CHIPS *for* AMERICA

A STRATEGY FOR THE CHIPS FOR AMERICA FUND

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The U.S. Department of Commerce
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TABLE OF CONTENTS

INTRODUCTION

This document describes the U.S. Department of Commerce's implementation strategy for the Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Fund, a $50 billion investment to catalyze long-term growth in the domestic semiconductor industry in support of our national and economic security.

The Department of Commerce (the "Department") has identified four strategic goals for the CHIPS for America Fund:

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

These objectives go beyond supporting the construction of a few semiconductor manufacturing facilities, or "fabs." Over the long term, the CHIPS for America Fund must enable and sustain a vibrant domestic industry that supports quality jobs, a diverse workforce, and a robust supplier base of large and small firms, while revitalizing high-volume semiconductor manufacturing, renewing U.S. strengths in design, materials, and process innovation, and benefiting the broader economy. Achieving these goals will require new thinking and partnerships from policymakers and the private sector to unlock the productive capacity of industry, workers, and communities. This document describes the principles that will guide the Department's program design, the industry context in which the CHIPS for America Fund will operate, the distinct initiatives within the Fund, and some considerations for future applicants for CHIPS funding that require long-term preparation.

Statutory Background

Sections 9902 and 9906 of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (referenced herein as "the 2021 NDAA"[2]) authorized semiconductor manufacturing and R&D activities, collectively called the "CHIPS program" in this document. The CHIPS Act of 2022 enhanced the CHIPS program with new authorities and appropriated $50 billion to the Department to implement it.[3]

Section 9902 of the 2021 NDAA authorizes the Department to provide funding to eligible applicants to incentivize investment in facilities and equipment in the United States for the fabrication, assembly, testing, advanced packaging, production, or research and development of semiconductors, materials used to manufacture semiconductors, or semiconductor manufacturing equipment.[4] The Department may provide funding in various forms, including grants, cooperative agreements, loans, and loan guarantees.[5] The CHIPS Act of 2022 appropriates $39 billion for these purposes.[6] With these funds, the Department will establish an incentives program to support the expansion of manufacturing capacity for mature nodes and to attract large-scale investments in advanced technologies such as leading-edge logic and memory.

Section 9906 of the 2021 NDAA authorizes the Department to establish a National Semiconductor Technology Center (NSTC) to conduct research and prototyping of advanced semiconductor technology and to establish a National Advanced Packaging Manufacturing Program (the "Advanced Packaging" program or "NAPMP") led by the director of the Department's National Institute of Standards and Technology (NIST). Section 9906 also authorizes NIST to establish up to three Manufacturing USA institutes to advance research and commercialization of semiconductor manufacturing technologies, and to carry out an R&D program to advance measurement science, standards, material characterization, instrumentation, testing, and manufacturing capabilities.[7] The CHIPS Act of 2022 appropriates $11 billion for these purposes.[8]

Both Sections 9902 and 9906 authorize and direct investments in the semiconductor workforce. Under

Section 9902, incentives recipients must make workforce development commitments and must secure "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."[9] The Advanced Packaging and Manufacturing USA institute programs established by Section 9906 will have elements of workforce development. Finally, the NSTC is tasked with incentivizing and expanding workforce development activities.[10] The Department will coordinate workforce development activities across these programs and with other agencies funded in this topic area, notably the National Science Foundation (NSF), and with interagency efforts through the CHIPS Implementation Steering Council established by President Biden in Executive Order 14080, "Implementation of the CHIPS Act of 2022,"[11] and the Subcommittee for Microelectronics Leadership established by Section 9906(a) of the 2021 NDAA.[12]

Section 107 of the CHIPS Act of 2022 creates a new advanced manufacturing investment tax credit (ITC) to be administered by the Internal Revenue Service of the Department of the Treasury. The ITC is equal to 25 percent 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.[13] The Department expects that the ITC will serve as an important tool to close the cost gap between investment in the United States and other countries. CHIPS program funding will be a significant, additional source of funding to enhance strategic and critical capabilities in the United States. The ITC is available for projects that start construction between January 1, 2023, and December 31, 2026.[14]

Industry and Stakeholder Input

Engagement with stakeholders throughout the implementation of the CHIPS program is a Department of Commerce imperative. This strategy paper is informed by extensive engagement with semiconductor industry leaders and experts in academia, nonprofits, local, state and federal government, public-private entities, national security entities, labor leaders, and international partners and allies.

The Department, pursuant to Executive Order 14017, "America's Supply Chains,"[15] engaged broadly with stakeholders to inform a 100-day review of the supply chains for semiconductor manufacturing and advanced packaging. That review identified vulnerabilities and fragilities and made recommendations for building more resilient supply chains.[16] This strategy document reflects the lessons and recommendations in that review and builds on work the Biden-Harris Administration and the Department have undertaken over the last 18 months to mitigate acute disruptions in semiconductor supply chains and build long-term resilience in the industry, with a focus on rebuilding domestic manufacturing capacity.

The Department also issued a Request for Information (RFI)[17] that closed at the end of March 2022 and sought information to inform the planning and design of CHIPS programs. The Department received over 250 responses from a wide range of companies representing multiple sectors of the semiconductor supply chain, including design software developers, integrated device manufacturers, materials suppliers, equipment vendors, fabless companies, automotive and industrials consumer companies, along with academics, labor unions, investors, and civil society stakeholders. The Department has hosted workshops and listening sessions with different parts of the semiconductor value chain, and has received extensive input from industry participants, state economic development officials, and other interested parties.

Industry and community input has highlighted specific risks to mitigate, and specific strengths and opportunities to exploit. Key themes—including ideas to attract private capital, commercialize new R&D and technology, improve supply chain and demand transparency, attract and train talented workers, and work with states and localities to expand economic clusters—are captured in this document. A complete report on feedback from the RFI is available here.

PART I: GUIDING PRINCIPLES

The Department of Commerce will balance urgent needs in the semiconductor industry with long-term strategic goals. The Department encourages participants to view CHIPS as a long-term program and a sustained collaboration between the public and private sectors.

As the Department embarks on program design, it will follow the implementation principles set forth by President Biden in Executive Order 14080, "Implementation of the CHIPS Act of 2022":

- **Protect taxpayer dollars**. The CHIPS program will include rigorous review of applications along with robust compliance and accountability requirements to ensure taxpayer funds are protected and spent wisely.
- **Meet economic and national security needs**. The CHIPS program must address economic and national security risks by building domestic capacity that reduces U.S. reliance on vulnerable or overly concentrated foreign production for both leading edge and mature microelectronics, and increasing U.S. economic productivity and competitiveness. U.S. long-term economic and national security interests require a sustainable, competitive domestic industry.
- **Ensure long-term leadership in the sector**. The CHIPS program will establish a dynamic, collaborative network for semiconductor research and innovation to enable long-term U.S. leadership in the industries of the future. The program will support a diversity of technologies and applications along many stages of product and process development.
- **Strengthen and expand regional manufacturing and innovation clusters**. Long-term competitiveness requires large economies of scale and investments across the supply chain. Regional clusters containing manufacturing facilities, suppliers, basic and translational research, and workforce programs, along with supporting infrastructure, will be the foundation for a competitive industry. The CHIPS program will facilitate the expansion, creation, and coordination of semiconductor manufacturing and innovation clusters that benefit many companies.
- **Catalyze private sector investment**. A successful CHIPS program will respond to market signals, fill market gaps, and reduce investment risk to attract significant private capital. The role of government in the CHIPS program is to shift financial incentives to maximize large-scale, private investment in production, break-through technologies, and workers. The CHIPS program will encourage new ecosystem collaborations that reduce risk, build on U.S. strengths, and facilitate such investments.
- **Generate benefits for a broad range of stakeholders and communities**. A successful CHIPS program will create benefits for startups, workers, small businesses, minority-owned, veteran-owned, women-owned and rural businesses, universities and colleges, and state and local economies, in addition to supporting semiconductor companies. The CHIPS program will encourage linkages to underserved regions and populations to draw in new participants to the semiconductor ecosystem.

PART II. BACKGROUND ON THE U.S. SEMICONDUCTOR INDUSTRY

The Semiconductor Industry and Wider Ecosystem of Software, Design, Tools, Materials, Equipment, Customers, Workers, and Investors Are a Unique National Asset, Critical to Economic and National Security.

Chips are an integral part of a consumer's everyday life. They are found in household items, such as coffee makers, garage door openers, and refrigerators, as well as in more complex products such as mobile phones, pacemakers, and automobiles. They are fundamental to the operation of virtually every military system, including communications and navigations systems, and complex weapons systems such as those found in sophisticated fighter jets. Semiconductors are key to the technologies of the future, including artificial intelligence and 5G.

The semiconductor industry creates high-wage jobs, including in construction, design, and manufacturing, and involves significant amounts of R&D spending. Economic activity in this ecosystem encompasses basic science, technology development, and capital-intensive manufacturing over an extraordinary variety of new products and niche applications. Moore's Law—the prediction that the performance of chips doubles every 2 years or so—has shaped the industry for more than 50 years, with a new generation of semiconductor devices emerging at a predictable pace. This pace of innovation and the resulting variety of chips and devices has revolutionized entire industries and unleashed new types of information processing and communications capabilities.

The Industry Structure for the Manufacturing of Semiconductors Has Changed Dramatically Over the Past 30 Years.

The United States no longer produces the world's most advanced semiconductors and has lost the ability to produce key supply chain inputs such as lithography tools, substrates, and some specialty chemicals.[18] The United States fabricates only 10 percent of global chip capacity today, and provides only 3 percent of global packaging, assembly, and test capacity.[19] Over two-thirds of the most advanced semiconductors are made in Taiwan, and since 2020, nearly 75 percent of new capacity for certain mature nodes has been added in the People's Republic of China (PRC).[20] The risks to national and economic security created by these changes are aggravated by the PRC's commitment of extensive resources to invest in semiconductor technologies critical to U.S. military superiority and economic competitiveness.[21]

The semiconductor industry is experiencing heightened demand across a range of end-use industries. Total revenues could exceed $1 trillion over the next decade.[22] As new capacity is built to meet long-term demand, the CHIPS program goal is to have much of that new capacity constructed in the United States by addressing some of the main challenges to increasing domestic semiconductor production including:

- The significant cost gap between building and operating a manufacturing facility in the United States, and building and operating the same facility elsewhere, which results from the differences in government subsidies, construction timelines, and ongoing operating costs.[23]
- The decline in U.S. capital investments in 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.
- Lack of visibility into demand forecasts has long driven a boom and bust cycle in the global semiconductor manufacturing industry, creating headwinds for domestic investment.
- 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.

At the Same Time, the United States Remains Strong, but Vulnerable, in Semiconductor Design, Research, and Development.

The United States is the world's leader in chip design and design automation tools, capturing roughly half the value of chips manufactured from these designs; it is critical that we capitalize on these strengths. However, the United States is at risk of losing this leadership position due to the erosion of the manufacturing base. As the manufacturing process becomes more complex, new chip designs require tight coordination with fabrication processes to ensure manufacturability. The challenge of moving designs and R&D to commercial production, sometimes called the "lab to fab" problem, threatens to shut out smaller firms and startups, deterring innovation.[24] The challenge is due to the following factors:

- At the design phase, chips need to be manufactured in small quantities to debug and validate the design, yet foundries and advanced packaging facilities are not set up to enable small runs. This prototyping process requires improved access to shared infrastructure such as multiproject wafer runs and design libraries.
- The costs of prototyping and proving designs has gone up worldwide. Venture capital and other investors are reluctant to invest in projects at the early stage given the high cost, the long time to validation, and the resulting risk.
- The industry lacks agreement on roadmaps to guide the concurrent development of tools, materials, and manufacturing processes.
- The industry faces difficulty in attracting and retaining domestic and international research scientists in the highly competitive broader market for technology talent.
- For innovations beyond design, such as new devices and materials, high development costs and long payoff times pose additional risks.

Future Trends

The United States cannot look back and simply try to recreate what has been lost. Instead, the success of the CHIPS program relies on recognizing and facilitating the continued evolution of the industry in a way that builds U.S. strength. The CHIPS program will consider these trends in its review and prioritization of projects to fund.

- Technology improvement must come from new sources. After decades of steady gains following the prediction of Moore's Law, the industry now exhibits diminishing returns as reflected in rising cost per transistor, slowing performance gains, and challenges with energy efficiency.[25] New hardware breakthroughs are needed from advanced packaging, new architectures, novel tools, and alternate materials.
- Mature nodes are critical to key sectors. As chip technology advances have slowed, many commercial customers (including in critical-sector industries) have delayed their migration to newer chips. These important applications rely on chips that are often built in overseas fabs and are vulnerable to the risks of concentrated offshore fabrication. Moreover, the shortage of even one simple, low-cost part from a mature node can halt the manufacturing line for a complex product.
- Risks are created by increased industry and geographic consolidation. The cost of semiconductor manufacturing has grown exponentially, with new leading-edge fabs now costing over $10 billion each, with the most advanced technology nodes requiring well above this amount. The cost of creating advanced chip designs is growing as well, sometimes exceeding $100 million to prove out a design for a leading-edge chip.[26] Rising development and production costs are continuing to drive business consolidation and raise barriers to entry for these activities, contributing to geographic and corporate consolidation. Geographic consolidation brings with it significant risk, including vulnerabilities to shutdowns caused by pandemics, severe weather events, cyber breaches, and social and geopolitical disruptions.
- Environmental sustainability will be increasingly important. The chip fabrication process has grown in its demand for electricity, water, and hazardous chemicals, requiring industry to respond to those customers, investors, and members of the public who are focused on ambitious net zero goals for energy, water, and waste.[27] Recently, major semiconductor customers have shown leadership by adopting renewable energy pledges, often not just for their own operations but also for their suppliers. The United States has a deeper and more cost-effective renewable energy market than many semiconductor competitor countries, which can enable fabs to contract for long-term, stable, renewable power.
- Resilient supply chains are a focus of business and government. The semiconductor supply chain has become fragile and susceptible to disruptions. Creating a more resilient domestic and global supply chain is important to protect U.S. economic growth and control costs for businesses and consumers alike. A resilient supply chain is one that recovers quickly from an unexpected event. In manufacturing, firms often use visibility, buffering, and agility to improve their resiliency.[28] For high-tech industries, like semiconductors, long-term competitiveness requires a strong ecosystem that supports both research and production.[29] This ecosystem, which includes production, innovation, skilled workers, and diverse small- and medium-sized suppliers, often requires co-location of resources in particular geographic regions to achieve economies of scale and spillover benefits that support R&D, production innovation, and capital formation.[30]

These trends will inform the implementation of the Department's semiconductor incentives and R&D programs.

PART III. IMPLEMENTING THE CHIPS PROGRAM

Organization

The Department intends to implement the CHIPS program with the creation of two new offices housed at NIST, the CHIPS Program Office (CPO) and the CHIPS R&D office. The CPO will be 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, working closely with the Office of the Secretary and the Under Secretary of Commerce for Standards and Technology, will work to ensure

coordination of all CHIPS-related activities across the Department. The CPO will actively participate 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 NSF, and the Office of the United States Trade Representative. The CPO will draw on the technical expertise of these agencies.

The CHIPS R&D office will incubate 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.

NIST was selected as the bureau to house these new units because of its deep technical expertise, industry focus, experience with public-private partnerships, and strong administrative functions.

In concert with other agencies and bureaus of the Department of Commerce, as appropriate, 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.

Eligibility

An eligible applicant for funding under the Section 9902 incentives program must be a "covered entity," which can be a private entity, a nonprofit 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.[31]

CHIPS funds must be used for facilities built in the United States[32] and cannot support facilities being constructed or operated abroad.[33] Domestic companies and foreign companies (except those that are a "foreign entity of concern"[34]) that seek to use CHIPS funds for qualifying investments in the United States can be eligible. The Department encourages potential applicants to consider forming collaborations with suppliers, customers, investors, state, local, or tribal governments, or other relevant entities as appropriate.

Key Initiatives

The Department's CHIPS program will consist of three distinct initiatives. Each initiative addresses a set of strategic challenges, has a different time horizon and speed of implementation, and involves a partially overlapping set of stakeholders and incentives.

1. **Large-scale investments in leading-edge logic and memory manufacturing clusters**

   The CHIPS program aims to establish domestic production of leading-edge logic and memory chips that require the most sophisticated processes available today. The Department will seek proposals for the construction or expansion of manufacturing facilities to fabricate, package, assemble, and test these critical components, particularly 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 of the CHIPS incentives funding under Section 9902, or approximately $28 billion.[35] The CHIPS funding may be available for grants or cooperative agreements, or to subsidize loans or loan guarantees—the Department expects to use loan and/or loan guarantee authority to increase the program's economic impact. The Department is still assessing the impact of the ITC on capital expenditure, which will generate significant additional project investment from participants and will reduce the required share of federal CHIPS incentive funding allocated for leading edge projects. Overall, CHIPS funding is only a small part of the total expected investment in the semiconductor industry. When combined with the ITC, private investment, loans, and state and local funding, total investment in the industry will be many multiples of the amounts available for CHIPS incentive funding.

   As part of this initiative, the CPO will work with the Department of Defense, the Office of the Director of National Intelligence, and other relevant agencies to define and meet requirements

for "secure and assured" microelectronics (secure design, production, and material handling processes mitigate against the risks of tampering with or counterfeiting microchips).

The CPO's solicitation for applications will include extensive information on the required components of the application and how proposals will be evaluated. To enable potential applicants to prepare in advance, this document includes some details on those program elements that require long-term planning in Part IV of this paper ("Considerations for Applicants").

The Department's goal is to begin soliciting applications within six months of enactment of the CHIPS Act of 2022. The CPO's process will include a preliminary application stage that will enable applicants to get feedback from the CPO before submitting a complete application.

2. **Expanding manufacturing capacity for mature and current-generation chips, new and specialty technologies, and for suppliers to the industry.**

   The CHIPS program will 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. This initiative is broad and flexible, encouraging industry participants to craft creative proposals. Examples of the types of proposals covered in this initiative include but are not limited to:

   - 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.
   - Equipment upgrades that provide near-term efficiency improvements in fabs.

   Funding will be provided only after a rigorous merit review and may include a mix of instruments, for example grants, loans, and loan guarantees. The value of the total financial assistance may vary considerably, depending on the specifics of each project.

   For this initiative, the Department expects dozens of awards with the total value expected to be at least one quarter of the available CHIPS incentives funding under Section 9902, or approximately $10 billion. Those amounts may be available for grants or cooperative agreements, or to subsidize loans or loan guarantees. As is the case for leading edge facilities, the ITC will generate significant additional project investment for participants and the Department is assessing the ITC impact on allocations between programs. The Department will also use loan and/or loan guarantee authority. The Department expects the total investment in the industry from all sources to be substantially greater than the amounts available for CHIPS financial assistance.

   The CPO's solicitation for applications will include extensive information on the required components of the application and how the applications will be evaluated. To enable companies to prepare in advance, this document includes detail on those program elements that require long-term planning in Part IV of this paper ("Considerations for Applicants").

   The Department's goal is to begin soliciting applications within six months of enactment of the CHIPS Act of 2022. The CPO's process will include a preliminary application stage that will enable applicants to get feedback from the CPO before submitting a complete application.

3. **Initiatives to strengthen and advance U.S. leadership in R&D**

   The R&D initiatives include the NSTC, the NAPMP, the Manufacturing USA Institute(s), and the NIST metrology investments that together received $11 billion in funding under the CHIPS Act of 2022. These R&D initiatives are expected to operate in coordination with each other, with the semiconductor incentives program under Section 9902 of the 2021 NDAA, and with microelectronics R&D

programs supported by other U.S. federal agencies. Such coordination may include the sharing of infrastructure, participants, and projects.

This constellation of programs is intended to create a dynamic, new network of innovation for the semiconductor ecosystem in the United States. This vision will take sustained investment over many years and require collaboration with other stakeholders engaged in semiconductor research. The long-term payoff will be reestablishing this sector as the engine of innovation for the U.S. domestic economy.

National Semiconductor Technology Center (NSTC)

The NSTC will be a public-private entity that includes participation from industry, universities, the Department of Defense, the Department of Energy, and the NSF to conduct research, provide prototyping capabilities, establish an investment fund, and expand workforce development programs.

The funding provided by the CHIPS Act of 2022 for the NSTC should be viewed as seed capital. The Department envisions an organization that grows over time to be a significant force for advancing innovation in semiconductors and microelectronics, with substantial financial and programmatic support from companies, universities, investors, and other government agencies, including those at the state and local levels. Industry programs will be built to ensure that the NSTC is responding to long-term market needs while meeting the national security and commercial objectives of the program, including building a plan for long-term financial sustainability. The NSTC will attract collaborators and research partners from around the world, including from partners in allied countries, to participate in compelling opportunities to advance future technologies. In brief, the Department envisions the NSTC as the center for excellence for the country in the semiconductor industry.

As the Department develops a governance structure for the NSTC, it will consider the following:

- Access rules that enable broad participation, including from startups, small firms, fabless semiconductor companies, in-house semiconductor designers, allied international entities, and universities, rather than being tuned to the needs of specific companies, technologies, or steps in the supply chain.
- Technical competence on par with the best engineering and scientific talent in the industry.
- Ability to attract leaders with in-depth understanding of the semiconductor ecosystem from materials to applications.
- Ability to attract leaders who understand the complexities of managing government and commercial interests in an R&D enterprise, including the responsible stewardship of public funds and protection of intellectual property.
- Responsiveness to government and industry advisors tasked with coordinating national and international R&D strategy for microelectronics.
- Ability to work across U.S. government agencies, including with microelectronics R&D programs supported by the Department of Defense, the Department of Energy, and NSF.
- A complementary and collaborative role relative to comparable organizations in allied countries.

The Department expects the NSTC to focus on advancing semiconductor design, scaling new manufacturing processes, developing new tools and materials, and improving the lab-to-fab product flow. The NSTC may support a range of programs including grand challenges identified by industry and the research community, the operation and provision of prototyping facilities, investment and technical support to new and emerging companies in partnership with the venture community, and potentially creating a shared physical and virtual infrastructure of enabling technologies such as design automation software. In addition, the NSTC is expected to support the development of standards and technical roadmaps to guide simultaneous development of materials, tools, software, and end-use applications.

Another critical role for the NSTC will be workforce development. This role will require a collaborative and well-funded nationwide effort to build the pipeline of workers needed to expand the semiconductor industry. There is a severe shortage of workers who are trained and ready to fill new roles in specialized construction, fab operations, and semiconductor design. At the same time, workers around the country are seeking quality jobs, even in a tight labor market.

The need to reimagine and scale education, training, and recruitment is one of the industry's greatest challenges. Employment in the U.S. semiconductor manufacturing industry has remained around 185,000 workers since 2009, with new hiring mainly to replace attrition.[36] The industry will need to significantly increase the intake of new workers annually to keep pace with new capacity. It is possible that up to $8 billion of investment may be needed over the next five years to substantially address the industry's workforce needs. The NSTC will play a key role in coordinating and scaling up the ongoing workforce development and recruitment efforts such as those currently led by industry associations, individual companies, state and local governments, and other federal agencies, including the Department of Labor, Department of Defense, NSF, and the Department's Economic Development Administration, to maximize their overall effectiveness.

The CHIPS R&D office will incubate the NSTC and continue to work closely with the NSTC to ensure accountability and stewardship in the use of public funds. In consultation with stakeholders, the CHIPS R&D office will work to ensure that the NSTC has a clear vision, an effective governance structure, and a 10-year financial plan that ensures long-term sustainability.

National Advanced Packaging Manufacturing Program (NAPMP)

After semiconductors are fabricated, they are "packaged" in a container that is adhered to a printed circuit board, ultimately ending up in the products that we use. Packaging is labor intensive and principally located in Asia. Many older devices and applications, including defense equipment, rely on conventional packaging. It is economically challenging to bring conventional packaging back to the United States. But the United States can compete in advanced packaging, which is anticipated to generate 50 percent of packaging revenue by 2024.[37]

To expand U.S. capabilities in advanced packaging, NIST will establish the National Advanced Packaging Manufacturing Program. The Department envisions forming a network of entities to create a robust domestic advanced packaging capacity including substrate production, heterogeneous integration, and the ability to work with and incorporate diverse new material systems. NIST will work with network participants to establish a pilot packaging facility to enable the testing and integration of new approaches and processes. This capability will be closely aligned with the NSTC and accessible to the broader community.

Manufacturing USA Institute

Manufacturing USA, a national network of 16 institutes engaging manufacturing, government, and academic organizations provides members with access to state-of-the-art facilities and equipment to promote research, propel new products to market, and train the workforce. NIST will launch a process to establish up to three new Manufacturing USA Institutes, bringing together a consortium of industry and university partners focused on addressing semiconductor manufacturing challenges.

The new Manufacturing USA institutes are expected to emphasize virtualization and automation, among other topics. Significant productivity and cost savings can be derived from more widespread adoption of virtualization and simulation of wafer production, and improved automation of manufacturing processes and materials handling and logistics. These techniques can bring down the cost of new designs and create more "tape-out" opportunities for more startups.[38] Such efforts can reduce barriers to innovation and improve connections and communications between product and process design and execution, which is particularly vital for advanced packaging. The institutes also will provide opportunities for workforce training on technologies critical across the industry.

Metrology Research

The ability to measure semiconductors throughout the fabrication process is an essential part of enabling the high-yield and high-quality fabrication that is required for economic viability. Advances in the industry are driving ever more exacting requirements for materials purity, defect tolerances, materials properties, and in-line processes. Measurement capabilities must improve quickly for the CHIPS investments to yield full value. NIST will expand ongoing metrology research programs to enable breakthroughs in measurement, standards, and process capabilities for the fabrication of next-generation semiconductors. Specific expansion efforts will include:

- Physical metrology for next-generation microelectronics, including 3D devices for logic and memory and 3D heterogeneous integration/advanced packaging.
- Computational metrology for computationally intensive and data-driven aspects of semiconductor metrology.
- Virtualization and automation for computationally intensive and data-driven aspects of semiconductor manufacturing.
- Measurement services such as standard reference materials, calibration services, and standard reference data.
- Measurement and documentary standards in areas of industry priority to include cybersecurity measures, metrics, and solutions.

Accountability, Reporting, and Oversight for Section 9902

The Department will maintain the highest ethical standards in the operation of the CHIPS program, working to uphold the public's trust by ensuring compliance with ethics laws and regulations and making all decisions in the best interest of the United States. The Department will seek to maximize the public benefits of federal investments, protect national security interests, and ensure funds produce broadly shared benefits. This effort is essential across all CHIPS initiatives, but especially in the incentives program under Section 9902. Accountability will begin at the application stage, with a rigorous review of proposals to ensure projects are economically viable and compatible with the overall CHIPS strategy. Proposals that satisfy this robust review will be subject to a variety of performance, reporting, audit, and oversight conditions established and overseen by the CPO. These conditions will enable the CPO to meet statutory requirements, protect taxpayer funds, and ensure compliance with agreed proposal goals.

Federal funding will be contingent on the necessity, appropriateness, and long-term economic viability of a project. The application process will verify the technical and financial merit of the project, rationale for public funding, and organizational structure and operational capabilities of the applicant. The review also will include an assessment of economic impact. The Department may recover funds if recipients fail to start or complete projects on time or fail to meet certain commitments, and the CPO expects that projects will be funded in increments over time as milestones are achieved.

The CPO also will implement congressionally-mandated guardrails to ensure recipients of CHIPS funds cannot compromise national security by sending the latest technology abroad. In addition, any company that receives funding will be prohibited for 10 years from engaging in significant transactions involving the material expansion of semiconductor manufacturing capacity in PRC or other countries of concern, subject to limited exceptions authorized in law.

The CPO will ensure that taxpayer investments maximize public benefits. Eligible applicants must provide evidence of significant worker and community investments along with commitments from educational institutions for worker training, including programs to expand opportunity for economically disadvantaged individuals. The Department expects to prioritize proposals that include significant worker and community investments. Davis-Bacon requirements will apply to CHIPS-funded construction projects, which ensures workers earn local prevailing wages. The CPO also will prioritize applicants with well-developed proposals designed to increase participation of and outreach to economically disadvantaged individuals, minority-owned businesses, veteran-owned businesses, women-owned businesses, and rural businesses in the geographic area of each project.

Finally, the private sector recipients cannot use any public funds on stock buybacks or dividend payments to shareholders. Further, the CPO will give preference in awards to applicants who commit to make future investments that grow the domestic semiconductor industry (such as through research and development, workforce training, or manufacturing investments) and not engage in stock buybacks.[39]

The CPO will strictly monitor the use of funds to ensure recipients are delivering on their commitments. This includes enforcing many important guardrails in the CHIPS Act, which cover appropriate uses of government funds, project delays, IP transactions that raise national security concerns, and investments in foreign countries of concern. The CPO may develop other guardrails, as needed and consistent with the law, to maximize the public purposes of federal investments and prevent recipients from seeking to evade

statutory requirements. The CPO will not hesitate to claw back funds or pursue other remedies if recipients misuse taxpayer dollars.

International Coordination

The CPO, in partnership with the relevant Department bureaus and other agencies, will engage with allies that are providing funding for semiconductor production or developing critical R&D, workforce, and supply chain capability.

This engagement will advance the overall resilience of the American and allied semiconductor supply chains. International engagement will focus on improving transparency of market conditions, including sharing information on public investments and supply chain disruptions. Coordination will aim to mitigate risk of oversupply and ensure that U.S investments in manufacturing and R&D are strategic. Coordination will include efforts to reduce geographic concentration in upstream materials and downstream industries. The CPO, relevant Department bureaus and other agencies, will work with allies and partners to promote investment guardrails and national security commitments. Finally, coordination will seek to limit escalation of subsidies for the industry, promoting government funding that is necessary and appropriate.

The CPO and relevant Department bureaus will coordinate with the Department of State as it implements the CHIPS for America International Technology Security and Innovation Fund. The CPO and relevant Department bureaus will coordinate with the U.S. Agency for International Development, the Export-Import Bank, and the U.S. International Development Finance Corporation in their efforts to support international semiconductor supply chain activities and projects.

PART IV: CONSIDERATIONS FOR APPLICANTS FOR CHIPS INCENTIVES

The CPO will articulate clear eligibility, evaluation, and selection criteria for proposals for CHIPS incentives under the Section 9902 program. This section identifies some evaluation factors the CPO will consider that require long-term planning in order to give early guidance to potential applicants as they prepare to submit projects for consideration.

Increase Scale and Attract Private Capital.

The CHIPS program seeks to improve U.S. manufacturing capacity by increasing the number and scale of U.S. fabs and associated assembly, packaging, and testing facilities. When it comes to semiconductor fabrication, economies of scale matter. Large-scale fabs are more competitive, more attractive for suppliers to co-locate, and more likely to see continued investments to extend their productive life. Yet, U.S. fabs average only about one-half the scale of an Asian fab.[40] The CPO will encourage large-scale investments that attract associated suppliers and workforce investments, thus catalyzing future upgrades and expansions, ensuring long-term economic viability.

Although $39 billion in federal funds and the ITC are crucial and significant investments, they will not be enough on their own to create the capacity needed for our national and economic security needs. Funding awards will be calibrated to provide the minimum federal investment required to attract significant private investment to create economically viable projects at sufficient scale. The Department encourages proposals that leverage private capital, both investments from the fab companies themselves as well as outside sources of capital. In addition to committing their own significant resources, semiconductor companies are encouraged to explore creative financing structures to tap a variety of sources of capital at different places on the risk-reward spectrum to reduce the overall cost of capital. Infrastructure funds and asset managers may find new investment opportunities in the sector due to the following factors:

- The industry has seen reduced cyclicality and high levels of utilization over the last decade, and, and despite some near-term uncertainty of demand, is expected to see robust long-term demand growth for semiconductors across multiple end-use industries.
- A fab project's significant industrial infrastructure needs (such as upgraded power grids, gas lines, and water treatment facilities) and other local infrastructure needs, such as housing and community amenities, may present familiar investment opportunities.

The Department plans to use loans and loan guarantees to leverage the impact of government grants. The Department can allocate up to $6 billion out of the $39 billion of total incentives to support loans and loan guarantees to covered entities. This $6 billion has a significant multiplier effect: the principal amount of financing available through loans and loan guarantees could be leveraged to support a $75 billion credit program. Applicants will be encouraged to consider loans or loan guarantees as part of their federal assistance application package. In addition to increasing the amount of available capital, government loans and guarantees may enable more flexible repayment terms, extend CHIPS benefits to a wider set of small manufacturers, and attract other lenders to step in with private debt financing.

Leverage Collaborations to Build Out Semiconductor Ecosystems.

The CPO will encourage collaboration between industry stakeholders, investors, customers, designers, and suppliers; and international firms to attract investors, foster innovation, reduce risk, increase transparency, and ensure that investments are consistent with future market demand.

Such collaborations could include, but not be limited to:

- **Purchase commitments and other initiatives to improve demand transparency**: The Department encourages projects where a manufacturer secures commitments from one or more customers to purchase a share of the project's output. Such commitments to purchase from an onshore project can help de-risk the project, attract more capital, and induce larger-scale, domestic investments. The Department encourages purchase commitments and collaborations across the supply chain to clarify future demand, improve transparency and trust, and mitigate the risk of future chip shortages or oversupply. These benefits are particularly valuable for mature logic, analog, and discrete technology projects that may be exposed to demand fragmentation and lower prices and margins.
- **Enabling fabless design firms**: Although much of the CHIPS program is focused on building fabs, the Department also encourages projects that enable fabless design firms to succeed. Projects that provide better access to design tools and IP, more flexible access to fab resources, and better portability of designs between fabs are encouraged.
- **Collaboration between producers and suppliers**: The Department encourages collaboration, including consortium-like proposals, by semiconductor fabricators and their upstream suppliers (e.g., of substrates or specialty chemicals), equipment providers, and downstream partners (e.g., of assembly, test, and packaging). Such downstream activities will improve the resiliency of the entire supply chain but may be financially viable only when combined with U.S. fabrication investments.

Secure Additional Financial Incentives and Support to Build Regional and Local Industry Clusters and Corridors That Strengthen Communities.

The 2021 NDAA requires that applicants demonstrate they have secured incentives from state or local government. Those incentives can take multiple forms, and can include workforce-related incentives, concessions with respect to real property, funding for R&D, and others to be specified in the future.[41] The Department expects to prioritize support for projects that include state and local incentive packages with the potential for large spill-over benefits, are based on performance, and maximize regional and local competitiveness as well as economic gains, including supporting a robust semiconductor ecosystem rather than a single company. Examples of encouraged incentives include:

- Investments in industrial infrastructure that specifically support the proposed project, but that also could support broader development of a supplier ecosystem such as shared utility, logistics, and production capacity.
- Workforce investment to ensure broad talent pipelines.
- Long-term tax credits to ensure that firms continually invest in upgrading and expanding facilities to maintain competitiveness.

Along with these incentives, the Department expects to prioritize funding for proposals that can move quickly, reduce project risk, demonstrate ample local support and/or regional cooperation, and provide broad-based benefits. State and localities could show this commitment in various ways, including:

- Expedited processes for environmental, health, and safety reviews and permits.
- Liaisons to assist with site selection, supplier discovery, and compliance with local laws.
- A systems integrator that works with ecosystem companies to address shared issues like navigating permits, building infrastructure, finding workers, and coordinating incentive applications.
- Planning and support for other ancillary investments such as housing and community development.
- Where relevant, partnership with other states and localities to develop regional ecosystems and corridors that encompass multiple jurisdictions.

Establish a Secure and Resilient Semiconductor Supply Chain.

In addition to providing direct financial assistance to produce secure and assured current generation and leading-edge chips from mature nodes for national security uses, the Department also seeks to improve the security of commercial semiconductor supply chains. The Department expects to prioritize projects that adhere to standards and guidelines on information security, data tracking and verification, and that collaborate on further development and adoption of such standards.

U.S. national and economic security relies on access to semiconductors in the face of supply shocks. Recent government reports highlight a wide range of supply chain risks that can disrupt the operation of CHIPS-funded manufacturing facilities.[42] The Department expects to prioritize investments that address these supply chain risks including, but not limited to, poor demand visibility, single sourcing and geographic chokepoints, transport and logistical bottlenecks, weather-related disruptions, counterfeiting and tampering, IP theft, and cybersecurity vulnerability.

Expand the Workforce Pipeline to Match Increased Domestic Capacity Workforce Needs.

The Department expects to encourage projects that include effective and creative workforce development solutions at the scale required to meet demand. A wide range of roles need to be filled, including process engineers, material scientists, industrial operations specialists, engineering technicians, equipment operators and installers, and specialty construction workers such as cleanroom architects, high-purity welders, and pipefitters. Meeting these goals will require creative recruitment and training efforts that provide opportunities for many people. Project proposals should include investments to scale proven models as well as ideas for pilot programs that are driven by market needs and are inclusive of populations that have traditionally been underrepresented in the industry.

The Department also encourages programs that enable employers, training providers, workforce development organizations, labor unions, and other key stakeholders to work in partnership to create more paid training and experiential apprenticeship programs, and to hire based on skills, not just degrees. Proposals should consider recruitment strategies that include targeted outreach to economically disadvantaged individuals and to populations that may be underrepresented in the industry such as women, people of color, workers in rural areas, and veterans. To enable this outreach, the CPO will encourage proposals that include comprehensive wraparound supports like child care, transportation, language supports, high-speed internet, mentoring, and career counseling. Creating quality jobs will be key to attracting and developing talent. The Department expects to prioritize investments in projects that connect workforce training dollars to quality jobs that exceed the local prevailing wage for an industry in the region, including basic benefits (e.g., paid leave, health insurance, retirement/savings plan) and/or are unionized.

The potential of well-crafted workforce programs funded through the CHIPS program is to offer life-changing opportunities for many individuals. The industry employs 277,000 people in semiconductor design, manufacturing, and related fields across 49

states, and those numbers will grow significantly due to the CHIPS program. More than one-third of the workers in the industry overall, and more than 60 percent in semiconductor manufacturing, do not have a college degree. The average wage in the industry is $170,000 and nearly $100,000 in production occupations—both well above the average wage in the economy.[43] While some occupations require years of specialized training, many do not; for a candidate with a technical associate degree or military experience, for instance, it could take just a few weeks to be trained as a technician and begin a career in the semiconductor industry. Applicants should consider how their workforce investments can create these exciting opportunities.

Create Inclusive and Broadly Shared Opportunities for Businesses.

The Department seeks to ensure that CHIPS investments result in measurable benefits to small and underrepresented businesses, including minority-owned, veteran-owned and women-owned businesses, and businesses in rural areas. The Department expects to prioritize projects that proactively work to ensure that such businesses are included in construction contracts, the production supply chain, R&D, and investment opportunities generated by the CHIPS programs. Such efforts may include but are not limited to:

- Submit robust plans for outreach to small and minority-owned, veteran-owned, women-owned, and rural businesses for construction contracts, supplier contracts, or capital investments.
- Establishing contracting, subcontracting, and payment processes where the requirement permits, which encourage participation by small- and minority-owned, veteran-owned, women-owned, and rural businesses.
- Using the services and assistance, as appropriate, of such organizations as the Minority Business Development Agency.

Financial Considerations

Applicants will be required to provide detailed project-specific and company-level financial data to ensure that CHIPS funds are meeting the economic and national security goals of the program. Forthcoming programmatic materials will detail financial considerations for CHIPS funding, addressing sponsor or other private sector contributions to project costs, project debt and equity ratios, repayment terms for loans and loan guarantees, fees and costs, and more.

Financial assistance will be structured based on robust and transparent financial analysis of each project. The Department expects proposed projects to vary significantly; however, certain principles will govern the CPO's approach to financial considerations.

- An executable plan to sustain the facility without further Section 9902 funding that covers the expected useful life of the facility receiving support.
- The plan should make provisions for necessary investments and upgrades to ensure that the facility remains competitive and commercially viable for its useful life.
- The plan should rely on commercially reasonable assumptions for revenue, operating costs, cash flows, and other drivers of financial sustainability.
- The plan should not result in an outsized rate of return relative to commercially reasonable expectations.
- The plan should include an analysis of how the ITC will impact the financial results of the project.

CONCLUSION

The Department will conduct robust stakeholder engagement in implementing the CHIPS program, including requesting feedback on specific questions through RFIs, publishing an e-mail newsletter and frequently asked questions, and offering webinars. Stay informed about progress in implementing CHIPS for America by signing up for the CHIPS newsletter at <www.chips.gov>.

The CHIPS for America Fund represents a substantial commitment by the Biden-Harris Administration and Congress to extend the leadership of the United States in the semiconductor ecosystem, a key driver of national and economic security, and the foundation upon which next-generation innovations and industries are built. The Department of Commerce strives to put together a set of initiatives that reflect the goals of Congress and the Administration, address the challenges of industry, and provide an opportunity to build together a stronger and more secure future.

ENDNOTES

[1] The word "chips" in this document broadly refers to packaged microelectronic systems, devices, and components that involve the use of semiconducting materials. Different audiences tend to use different terms to refer to these items. For instance, technical and national security audiences often prefer the term "microelectronics"; economic literature often uses the term "semiconductors"; nontechnical and broader media audiences use the word "chips." The CHIPS program statutes use all these terms. These terms are used colloquially and interchangeably in this document. The document does not contain an official definition of the term "semiconductor" or any of these other terms for statutory purposes. The Department will provide official definitions in future programmatic guidance.

[2] Pub. L. No. 116-283, tit. XCIX, §§ 9902, 9906 (2021) (codified at 15 U.S.C. §§ 4652, 4656).

[3] CHIPS Act of 2022, Pub. L. No. 117-167, Div. A (2022) ("CHIPS Act of 2022").

[4] 15 U.S.C. § 4652(a)(1).

[5] 15 U.S.C. §§ 4652; 4659(a)(1).

[6] CHIPS Act of 2022, § 102(a)(2).

[7] Refer to Refer to 15 U.S.C. § 4656.

[8] CHIPS Act of 2022, § 102(a)(2).

[9] 15 U.S.C. § 4652(a)(2)(B)(ii).

[10] 15 U.S.C. § 4656(c)(2)(C).

[11] Executive Order Number 14,080, 87 Federal Register 52,847 (Aug. 25, 2022).

[12] 15 U.S.C. § 4656(a).

[13] 26 U.S.C. § 48D.

[14] Id.

[15] Executive Order Number 14,017, 86 Federal Register 11,849 (Mar. 1, 2021).

[16] "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-based Growth," The White House, June 2021.

[17] "Notice of Request for Public Comments on Risks in the Semiconductor Supply Chain," 86 Federal Register 53,031 (Sept. 24, 2021), <www.federalregister.gov/d/2021-20348>.

[18] "Semiconductors: US industry, global competition, and federal policy," Congressional Research Service, October 2020.

[19] Various reports by Semiconductor Industry Association and Boston Consulting Group including "2021 State of the US Semiconductor Industry," September 2021; "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era," April 2021; and "Government Incentives and US Competitiveness in Semiconductor Manufacturing," September 2020.

[20] Department of Commerce analysis of data from SEMI World Fab Forecast dataset.

[21] Various reports by Center for Security and Emerging Technology including "Sustaining US Competitiveness in Semiconductor Manufacturing: Priorities for CHIPS Act Incentives," January 2022 and "The Semiconductor Supply Chain: Assessing National Competitiveness," January 2021.

[22] "The Semiconductor Decade: A Trillion-Dollar Industry," McKinsey & Company, April 2022.

[23] "Government Incentives and U.S. Competitiveness in Semiconductor Manufacturing," Semiconductor Industry Association, September 2020.

[24] For an example, refer to "American innovation, American growth," The Semiconductor Alliance, November 2021; also see "Accelerating Semiconductor Research, Accelerating America," American Semiconductor Innovation Coalition, March 2022.

[25] For an example, refer to "After Moore's Law," The Economist's Technology Quarterly, March 2016. The topic is covered in various other ways in both technical and nontechnical literature. For instance, technical literature points to the end of both Dennard Scaling and Moore's Law (John L. Hennessy and David A. Patterson, "A New Golden Age for Computer Architecture," Turing Lecture, June 2018). Nature magazine calls attention to the International Technology Roadmap for Semiconductors and its shift in focus from Moore's Law to the More than Moore strategy ("The Chips Are Down for Moore's Law," Nature, February 2016). And economists who monitor the quality-adjusted price of IT equipment, and underlying semiconductor device prices, point to a significant deceleration in the historical decline of quality-adjusted prices after 2005.

[26] "Semiconductor Design and Manufacturing: Achieving Leading-Edge Capabilities," McKinsey & Company, August 2020.

[27] Refer to Udit Gupta, et al., "Chasing Carbon: The Elusive Environmental Impact of Computing," Proceedings of the 2021 IEEE International Symposium on High-Performance Computer Architecture, February 2021.

[28] "When the Chips Are Down: Preventing and Addressing Supply Chain Disruptions," The White House, September 23, 2021.

[29] "Economic Report of the President," (Chapter 6). The White House, April 2022.

[30] "Economic Report of the President," (Chapter 6&7). The White House, April 2022.

[31] 15 U.S.C. § 4651(2).

[32] 15 U.S.C. § 4652(a)(1).

[33] 15 U.S.C. § 4652(i).

[34] 15 U.S.C. § 4657.

[35] The CHIPS Act of 2022 makes available 2 percent of program funds for salaries and expenses, administration, and oversight purposes to carry out the semiconductor incentives program. CHIPS Act of 2022, § 102(a)(2)(B)(ii).

[36] United States Bureau of Labor Statistics, Current Employment Statistics dataset. This 185,000 employment figure covers semiconductor manufacturing jobs only. 277,000 people are employed in the broader semiconductor industry, including manufacturing, design, and related fields.

[37] "Reshoring Advanced Semiconductor Packaging: Innovation, Supply Chain Security, and US Leadership in the Semiconductor Industry," Center for Security and Emerging Technology, June 2022.

[38] "Tape-out" refers to the end of the design process, when the electronic design file for a new integrated circuit is used to create a photomask that is then used in the fabrication process.

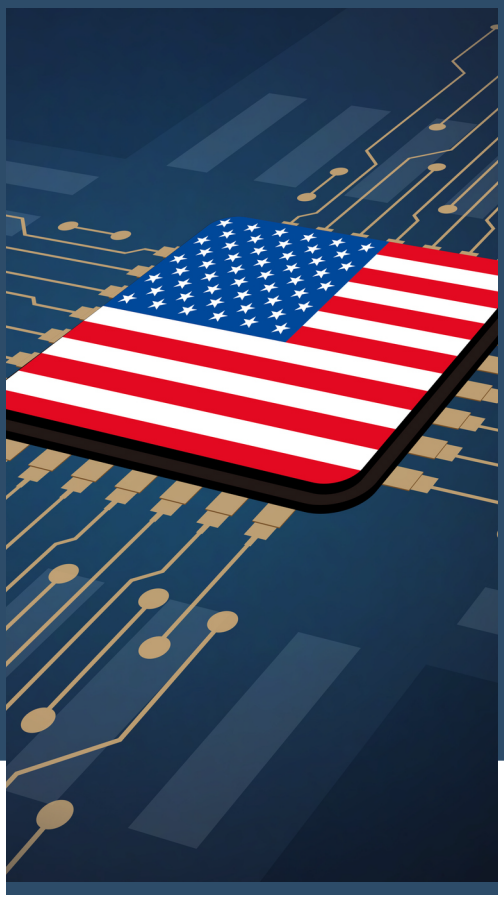
[39] "Taxpayer Protections," CHIPS.gov, <www.nist.gov/chips/taxpayer-protections>.

[40] "Government Incentives and US Competitiveness in Semiconductor Manufacturing," Semiconductor Industry Association, September 2020.

[41] Refer to 15 U.S.C. § 4651(3).

[42] Refer to "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews Under Executive Order 14017," report by White House, June 2021, including a review of semiconductor manufacturing and advanced packaging. Also refer to "Assessment of the Critical Supply Chains Supporting the US Information and Communication Technology Industry," prepared by U.S. Department of Commerce and U.S. Department of Homeland Security, February 2022.

[43] "Chipping In," report by Semiconductor Industry Association on the impact of the semiconductor industry on the American workforce, May 2021.



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