the CHIPS for America Fund, the CHIPS for America Defense Fund, the CHIPS for America International Technology Security and Innovation Fund, and the CHIPS for America Workforce and Education Fund are used only for the purposes specified in the act. These provisions are referred to broadly in policy discussions as *guardrails*.

- The act establishes a guardrail to ensure that recipients of CHIPS funding do not expand manufacturing capacities below the 28 nm level technology node in China or other countries of concern for 10 years after receiving the financial award, even with their own non-CHIPS funds.
- The act also establishes a guardrail to prevent companies from using taxpayer funds for stock buybacks and shareholder dividends. Specifically, the act prohibits the use of these funds for the purchase of an equity security of the incentive recipient that is listed on a national securities exchange or any parent company of the incentive recipient; or to pay dividends or make other capital distributions with respect to the common stock of the incentive recipient.

The Department of Commerce indicates no foreign entities of concern are eligible to receive CHIPS incentives.⁴¹ Additionally, applications for awards will be evaluated to ensure foreign entities of concern do not present national security risks through control, access to information, or other means.⁴²

In addition, entities that receive awards over \$150 million must share a portion of any returns on investment that exceed a mutually agreed-upon threshold with the U.S. government (i.e., upside sharing).

How long might it take before U.S. semiconductor facilities supported by the act begin to produce chips?

Globally, fab construction on a new site (also referred to as a greenfield site) typically takes two to four years. Between 2010 and 2020, fabs constructed in the United States have taken an average of about 2.5 years from the start of construction to the beginning of production. In contrast, during the same period, fabs built in China and Taiwan required about 1.8 years to

⁴¹ Foreign entities of concern as defined in 15 U.S.C. § 4651(8).

⁴² The Department of Commerce defines “control” as “any direct or indirect investment in a corporate entity that provides the investor with the means to influence important matters affecting the project.” Examples include involvement with the board of directors and technology licensing decisions. NIST, *NOFO CHIPS Incentive Program—Commercial Fabrication Facilities*.

complete construction.⁴³ According to Intel executives discussing plans for fabs in the United States and Germany, “best-in-class” semiconductor fabs take three to five years to build after the land is acquired and the construction team is secured.⁴⁴ Pre-construction activities include design and permit approvals, followed by a number of other steps, including site development, installation of various utility and process systems (e.g., clean room and delivery systems for chemical and gases), and installation of equipment used to process wafers.

Some industry analysts have identified the role of extensive permitting requirements in increasing time associated with fab construction. For example, the process for obtaining pre-construction and operating permits required under the Federal Clean Air Act can take 12 to 18 months.⁴⁵ Additionally, domestic fab construction projects that receive financial incentives under the CHIPS Act of 2022 may require review under the National Environmental Policy Act, which applies to construction projects considered as major federal actions. Potential strategies to reduce time associated with permitting include expedited reviews and resolution of redundant federal and state permit requirements. Other federal agencies involved in regulating environmental health and safety aspects of fab construction and operation include the U.S. Army Corps of Engineers and the U.S. Department of the Interior.

Promoting Domestic Semiconductor R&D and with CHIPS Funds

What is the role of the National Semiconductor Technology Center (NSTC)?

The Department of Commerce describes the NSTC, authorized by Section 9906(c) of the 2021 NDAA, as the “focal point” of the \$11 billion provided in the CHIPS Act of 2022 for research and development. The NSTC is to be a public-private consortium⁴⁶ that will serve as an innovation hub to “advance semiconductor technology and seed new industries built on the capabilities of a wide range of advanced chips.” Conceptually, according to NIST, government, industry, customers, suppliers, educational institutions, entrepreneurs, workforce representatives, and investors will converge in the NSTC to address semiconductor ecosystem challenges and opportunities.

According to the Department of Commerce, the NSTC will develop a comprehensive semiconductor R&D program that will include research, prototyping capabilities, an investment fund, and workforce development programs. Additionally, according to the Department of Commerce:

⁴³ John VerWey, *No Permits, No Fabs*, Center for Security and Emerging Technology, October 2021, pp. 6-8.

⁴⁴ Dylan Martin, “Intel: The Economy Is Bad Right Now, but We Still Need More Fabs,” *The Register*, November 29, 2022.

⁴⁵ President’s Council of Advisors on Science and Technology, *Ensuring Long-Term U.S. Leadership in Semiconductors*, January 2017, p. 17, at https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_ensuring_long-term_us_leadership_in_semiconductors.pdf.

⁴⁶ The Department of Commerce anticipates the NSTC will be an independent entity with NSTC leadership reporting to a governing board informed and advised by industry, academia, government, and key stakeholders. Further, the department anticipates that the governing board will include public interest directors to help ensure that public objectives are met and to help provide accountability for public funds.

The NSTC will have a core of centrally operated, in-house research, engineering, and program capabilities combined with a network of directly funded and affiliated entities that takes advantage of regional expertise and assets throughout the country. The NSTC also will serve as a key convening body for the ecosystem.

The NSTC will work across a range of activities including applied research, start-up company support, prototyping of devices and processes in a real-world environment, challenges related to scaling, or development of advanced manufacturing tools and processes

The NSTC will work across the semiconductor technical stack and its supply chain, including design, materials, capital equipment, and facilities. The NSTC charter also extends to the broader community that supports and enables the industry, such as workforce and training institutions, capital providers, and semiconductor end users.

The NSTC will engage in and support research through collaboration, technical exchanges, convenings, and grant programs.

The NSTC will focus research and engineering on challenging projects with a time horizon beyond 5 years. The NSTC will focus on delivering broad benefits to the U.S. semiconductor ecosystem, even when working with individual entities.

The NSTC will work with allies to complement and reinforce existing research assets and capabilities, while strengthening and growing U.S. capacity.

The NSTC will welcome the participation of semiconductor users, device makers, designers, application and software product developers, and other market shapers to develop promising use cases to bring to commercialization.⁴⁷

What is the implementation status of the NSTC?

The Department of Commerce has conducted, and continues to conduct, stakeholder engagements to inform its development of the NSTC. These efforts include requests for information (RFIs), workshops, and listening sessions. In addition, the department is considering recommendations made by the President’s Council of Advisors on Science and Technology (PCAST).

The Department of Commerce states that it expects to release a white paper in the first quarter of 2023 that will summarize the results of its landscape analysis, governance structure, and preliminary operating and financial model, and will issue guidance at that time on when to expect requests for proposals.⁴⁸

What is the role of the National Advanced Packaging Manufacturing Program?

According to the Department of Commerce, the National Advanced Packaging Manufacturing Program (NAPMP, authorized under Section 9906(d) of the 2021 NDAA) is intended to strengthen semiconductor advanced test, assembly, and packaging capability in the domestic ecosystem. The department asserts that “advanced packaging is the current state of the art, but the U.S. has little to no capacity for advanced packaging at present” and whereas “it is cost prohibitive to bring conventional packaging back to the [United States]” the potential of advanced

⁴⁷ NIST, “The National Semiconductor Technology Center Update to the Community,” November 16, 2022, at <https://www.nist.gov/chips/national-semiconductor-technology-center-update-community>.

⁴⁸ Ibid.

packaging provides an opportunity to leap-frog to advanced packaging capabilities as they are developed worldwide.⁴⁹

Potential technology areas targeted by the NAPMP include co-design, chiplets (described in the next section), heterogeneous integration, design, platforms, advanced tooling, and materials and substrates. NIST's initial approach is to identify areas of focus and services needed to build domestic capacity for key areas and to identify opportunities to strengthen alignment of key areas with facilities, partnerships, and program integration.⁵⁰

What is the implementation status of the NAPMP and what are the views and priorities of stakeholders?

In January 2022, the Department of Commerce issued a Request for Information on the NAPMP and other activities included in the 2021 NDAA and proposed in the U.S. Innovation and Competition Act of 2022 (S. 1260, 117th Congress), a forerunner legislation to P.L. 117-167.

According to the Department of Commerce, RFI respondents recommended the NAPMP “serve as a critical resource to develop advanced packaging and related R&D, as part of a larger effort to strengthen the resiliency of the semiconductor supply chain.” In particular, respondents identified the following competencies the NAPMP should focus on:

- **heterogeneous integration**, the process of combining semiconductor components from different manufacturers such as sensors, power electronics, and 5G communications into one packaged system;
- **chiplets**, the process of dividing functions previously performed by a single chip into discrete functions and fabricating them in smaller building blocks that can be connected together;
- **photonics**, chips that use or generate light signals instead of electricity (e.g., semiconductor lasers, telecommunications, and photonic computing); and
- **co-design**, design of semiconductors and packaging solutions involving two or more partners (e.g., designing optimized chip hardware with consideration of the downstream value chain, including packaging, software, and end device application such as chips tailored for artificial intelligence).⁵¹

In addition, respondents recommended the NAPMP have “easily accessible and flexible facilities or hubs that focus on low volume, cost-effective prototyping capabilities,” as well as “broad capabilities in material characterization, metrology, modeling and simulation, and standards.”

Respondents also identified certain critical needs the NAPMP should meet, including strengthening the resiliency of the semiconductor supply chain, supporting a broad set of

⁴⁹ Remarks of Laurie E. Locascio, Director, NIST, before the American Association for the Advancement of Science, “AAAS Business Meeting: When the Government Makes Big Bets on Science and Technology: The CHIPS Act,” March 4, 2023.

⁵⁰ Eric Lin, “Chips R&D Update,” December 8, 2022, at https://www.nist.gov/system/files/documents/2022/12/15/1.%202022-12-08_RD_Deck_final.pdf.

⁵¹ NIST, *Incentives, Infrastructure, and Research and Development Needs to Support a Strong Domestic Semiconductor Industry: Summary of Responses to Request for Information*, NIST Special Publication (NIST SP 128), August 2022, at <https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1282.pdf>.

technologies and applications, encouraging collaboration and information sharing, providing a flexible and accessible low-volume prototyping facility, and facilitating workforce development.

Further, respondents expressed the view that, given the interrelated nature of packaging and chip technologies, the efforts of the NAPMP and the NSTC should be closely aligned, and that the two organizations should be collaborative and complementary to avoid duplication of efforts and resources.⁵²

Promoting Workforce Training with CHIPS Funds

What workforce development and education provisions are included in CHIPS?

There are several provisions related to semiconductor workforce education and training in the CHIPS for America title of the 2021 NDAA and in the CHIPS Act of 2022.

The CHIPS Act of 2022 includes a sense of Congress that states, in part, that in carrying out the incentives program, the Secretary of Commerce should allocate funds in a manner that bolsters the semiconductor and skilled technical workforces in the United States.⁵³ Support for workforce development is one of the 2021 NDAA authorized uses of CHIPS Act of 2022 funding.⁵⁴

In addition, the CHIPS Act of 2022 directs the Secretary of Commerce to assign personnel to lead and support the activities carried out under the “Opportunities and Inclusion” section of the act, including coordination with other workforce development activities of the Department of Commerce and other federal agencies.⁵⁵ The Department of Commerce states that it will coordinate workforce development activities across these programs with other agencies funded by the CHIPS Act of 2022 (e.g., NSF), with interagency efforts through the CHIPS Implementation Steering Council established by President Biden in Executive Order 14080, “Implementation of the CHIPS Act of 2022,” and the Subcommittee for Microelectronics Leadership established by Section 9906(a) of the 2021 NDAA.⁵⁶

Applicants for Section 9902 incentive funding must make workforce development commitments and must have

secured commitments from regional educational and training entities and institutions of higher education to provide workforce training, including programming for training and job placement of economically disadvantaged individuals.⁵⁷

An applicant for Section 9902 incentives program funding must demonstrate that it has secured a “covered incentive,” which the act defines as including a workforce-related incentive, including a grant agreement relating to workforce training or vocational education.⁵⁸ Further, an applicant must demonstrate that it has “documented, to the extent practicable, workforce needs and developed a strategy to meet such workforce needs consistent with” its other commitments in the

⁵² Ibid.

⁵³ P.L. 117-167, Section 103(b), and codified at 15 U.S.C. §4652(d)(5).

⁵⁴ P.L. 116-283, Section 9902(a)(4), and codified at 15 U.S.C. §4652(a)(4)(B).

⁵⁵ P.L. 117-163, Section 104(b), and referenced at 15 U.S.C. §4652 in the “Statutory Notes and Related Subsidiaries.”

⁵⁶ NIST, *CHIPS for America: A Strategy for the CHIPS for America Fund*, September 6, 2022.

⁵⁷ P.L. 116-283, Section 9902, and codified at 15 U.S.C. §4652(a)(2)(B).

⁵⁸ P.L. 116-283, Section 9901(3)(B), and codified at 15 U.S.C. §4651(3)(B).

application.⁵⁹ Incentives program applicants must have made, among other things, commitments to worker and community investment, including through training and education benefits paid by the covered entity, and programs to expand employment opportunity for economically disadvantaged individuals.⁶⁰

In addition, the NSTC and Manufacturing USA institute programs established by Section 9906 are charged with elements of workforce development. In directing the establishment of the NSTC, Congress directed the Secretary of Commerce to work with the Secretaries of Labor and Energy, Director of the National Science Foundation, the private sector, institutions of higher education, and workforce training entities to incentivize and expand geographically diverse participation in graduate, undergraduate, and community college programs relevant to microelectronics. This is to be done through the development and dissemination of curricula and research training experiences, and the development of workforce training programs and apprenticeships in advanced microelectronic design, research, fabrication, and packaging capabilities.⁶¹ Beyond their R&D mission, the Manufacturing USA institutes established under CHIPS are authorized to develop and deploy “educational and skills training curricula needed to support the industry sector and ensure the United States can build and maintain a trusted and predictable talent pipeline.”⁶²

The CHIPS Act of 2022 also establishes a CHIPS for America Workforce and Education Fund and appropriates \$25 million in each of FY2023 and FY2024, and \$50 million in each of FY2025, FY2026, and FY2027, for a total of \$200 million over the five-year period. These funds are appropriated to the NSF for microelectronics workforce development activities to meet the requirements of Section 9906 of the NDAA (as amended), which includes, among other things, the establishment of the NSTC, NAPMP, and up to three semiconductor technology-focused Manufacturing USA institutes.⁶³

Congress directed the Government Accountability Office (GAO) to review the CHIPS program and to include a description of workforce training programs carried out with awards made under the program, including efforts to hire individuals from disadvantaged populations. GAO is also directed to include aggregated workforce data, including data by race or ethnicity, sex, and job categories in its review. GAO is to produce and submit its review to Congress not later than two years from the date of disbursement of the first CHIPS financial incentive award, and then every two years thereafter for ten years.⁶⁴

For additional information on Department of Commerce and NIST implementation of the workforce provisions in its domain of responsibility, see *CHIPS for America: A Strategy for the CHIPS for America Fund*.⁶⁵

⁵⁹ P.L. 117-167, Section 103(b)(2)(B)(iii), and codified at 15 U.S.C. §4652 (a)(2)(B)(ii)(VI).

⁶⁰ P.L. 116-283, Section 9902(a)(2)(B)(ii), and codified at 15 U.S.C. §4652(a)(2)(B)(ii)(III).

⁶¹ P.L. 116-283, Section 9906(c)(2)(C), as amended by P.L. 117-163, Section 103(b), and codified at 15 U.S.C. §4656(c)(2)(C).

⁶² P.L. 116-283, Section 9906(f)(3), and codified at 15 U.S.C. §4656(f)(3).

⁶³ P.L. 117-163, Section 102(d).

⁶⁴ P.L. 116-283, Section 9902(c)(1)(C)(iii), as amended by P.L. 117-163, Section 105(a)(2), and codified at 15 U.S.C. §4652(c).

⁶⁵ NIST, *A Strategy for the CHIPS for America Fund*, September 6, 2022, at <https://www.nist.gov/system/files/documents/2022/09/13/CHIPS-for-America-Strategy%20%28Sept%20%2C%202022%29.pdf>.

Considerations for Congressional Oversight

What are the aspects of CHIPS program implementation that Congress might choose to explore?

The CHIPS Act gives the Secretary of Commerce discretion in key areas of implementation. There is broad discretion in how the Secretary may review applications and grant monies according to criteria that the law has set. The law seeks to prioritize companies that manufacture chips “to address gaps and vulnerabilities in the domestic supply chain across a diverse range of technology and process nodes” and “for the national security, manufacturing, critical infrastructure, and technology leadership of the United States.”

In this context, Congress may opt to explore a number of oversight issues:

- How can CHIPS funds best be balanced to achieve the program’s goals (e.g., technological leadership in leading edge semiconductor nodes that require more capital investments; supply chain security across many technology nodes, including mature chips)?
- How is CHIPS funding allocated with regard to particular firms, types of chips/materials produced, location of facilities, parts of the supply chain, and size or type of firm?
- What are the strengths and weaknesses of the business models of manufacturing facilities receiving financial assistance and the accessibility of domestic semiconductor chip designers to utilize them (e.g., broad access foundries, prototyping facilities, private integrated device manufacturers (IDMs))?⁶⁶
- How effective is the allocation of CHIPS resources and specific decisions on beneficiaries of funding in advancing U.S. national competitiveness, national security, and economic security?
- How could the R&D and manufacturing incentives promote innovation by enabling access to prototyping and manufacturing facilities for start-ups, universities, and small businesses?

Congress might also consider establishing additional regular reporting requirements in this regard to ascertain progress and assess performance on key benchmarks.

What potential issues exist with respect to manufacturing funding allocations based on the type and generation of semiconductor chip technology or supply chain segment?

The CHIPS Act of 2022 specifies \$2 billion of the \$19 billion allocated for the first funding year is to support the production of “mature technology nodes.”⁶⁷ The act directs the Secretary of

⁶⁶ Foundries are contract manufacturers that produce chips for a variety of customers; integrated device manufacturers typically manufacture their own proprietary chip designs. Some companies do a mix of both. For more information, see the **Appendix** for additional information on various semiconductor industry business models.

⁶⁷ Technology node is an industry label used to gauge different generations of certain chips, such as logic chips. However, this metric may not be appropriate for use in guiding investments in other types of semiconductor technologies, including some memory chips (e.g., 3D NAND chips are built with increasing layers rather than

Commerce to determine which technology nodes are to be considered “mature” with respect to this funding. The Department of Commerce anticipates committing approximately three quarters of financial incentives funding (around \$28 billion) to domestic facilities producing “leading-edge” logic and memory chips which typically require the highest capital costs and at least one quarter (around \$10 billion) will be for “mature and current-generation chips, new and specialty technologies, and for semiconductor industry suppliers.”⁶⁸ Descriptions of facilities which may qualify as leading-edge, current-generation, or mature-node are provided in the first NOFO.⁶⁹ This NOFO focuses on facilities producing semiconductor chips or participating in post-production activities such as packaging and testing. Additional NOFOs are expected to be released later in calendar year 2023 for facilities which produce semiconductor materials or equipment, as well firms that participate in R&D.

While leading-edge logic and memory chips can promote technological leadership in areas such as artificial intelligence and high performance computing, manufacturers also face ongoing demand for more established products, such as mature-node chips, the scarcity of which forced auto manufacturers to temporarily shut down some assembly lines in early 2022. Additionally, some technical innovations in semiconductors do not use the technology node criterion and employ such strategies as novel semiconductor materials and device designs. For example, higher production of electric vehicles and the need for increasingly sophisticated systems to integrate renewable power generation into the electric grid are also likely to increase demand for advanced semiconductors for power management that are not built on leading-edge nodes but alternative semiconducting materials which enable superior performance (e.g., silicon carbide and gallium nitride). Additionally, the semiconductor industry is moving towards advanced packaging techniques to enhance functionalities of semiconductor-based devices using novel device designs (e.g., stacking chips on top of one another). Leadership in these techniques may be an important pillar for semiconductor innovation during a time when traditional strategies for innovation are becoming increasingly complex and costly to manufacture.

Congress may opt to consider how funding allocations for different types and generations of chips as well as different parts of the semiconductor supply chain balance the law’s goals of technological leadership and economic security of critical manufacturing industries. Congress may also choose to consider how the releasing of separate NOFOs over the year for different parts of the semiconductor supply chain and separate application submission dates for leading-edge versus non-leading edge facilities impact the availability of funds for downstream applicants such as semiconductor material and equipment suppliers.

What are potential issues with intellectual property protections and other provisions related to entities of concern in the CHIPS program?

The CHIPS Act of 2022 includes a technology clawback provision authorizing the Department of Commerce to

shrinking components) and power chips (e.g., advanced power chips use new semiconductor materials such as silicon carbide and gallium nitride). For more information, see “Process/Technology Nodes.”

⁶⁸ NIST, *A Strategy for the CHIPS for America Fund*, September 6, 2022, at <https://www.nist.gov/system/files/documents/2022/09/13/CHIPS-for-America-Strategy%20%28Sept%206%2C%202022%29.pdf>.

⁶⁹ *Notice of Funding Opportunity (NOFO), CHIPS Incentives Program—Commercial Fabrication Facilities*, February 28, 2023

recover the full amount of an award if, during the applicable term with respect to the award, the [award recipient] knowingly engages in any joint research or technology licensing effort with (i) a foreign entity of concern⁷⁰ and (ii) that relates to a technology or product that raises national security concerns, as determined by the Secretary and communicated to the covered entity before engaging in such joint research or technology licensing.⁷¹

A proposed rule published by the Department of Commerce on March 23, 2023, defines the covered technologies and products as semiconductors critical to national security and electronics-related products or technologies controlled for national security or regional stability reasons in the Export Administration Regulations (EAR) and extends the prohibition to funding recipients' affiliates.⁷² Companies are invited to submit comments on pre-existing arrangements which may raise national security concerns. The first NOFO for manufacturing facilities states that the Department will not approve applications where foreign entities of concern pose undue risk to national security through control, access to information, or other mechanisms. The definition of "control" includes investments in a corporate entity which enable undesirable investors to influence important matters affecting the project.⁷³

Additionally, a clawback section in the law restricts companies that receive CHIPS incentive funding from expanding manufacturing in China or other countries of concern for the production of "legacy" technology nodes, defined as 28 nm and larger.⁷⁴ Congress may choose to conduct oversight of how the Department of Commerce is tracking technology transfer at the 28 nm and larger nodes and mature technologies that are not restricted but might still offer meaningful technology capabilities to China. These more mature nodes are frequently used in defense applications and appear to be the segment of chips that China is exporting to Russia—an issue of particular congressional interest in light of U.S. sanctions against Russia following its invasion of Ukraine.⁷⁵ Congress may choose to examine the extent to which current 28 nm node size and other restrictions are sufficient in policy and in practice for creating guardrails and protections. Congress may consider whether these regulations and restrictions are sufficient to prevent entities of concern from accessing production capacity either in country or through exports. Congress might wish to inquire about how the Department of Commerce plans to address this issue or consider whether additional requirements may be needed.

Congress may also choose to examine how the executive branch is protecting U.S. investments in semiconductors and the sector more broadly. For example, there have been reports that TSMC might be using the Nanjing, China, branch of its facilities supplier, United Integrated Services

⁷⁰ 15 U.S.C. § 4651(8).

⁷¹ 15 U.S.C. § 4652(a)(5)(C).

⁷² CHIPS Program Office, NIST, "Preventing the Improper Use of CHIPS Act Funding," 88 *Federal Register* 17439-17450, March 23, 2023.

⁷³ "The term 'control' for this purpose is defined as any direct or indirect investment in a corporate entity that provides the investor with the means to influence important matters affecting the project. The term 'means to influence important matters' includes membership or observer rights on, or the right to nominate an individual to a position on, the board of directors or equivalent governing body of the corporate entity; any involvement, other than through voting of shares, in substantive decision-making by the corporate entity; and consultation rights with respect to technology licensing to third parties." NIST, *Notice of Funding Opportunity (NOFO), CHIPS Incentives Program—Commercial Fabrication Facilities*, February 28, 2023.

⁷⁴ P.L. 117-167, Section 103(b)(5).

⁷⁵ CRS In Focus IF12120, *China's Economic and Trade Ties with Russia*, by Karen M. Sutter and Michael D. Sutherland; Andrew David, Sarah Stewart, Megan Reid, Dmitri Alperovitch, "Russia Shifting Import Sources amid U.S. and Allied Export Restrictions: China Feeding Russia's Technology Demands," Silverado Policy Accelerator, January 2023.

Co., Ltd., for the piping work at its new Arizona fab.⁷⁶ It is unclear which federal agency is responsible for ensuring that new facilities supported by CHIPS funding are secure against espionage or theft. A recent intellectual property (IP) case brought by the U.S.-headquartered company Femometrix highlights China’s continuing pattern of IP theft and talent poaching. According to the charges, Femometrix employees who are PRC nationals stole technology and established a new firm in China that is supported by three venture funds tied to the PRC government and its national semiconductor industrial program.⁷⁷

What are the goals and organizational structures of the R&D programs funded by the act?

The CHIPS Act of 2022 includes a number of provisions that fund federal semiconductor R&D initiatives. NIST in partnership with U.S. industry is to develop an NSTC to conduct research and prototyping of advanced semiconductor technologies. Also, NIST is to develop a NAPMP to strengthen advanced semiconductor testing, assembly, and packaging. In addition, NIST is authorized to establish up to three Manufacturing USA institutes for semiconductor manufacturing. Further, the act appropriates a separate fund for the Department of Defense to support a National Network for Microelectronics Research and Development (also known as the Microelectronic Commons) to enable “lab-to-fab” transitions of microelectronics innovations.⁷⁸ The lab-to-fab gap refers generally to the inability of certain entities (e.g., universities, startups, small businesses) to prototype and scale the manufacturing of their advanced semiconductor designs due to barriers such as high costs and difficulties in competing with demand for manufacturing capacity from larger firms.

The first NOFO states that applicants should commit to participating in the NSTC by, for example, reserving production capacity for R&D projects and prototyping for small businesses and universities. With regard to implementation, Congress may opt to examine a variety of topics:

- What should be the governance structure of the NSTC (e.g., should there be a fiduciary board as recommended by the Industrial Advisory Committee or other structure to promote public private partnerships and the R&D goals put forth by the committee)? To what extent have models and lessons learned from similar U.S. government efforts been incorporated in the NSTC governance structure?
- How has the NSTC and NAPMP enabled access to prototyping and volume manufacturing facilities for small businesses, start-ups, universities, and the Department of Defense? Have the programs provided value to large entities to sustain this accessibility?
- How will the work of the NSTC and NAPMP be integrated with other semiconductor initiatives, including federal activities (e.g., Microelectronics Commons, the National Science Foundation, Defense Advanced Research Projects Agency) and semiconductor industry consortiums (e.g., Semiconductor Research Council)?
- Has NIST been effective in setting up the new CHIPS Research and Development office to carry out these efforts?

⁷⁶ Ramish Zafar, “TSMC Supplier Expects to Equip U.S. Chip Plant in September Next Year,” WCCF Tech, April 20, 2021.

⁷⁷ FemtoMetrix Taps Perkins Coie in Trade Secrets Suit over Semiconductor Tech,” ALM Law, September 1, 2022.

⁷⁸ For more information on the CHIPS for America Defense Fund, see “CHIPS Act of 2022 provisions and appropriations for each fund and activity.”

- Has the NSTC attracted appropriate sustained investments and commitments from industry members to become sustainable in the long term?

What are the implications of the open source technology movement in semiconductors?

The United States is a global leader in semiconductor IP and design. This part of the supply chain is under significant evolution as companies such as Amazon, Apple, and Facebook design their own chips. There is a growing movement toward open source technology platforms. Some analysts contend that development and promotion of an open-access design ecosystem for mature chips can encourage semiconductor innovation by lowering the barrier of access for domestic companies to design semiconductor chips for their specific applications.⁷⁹ However, China is leveraging access to U.S.-led open-source technology IP and technical design support. These changes pose additional questions Congress may opt to consider:

- Given the accessible nature of open source technology, is it possible to exclude certain entities from participation? Should countries or entities of concern be excluded from certain open source technology projects, or otherwise be limited? If so, how?
- Should open-source platforms be subject to U.S. export controls or other authorities Congress might consider or develop?
- Does the federal government’s approach take into consideration the changes occurring within the industry, such as the use of new materials; open source architectures for both hardware and software; the future of fabless development; the trend toward smaller node chips; the creation and use of chiplets and system-on-chip (SoC) methods; AI applications; and the use of chips in a wider array of products and applications?
- Do federal policies on foreign participation in R&D require revision or increased oversight? The U.S. federally funded research system is, in large measure, open to the participation of PRC nationals and firms to work alongside U.S. and other researchers at the leading edge of development of new types of chip materials and approaches. Some types of research are subject to export controls, including deemed exports. Unclassified research that is not export controlled is generally open, per long-standing federal policy. This policy was enacted during the Cold War to prevent Eastern Bloc nations from acquiring U.S. technology that could enhance their military capabilities, while preserving a “research environment conducive to creativity, an environment in which the free exchange of ideas is a vital component.”⁸⁰

Chinese firms with a U.S. market presence or a U.S.-based R&D center can use that presence to support their semiconductor operations in China and benefit from proximity to U.S. technology and talent in the United States. For example, China’s national champion in optoelectronics chips, San’an, operates in California through its subsidiary, Luminus. The 2013 merger agreement between Luminus and Lightera Corporation, a wholly-owned affiliate of San’an Optoelectronics

⁷⁹ Jan-Peter Kleinhans, *The EDA Chokepoint Dilemma? Openness, Oligopolies, and China’s Ecosystem*, UC Institute on Global Conflict and Cooperation, December 2022.

⁸⁰ See National Security Decision Directive NSDD-189, *National Policy on the Transfer of Scientific, Technical and Engineering Information*, September 21, 1985, at <https://irp.fas.org/offdocs/nsdd/nsdd-189.htm>.

Co., Ltd., stated that Luminus gained access to an advanced R&D operation in California as well as the overall technical strength of San'an's corporate R&D technical center.⁸¹ In another example, China's national semiconductor fabless champion GigaDevice, supported by China's national semiconductor fund, was established in the United States in 2005 and listed on the Shanghai Stock Exchange in 2016. The company eventually transferred its U.S. technology and core operations to China. Venture capital and private equity firms with ties to China maintain U.S. offices to spot investment opportunities in both U.S. and Chinese firms operating in the United States. For example, WestSummit Capital, an investment firm that has supported deals to advance China's national semiconductor champions, maintains an office in Menlo Park, CA, home to a concentration of Silicon Valley technology and venture capital firms.⁸² Whether there should be restrictions in how Chinese firms are allowed to operate in the U.S. market, including with regard to partnerships with U.S. research institutes and ability to hire U.S. talent, could be an issue of congressional interest.

What opportunities exist for Congress to oversee and influence trade policies regarding CHIPS program and objectives?

Congress might choose to examine the extent to which U.S. foreign and trade policies are advancing the goals and provisions in the act. For example:

- How do U.S. foreign policy efforts with allies and like-minded countries align with implementation of provisions in the act?
- To what extent do U.S. foreign policy actions seek to avoid a potentially counterproductive semiconductor subsidies competition among allies and other friendly nations?
- To what extent are U.S. export controls and other restrictions with regard to countries of concern such as China and Russia aligned with the intent and provisions in the act, both with respect to U.S. policies and their implementation as well as with regard to U.S. coordination of policies with allies and like-minded countries with significant semiconductor sectors?

Following the U.S.-European Union Trade and Technology Council (TTC) meetings in May 2022, both sides said that they would aim to avoid a semiconductor subsidy competition by abiding by WTO rules and setting “common goals for incentives granted in respective territories and an exchange of information regarding such incentives on a reciprocal basis.”⁸³ Some analysts have noted, however, that this commitment appears to be open-ended and “soft” without more specific policy efforts.⁸⁴ Congress may opt to explore related issues, such as:

⁸¹ Luminis, press release, “Luminus Devices, Inc. Announces Merger Agreement with Lightera Corporation, a Wholly Owned Affiliate of Sanan Optoelectronics Co., Ltd.,” June 11, 2013, at https://www.luminus.com/datasheets/Press_Releases_Acquisition_Press_Release_FINAL.pdf.

⁸² See <https://www.westsummitcap.com/about-us/>; Adam Lysenko, Thilo Hanemann, Daniel H. Rosen, “Disruption: US-China Venture Capital in a New Era of Strategic Competition,” U.S.-China Investment Project, January 2020, at https://publications-research.s3-us-west-2.amazonaws.com/RHG_Disruption_US+China+VC_January2020.pdf.

⁸³ “U.S.-EU Joint Statement of the Trade and Technology Council,” press release, May 16, 2022, at <https://www.commerce.gov/sites/default/files/2022-05/US-EU-Joint-Statement-Trade-Technology-Council.pdf>.

⁸⁴ Paul Timmers, “How Europe Aims to Achieve Strategic Autonomy for Semiconductors,” The Brookings Institution, August 9, 2022.

- With many competing incentives in different countries, should U.S. firms be allowed to accept incentives from both the United States and other countries? Some analysts have noted that Europe, and arguably the United States, will need help from like-minded countries in Asia to realize its policy objectives.⁸⁵
- How are the Department of Commerce and other U.S. agencies ensuring that efforts among allies are coordinated and mutually beneficial?
- What can be done to ensure greater alignment and collaboration with allies and partners to prevent China from exploiting gaps in different countries' policies toward trade and investment with China and any particular restrictions or lack of such restrictions among key U.S. allies and trading partners?
- With many countries supporting increased semiconductor industry capacity, what can be done to avoid global overcapacity?

In March 2022, the U.S. government proposed closer semiconductor policy collaboration—under the U.S.-East Asia Semiconductor Supply Chain Resilience Working Group, sometimes called the “Chips4 alliance”—among the United States, Japan, South Korea, and Taiwan to strengthen supply chain ties and leverage the respective capabilities of each partner.⁸⁶ In addition, the United States has created a policy initiative to coordinate with India on semiconductors and other technologies.⁸⁷ The Biden Administration recently announced new export controls on AI chips, as well as certain semiconductor equipment, software, and services for the production of advanced chips in China.⁸⁸ Additionally, the United States has reached an agreement with the Netherlands and Japan to coordinate control of the export of certain semiconductor equipment to China.⁸⁹ Congress may opt to explore to what extent such controls will involve licenses or prohibitions on exports, as well as how strong and comprehensive are the provisions with regard to other types of chips and other parts of the supply chain that might remain unrestricted or less restricted.

How can Congress assess the effectiveness of the CHIPS program? Are there additional reporting requirements that would be helpful in such assessments?

Congress may opt to assess the effectiveness of the various provisions of the CHIPS Act of 2022 and its implementation. In doing so, Congress might identify specific criteria, methodology, benchmarks, and reporting requirements for the assessment or the implementation itself. Among the topics that Congress may opt to consider in this context:

- The semiconductor sector is a capital-intensive industry in which the larger players are arguably heavily resourced. Have established large firms and existing

⁸⁵ Arjun Kharpal, “Europe Wants to Become a Leader in Chips. But It’s Going to Need Help,” CNBC, February 10, 2022.

⁸⁶ Dashveenjit Kaur, “Japan, US Join Forces to Stay Ahead in the Semiconductor Race,” TechHQ, August 2, 2022, at <https://techhq.com/2022/08/semiconductor-chip-supply-chain-japan-us/>.

⁸⁷ The White House, “Fact Sheet: United States and India Elevate Strategic Partnership with the Initiative on Critical and Emerging Technology (iCET),” January 31, 2023.

⁸⁸ 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,” 87 *Federal Register* 62186-62215, October 13, 2022.

⁸⁹ Cagan Koc and Jenny Leonard, “Biden Wins Deal with Netherlands, Japan on China Chip Export Limit,” *Bloomberg*, January 27, 2023.

- technologies been favored over smaller or newer firms and efforts? Have certain parts of the supply chain or certain types of chips been neglected?
- To what extent are U.S.-headquartered and U.S.-based end users of chips committing to use chips produced in the United States? To what extent are these end users and other U.S. investors investing in the U.S. semiconductor industry?
 - To what extent is government mobilizing the private sector or, conversely, potentially displacing investments the industry would have undertaken on its own?
 - To what extent is U.S. support encouraging firms to invest further in the United States, or conversely, freeing up companies' monies to invest outside the United States?
 - To what extent is the Department of Commerce addressing issues that could delay or inhibit investment in the U.S. semiconductor industry, such as permitting requirements and processes? To what extent is CHIPS funding sustaining current dominant players in the industry or fostering new firms?
 - To what extent is CHIPS sustaining existing technologies in the United States or breaking new ground to develop new capabilities?
 - To what extent has the U.S. developed a secure supply chain for strategic and defense applications? Are there areas in which this supply chain still has points of failure or vulnerabilities? To what extent is CHIPS likely to meet critical and strategic needs for reliable and secure chips?

Are there other considerations Congress might explore with respect to the U.S. position in semiconductors and related policies?

Some analysts have argued that U.S. policymakers will need to continually evaluate and address issues related to industrial competitiveness and the challenge that China's industrial policies pose to the United States. Congress might look ahead to assess whether current efforts are sufficient. Among the issues that Congress may want to consider:

- Are current approaches the right ones or should other types of support or protections be considered? If additional actions are required, what might new measures entail?
- To what extent should the U.S. government consider the semiconductor sector holistically with respect to how it is seeking to position the industry within the larger ecosystem of consumer electronics manufacturing and the growing range of products that now use a wide variety of chips and sensors?
- How might U.S. efforts to fund the semiconductor sector align with efforts to diversify production supply chains out of China and efforts to work with like-minded countries to secure critical minerals and inputs for such production?
- Should finished products that use U.S.-produced chips receive governmental preferences (e.g., procurement)?
- How might U.S. trade policies encourage supply chains among free trade agreement partners?

Appendix. Key Concepts Related to Semiconductors and CHIPS

Semiconductors (also known as integrated circuits or, simply, chips) are small electronic devices composed of billions of components that process, store, sense, and move data—essentially serving as the brains, memory, sensors, and traffic cops of electronic devices. There are a number of types of chips—including logic, memory, analog, optoelectronics, sensors, and discretets—each performing different functions and requiring specialized manufacturing processes.

Semiconductors are a uniquely important enabling technology. They are fundamental to nearly all modern industrial and national security activities, and they are essential building blocks of other emerging technologies, such as artificial intelligence, autonomous systems, advanced robotics, 5G communications, and quantum computing.

The following information provides a short overview of semiconductors to provide context for CHIPS Act of 2022 discussion.⁹⁰

Types of Chips

The semiconductor industry produces a wide variety of chips that perform different functions and that are designed for different applications including processing, storing, sensing, and transmitting data, as well as power management (see **Table A-1**). Generally, the production of each type of chip requires unique semiconductor manufacturing or fabrication facilities (referred to as fabs).

Table A-1. Semiconductor Chips: Types and Functions

| Type | Function/Applications |
|--------------|---|
| Logic chips | Logic chips typically function as the “brains” of computing devices. Logic chips include microprocessors, such as central processing units (CPUs) for general-purpose computing and graphics processing units (GPUs) for video rendering. They also include relatively less expensive chips designed to perform a particular task (e.g., operating power windows and seats in cars). The largest markets for logic chips include smartphones, personal and high performance computing (e.g., supercomputers and servers), Internet of Things devices (e.g., “smart” connected devices like activity tracker watches and speakers, home automation, and surveillance systems) and the automotive sector (e.g., advanced infotainment and driver assistance systems). |
| Memory chips | Memory chips store data. The two primary types are dynamic random access memory (DRAM) and not-and (NAND) flash. DRAM typically holds short-term data while a device is powered on, such as code needed by a computer processor to run programs. NAND flash provides long-term storage to store data like photos and music that remains available after the device is powered off. The largest applications markets for memory chips include mobile phones, data centers, and personal computing devices. |
| Analog chips | Analog chips provide a wide range of functions including working with sensors to convert and modify analog signals from the environment (such as temperature, speed, and pressure, which can span a range of continuous values) into digital signals used by computers; for power management to convert, control, and distribute electrical power in vehicle electrification; and for communications, including mobile phones and military applications such as detection and surveillance equipment (e.g., radar and sonar equipment, infrared imaging). |

⁹⁰ For more detailed information on types of semiconductors, see CRS Report R47508, *Semiconductors and the Semiconductor Industry*, by Manpreet Singh, John F. Sargent Jr., and Karen M. Sutter.

| Type | Function/Applications |
|-------------------------------------|---|
| Optoelectronics, sensors, discretes | Optoelectronic semiconductors are used to interact with or produce light; the largest applications markets for optoelectronics include light emitting diodes (LEDs), image sensors like those used in cameras, and laser diodes like those used in fiber optic communications. Other sensor applications include semiconductors designed to detect or control properties such as temperature, pressure, and acceleration. Sensors have a wide array of applications in consumer electronics like mobile phones, automobiles, and industrial equipment. Discrete semiconductors typically perform a single electrical function like controlling electric current in an integrated circuit. |

Source: CRS; for more information, see CRS Report R47508, *Semiconductors and the Semiconductor Industry*, by Manpreet Singh, John F. Sargent Jr., and Karen M. Sutter.

Process/Technology Nodes

The semiconductor industry uses the terms “process node,” “technology node,” or simply “node” to define and track successive generations of particular chip technologies over the last six decades. “Node” historically represented the actual size of transistor gates on logic chips measured in metric length; the size of these features has now reached the scale of nanometers (nm), or one billionth of a meter.⁹¹ Over time, the semiconductor industry has been able to reduce the size of these features, enabling higher performance by allowing more transistors on the same chip. However, decreasing the size of the electronic features on chips for successive generations is increasingly challenging and more costly. Semiconductor companies adopted new strategies (e.g., 3D transistor architectures and new materials and processes) to improve chip performance, but continued to use the “node” label to market new products. For advanced chips, industry uses a node number that is not reflective of the actual gate size and instead is a marketing term, with smaller numbers implying more powerful chips. While generally the case, comparative node size does not necessarily indicate the relative power or complexity of chips. Today, chips are fabricated in a wide variety of nodes, the smallest currently in production are 5 nanometer (nm) chips produced by Taiwan Semiconductor Corporation (TSMC) and South Korea-based Samsung.

Semiconductor manufacturers currently employ additional strategies to improve chip performance beyond reducing the size of electronic features. Therefore, node size or power may not be the most appropriate metric to capture advancements in performance.⁹² For example, some manufacturers of NAND flash chips stack layers of memory cells on top of one another—like adding floors to a skyscraper—to create three-dimensional (3D) structures called 3D NAND. The most advanced NAND memory chips have over 200 layers (a larger number of layers generally indicates a more advanced memory chip). Some power management chips, such as those used in electric vehicles and the electric grid, use semiconducting materials other than silicon—like silicon carbide and gallium nitride—to improve performance.

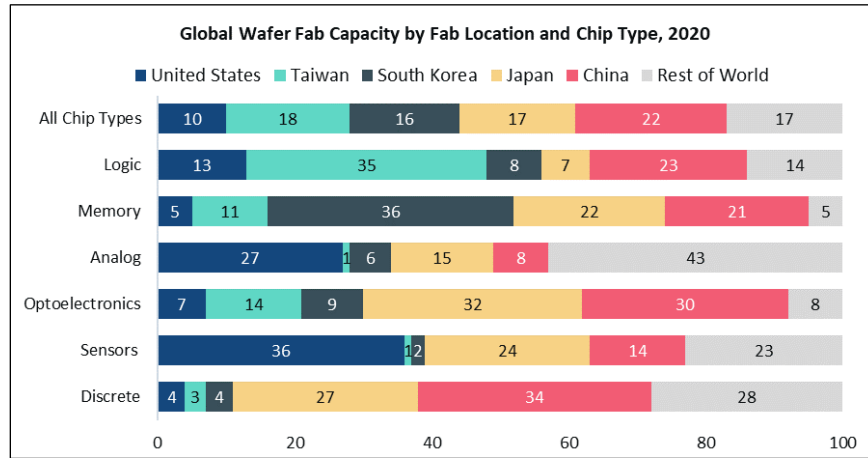
⁹¹ For logic chips, process node has historically been a measurement of transistor gate length (the gate is what controls the on/off state of the transistor to produce 0’s and 1’s for processing data). For DRAM memory chips, memory cells are the key electronic features and node sizes are still measured in nanometers but generally presented using “half-pitch” or half the distance between adjacent memory cells.

⁹² For more information, see CRS Report R47508, *Semiconductors and the Semiconductor Industry*, by Manpreet Singh, John F. Sargent Jr., and Karen M. Sutter.

Semiconductor Fabrication Capacity

Today, most semiconductor manufacturing activities currently take place in East Asia, including Taiwan, South Korea, Japan, and China. **Figure A-1** illustrates the share of manufacturing capacity for each type of chip by fab location.

Figure A-1. Wafer Manufacturing Capacity by Fab Location and Chip Type



Source: CRS, adapted from SEMI, *World Fab Forecast*, November 2020.

The majority of global chip manufacturing capacity in 2020 was owned by firms headquartered in the United States (22%), South Korea (20%), Taiwan (19%), China (15%), and Japan (12%).⁹³ These shares differ from those indicated in the figure above because some companies build fabs in countries other than the one in which they are headquartered.

Companies choose to build fabs outside countries in which they are headquartered for a variety of reasons, including capital costs; labor costs and availability; regulatory environment; land costs; water, waste treatment, and electricity costs and reliability; transportation infrastructure; proximity to customers; political stability; trade barriers (e.g., tariffs and technology transfer or localization requirements); national security requirements (e.g., export controls, trusted foundry requirements); and financial incentives and subsidies offered by national, regional, and local governments.

Stages of Semiconductor Production

The process required to produce a finished semiconductor chip involves design, fabrication, assembly, testing, and packaging. In many cases, these stages now occur across national borders among a small group of countries that specialize in particular parts of the supply chain. (**Table A-2** contains a description of each stage of the semiconductor production process, and global leaders in each.) In some cases, a semiconductor chip can cross national borders up to 70 times during the production process.⁹⁴

⁹³ Center for Security and Emerging Technology, *The Semiconductor Supply Chain: Assessing National Competitiveness*, January 2021, p. 20, at <https://cset.georgetown.edu/wp-content/uploads/The-Semiconductor-Supply-Chain-Issue-Brief.pdf>.

⁹⁴ Accenture and Global Semiconductor Alliance, *Globality and Complexity of the Semiconductor Ecosystem*, 2020, p. 6, at https://www.accenture.com/_acnmedia/PDF-119/Accenture-Globality-and-Complexity-Semiconductor-POV.pdf.

Table A-2. Stages of Semiconductor Production

| Stage | Description |
|-------------------------------|--|
| Design | <p>Companies conceive new products and specifications to meet customer needs and reduce these ideas to particular logic and circuit designs for manufacture.</p> <p>To handle the design of complex circuits with billions of electronic features such as transistors, chip designers typically use software called electronic design automation (EDA). EDA providers usually license certain parts of the fundamental chip design so that they do not need to recreate it, saving time and cost. These proprietary designs are also referred to as intellectual property (IP) blocks. Chips used in personal computers contain dozens of IP blocks for various functions.</p> |
| Fabrication | <p>Semiconductor chips are manufactured, or fabricated, in facilities often referred to as fabs or foundries. Chips are manufactured on circular sheets of silicon or, less commonly, other semiconducting materials, called wafers. Each wafer typically contains hundreds of different chips. To produce billions of electronic features such as transistors on each chip, the wafer is covered in a light-reactive material and exposed to particular sources of light through a mask (similar to a stencil) containing the blueprints for the circuit pattern (a process known as photolithography).</p> <p>After exposure, the unreacted materials and underlying silicon can be etched or removed to create complex circuit patterns on the wafer.</p> <p>Other manufacturing steps include adding materials (deposition and implantation), wafer cleaning and smoothing (wet cleaning and planarization), and thermal treatments (diffusion and annealing).</p> |
| Assembly, Test, and Packaging | <p>After front-end fabrication, wafers are usually sent to other facilities for manufacturing activities such as assembly, test, and packaging (collectively known as “ATP”). During these steps, chips are cut from the silicon wafer, tested for performance, and packaged to protect the chip and to allow for its integration into finished electronic devices by attaching electrical interconnections. Multiple chips with different functions, such as microprocessors, graphics processors, and memory are traditionally individually packaged and mechanically assembled on a printed circuit board.</p> <p>Contract ATP manufacturers, similar to foundries used in fabrication, are often referred to as Outsourced Semiconductor Assembly and Test (OSAT) firms.</p> |

Source: CRS; for more information, please see CRS Report R47508, *Semiconductors and the Semiconductor Industry*, by Manpreet Singh, John F. Sargent Jr., and Karen M. Sutter.

Integrated Device Manufacturers Versus Fabless Firms

Until the 1980s, a single semiconductor company typically operated most or all stages of production, known as integrated device manufacturers or IDMs. Today, multiple, specialized companies operating at different stages of the semiconductor supply chain are involved in the production of advanced or specialized semiconductors, such as logic chips. Specialization allows companies to manage the costs of design and production and to benefit from economies of scale. U.S.-based semiconductor firms first offshored labor-intensive and low-value-added activities such as assembly, test, and packaging in the 1960s, followed by wafer fabrication in the 1980s with the advent of the “fabless/foundry” business model.

A *fabless* semiconductor firm designs chips but does not have its own fabrication facilities, instead contracting out the manufacture of its chips to *foundries*, companies that specialize in manufacturing chips for other companies. As the process node decreased, the cost and the complexity of semiconductor fabrication increased, and the number of IDMs operating fabs producing at the smaller (more powerful, complex) nodes fell

In 2022, four of the top 10 semiconductor vendors globally (as measured by revenue) were U.S.-headquartered fabless chip designers (Qualcomm, Broadcom, AMD, and Apple).⁹⁵

⁹⁵ Gartner, “Gartner Says Worldwide Semiconductor Revenue Grew 1.1% in 2022,” press release, January 17, 2023, at

<https://www.gartner.com/en/newsroom/press-releases/2023-01-17-gartner-says-worldwide-semiconductor-revenue-grew-one-percent-in-2022>.

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