CHIPS *for* AMERICA

VISION FOR SUCCESS:
COMMERCIAL FABRICATION FACILITIES

CHIPS Incentives Program

February 28, 2023

CHIPS *for* AMERICA

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

CHIPS for America includes the CHIPS Program Office, responsible for semiconductor incentives, and the CHIPS Research and Development Office, responsible for the R&D programs, that both sit within the National Institute of Standards and Technology (NIST) at the Department of Commerce.

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Vision for Success: Commercial Fabrication Facilities

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TABLE OF CONTENTS

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

CHIPS for AMERICA

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EXECUTIVE SUMMARY

Semiconductors are integral to America's economic and national security, powering our consumer electronics, automobiles, data centers, critical infrastructure, and virtually all military systems. Yet while the United States remains a global leader in semiconductor design and research and development (R&D), it has fallen behind in manufacturing and now accounts for only about 10 percent of commercial global production. Today, none of the most advanced logic and memory chips—the chips that power PCs, smartphones, and supercomputers—are manufactured at commercial scale in the United States.

In addition, many elements of the semiconductor supply chain are geographically concentrated, leaving them vulnerable to disruption and endangering the global economy and U.S. national security. Moreover, because continued investment in manufacturing technology and related R&D improves technical knowledge and spurs virtuous cycles of innovation, America's lack of production capacity also jeopardizes its technology leadership and ability to compete globally over the long term.

Against this backdrop, the U.S. Department of Commerce's CHIPS Program Office has released its first funding opportunity, which seeks applications for projects for the construction, expansion, or modernization of commercial facilities for the front- and back-end fabrication of leading-edge, current-generation, and mature-node semiconductors. This document lays out the CHIPS Program Office's "Vision for Success" for these investments. Later in 2023, the CHIPS Program Office will release separate funding opportunities for semiconductor materials and manufacturing equipment facilities, and for R&D facilities.

In releasing this document, the CHIPS Program Office has three principal aims:

1. to help applicants develop proposals consistent with program goals;
2. to explain program ambitions to a broader set of stakeholders, including customers, workers, universities, investors, Congress, state and local governments, allies and partners, and the wider economic and national security communities; and
3. to offer the public a clear sense of where their tax dollars will go as the federal government begins to execute on an investment in American industry of a scale and ambition that is unprecedented in our recent history.

The CHIPS Program Office's vision for success involves meeting the following objectives by the end of the decade:

Leading-Edge Logic: The United States will have at least two new large-scale clusters of leading-edge logic fabs, where clusters are geographically compact areas with multiple commercial-scale fabs owned and operated by one or more companies; a large, diverse, and skilled workforce; nearby suppliers; R&D facilities; utilities; and specialized infrastructure. Each cluster will have the scale, infrastructure, and other competitive advantages required to ensure that chipmakers view continued expansion in the United States as economically attractive and core to their business models, even in the absence of future funding from the CHIPS Program Office. Further, U.S.-based workers will develop and scale the process technologies underlying future generations of logic chips; each CHIPS-funded fab will be supported by an ecosystem of reliable suppliers committed to operating and innovating in the United States; and the U.S. Department of Defense and national security community will have access to secure leading-edge logic chip manufacturing in a commercial production environment in the United States.

Advanced Packaging: The United States will be home to multiple high-volume advanced packaging facilities. In addition, the United States will be a global technology leader in commercial-scale advanced packaging for both logic and memory chips, and semiconductors produced by CHIPS-funded fabs will have multiple options for packaging services, including from both U.S.-based facilities and other facilities in diverse locations outside of countries of concern.

Leading-Edge Memory: U.S.-based fabs will produce high-volume leading-edge dynamic random-access memory (DRAM) chips on economically competitive terms. In addition, R&D for next-generation memory technologies critical to supercomputing and other applications will be conducted in the United States.

Current-Generation and Mature-Node Semiconductors: The United States will have increased its production capacity for the current-generation and mature-node chips most vital to U.S. economic and national security. The United States will increase production of and maintain technology leadership in compound semiconductors and other specialty chips. The United States will also coordinate with its allies and partners to ensure resilient production of and access to current-generation and mature-node chips, and chipmakers will be able to respond more nimbly to supply and demand shocks.

The funding the CHIPS Program Office is charged with administering represents a small fraction of the investments necessary to realize this vision for success. Trade-offs will be necessary. Not every applicant will receive funding, and many projects will not receive as much support as applicants request. Moreover, although the CHIPS Program Office is launching its first funding opportunity amid a cyclical downturn in the industry, CHIPS funding will not be used as a crutch to help companies endure temporary slumps. Instead, the CHIPS Program Office will be laser-focused on advancing U.S. economic and national security objectives.

The CHIPS Program Office is clear-eyed about the scale of the challenge it faces. It will not be easy to rebuild a highly complex manufacturing industry that has been declining for decades in the United States. Success will require long-term ambition: building a domestic semiconductor ecosystem, revitalizing American manufacturing, and training the next generation of scientists, engineers, and technicians.

To meet this challenge, the CHIPS Program Office has identified nine cross-cutting themes to guide its implementation efforts. These are:

1. catalyzing private investment;
2. encouraging customer demand;
3. engaging with U.S. partners and allies;
4. building a skilled and diverse workforce;
5. reducing time-to-build;
6. reducing costs through innovation;
7. promoting the operational security, supply chain security, and cybersecurity of CHIPS-funded facilities;
8. spurring regional economic development and inclusive economic growth; and
9. enforcing guardrails.

Success across these themes will help ensure that CHIPS funding promotes U.S. leadership in chipmaking, enhances stability in the semiconductor supply chain, and advances U.S. economic and national security.

INTRODUCTION

The CHIPS and Science Act of 2022 appropriates $52.7 billion in funding to the Department of Commerce, the Department of Defense, the Department of State, and the National Science Foundation to advance U.S. leadership in the semiconductor industry.[1] The CHIPS Program Office within the Department of Commerce is responsible for administering $39 billion to support semiconductor production in the United States pursuant to Section 9902 of Title XCIX—Creating Helpful Incentives to Produce Semiconductors for America of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (CHIPS Act).[2] Of the $39 billion, the Department can allocate up to $6 billion to support loans and loan guarantees to covered entities, which could be leveraged to support a $75 billion credit program.

Today, the CHIPS Program Office released its first funding opportunity, which seeks applications for projects for the construction, expansion, or modernization of commercial facilities for the front- and back-end fabrication of leading-edge, current-generation, and mature-node semiconductors. This document outlines the CHIPS Program Office's "Vision for Success" for these investments.

Later in 2023, the CHIPS Program Office will release separate funding opportunities for semiconductor materials and manufacturing equipment facilities, and for R&D facilities. In addition, the Department of Commerce will release a strategy for the implementation of the National Semiconductor Technology Center, a key component of the $11 billion appropriated to the Department for semiconductor R&D under Section 9906 of the CHIPS Act.[3]

Semiconductors, or chips, are integral to America's economic and national security. They have allowed humans to land on the moon, ushered in the era of personal computing, placed the internet in our pockets, and enabled long-distance mobile communication. Smaller than a postage stamp, with individual transistors no larger than a few strands of DNA, chips are key inputs to more than 300 downstream sectors—telecommunications, medical devices, and car manufacturing, among many others—that together account for more than 26 million American jobs.[4] They also underpin our critical infrastructure, from satellite communications to cellular connectivity; power virtually all military technology; and are foundational to the advanced technologies that will shape our future, including artificial intelligence, biotechnology, and clean energy.

Developed by scientists in the United States and brought to market by U.S.-based workers, semiconductors are a testament to U.S. innovation and strong public-private partnerships.[5] Indeed, U.S. government funding helped to shape the nascent semiconductor market at the height of the Cold War.[6] Yet although the United States remains a global leader in chip design and R&D, it has fallen behind in manufacturing and today accounts for only roughly 10 percent of commercial global production.[7] Even in leading-edge production, a long-time strength of American chipmakers, the United States has fallen behind. The most advanced logic and memory chips—the chips that power PCs, smartphones, and supercomputers—are now all manufactured at commercial scale in East Asia.[8]

The geographic concentration of production—which characterizes not just leading-edge manufacturing but many elements of the supply chain—leaves international supply chains vulnerable to disruption, endangering the global economy and U.S. national security. Chip shortages can have devastating ripple effects, as demonstrated by recent chip-related production shortfalls in automobiles, consumer electronics, and medical devices.[9] Moreover, because continued investment in manufacturing technology and related R&D improves technical knowledge and spurs virtuous cycles of innovation, America's lack of production capacity also jeopardizes its technology leadership and ability to compete globally over the long term.

In June 2021, pursuant to Executive Order 14017, "America's Supply Chains," the Department of Commerce issued a report identifying risks in the semiconductor manufacturing and advanced packaging supply chains.[10] In January 2022, the Department of Commerce published the results from its Request for Information on the semiconductor supply chain, which underscored the fragility of the semiconductor supply chain.[11] After the passage of the CHIPS and Science Act of 2022, the Department of Commerce released "A Strategy for the CHIPS for America Fund," describing its approach to implementing CHIPS funding to catalyze long-term growth in the domestic semiconductor industry and advance economic and national security.[12]

Against this backdrop, the CHIPS Program Office has released its first funding opportunity, which will focus on projects for the construction, expansion, or modernization of commercial fabrication facilities. This document outlines the CHIPS Program Office's vision for success for these investments across four categories: leading-edge logic; advanced packaging; leading-edge memory; and current-generation and mature-node semiconductors.

In releasing this document, the CHIPS Program Office has three principal aims:

1. to help applicants develop proposals consistent with program goals;
2. to explain program ambitions to a broader set of stakeholders, including customers, workers, universities, investors, Congress, state and local governments, allies and partners, and the wider economic and national security communities; and
3. to offer the public a clear sense of where their tax dollars will go as the federal government begins to execute on an investment in American industry of a scale and ambition that is unprecedented in our recent history.

The funding the CHIPS Program Office is charged with administering is an enormous sum in absolute terms, but it represents a small fraction of the investments necessary to realize this vision for success. Trade-offs will be necessary. Not every applicant will receive funding, and many projects will not receive as much support as applicants request. Moreover, although the CHIPS Program Office is launching its first funding opportunity amid a cyclical downturn in the industry, CHIPS funding will not be used as a crutch to help companies endure temporary slumps. Instead, the CHIPS Program Office will be laser-focused on advancing U.S. economic and national security objectives.

The CHIPS Program Office is clear-eyed about the scale of the challenge it faces. It will not be easy to rebuild a highly complex manufacturing industry that has been declining for decades in the United States. But the CHIPS Program Office believes that this country—bolstered by its unbridled innovation and diversity of talent—is up to the task. Success will require long-term ambition: building a domestic semiconductor ecosystem, revitalizing American manufacturing, and training the next generation of scientists, engineers, and technicians.

To meet this challenge, the CHIPS Program Office has identified nine cross-cutting themes to guide its implementation efforts. These are:

1. catalyzing private investment;
2. encouraging customer demand;
3. engaging with U.S. partners and allies;
4. building a skilled and diverse workforce;
5. reducing time-to-build;
6. reducing costs through innovation;
7. promoting the operational security, supply chain security, and cybersecurity of CHIPS-funded facilities;
8. spurring regional economic development and inclusive economic growth; and
9. enforcing guardrails.

Success across these themes will help ensure that CHIPS funding promotes U.S. leadership in chipmaking, enhances stability in the semiconductor supply chain, and advances U.S. economic and national security.

Leading-Edge Logic

U.S. economic and national security depends on our ability to design and produce leading-edge logic chips. These advanced chips power our computers, smartphones, servers, and supercomputers. They are increasingly foundational to U.S. critical infrastructure and to military modernization efforts. And they will be essential to the technologies of the future, from artificial intelligence to biotechnology to clean energy.

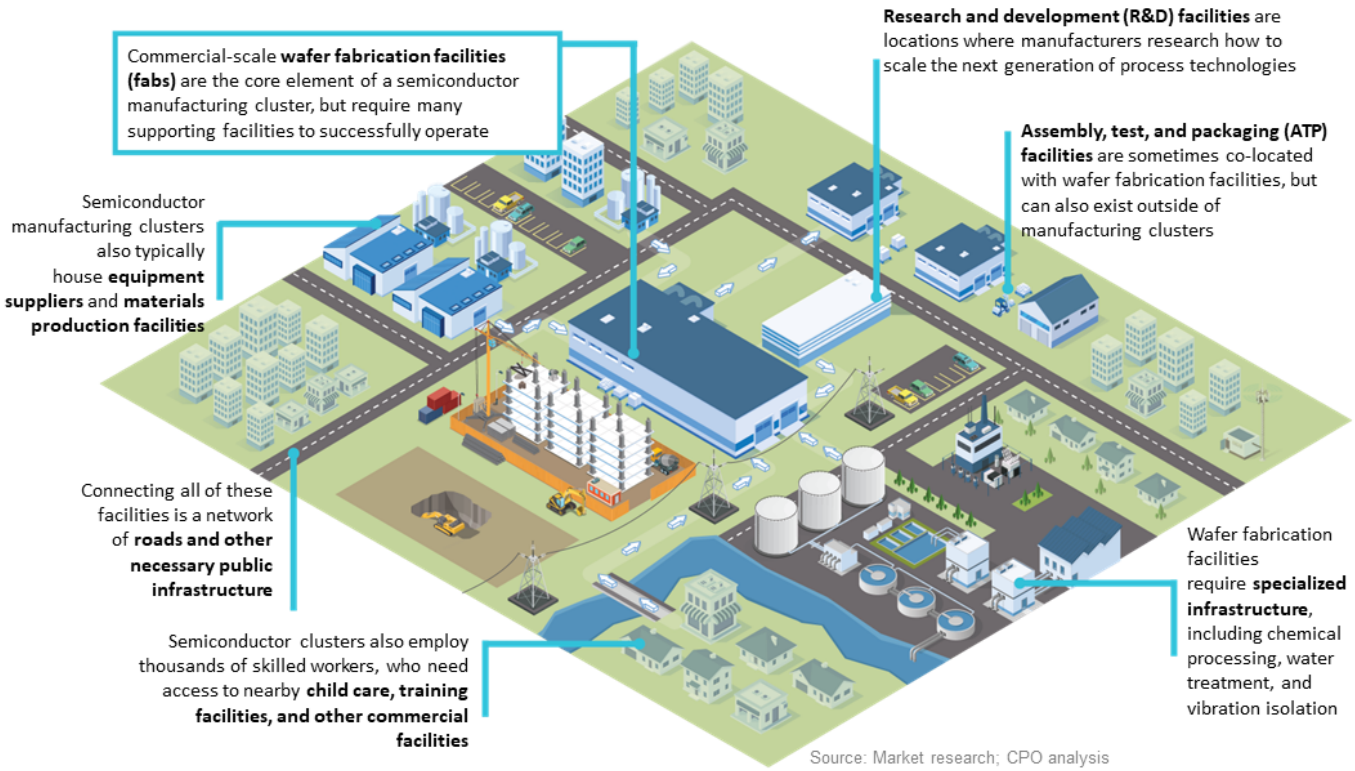
Today, all commercial production of leading-edge logic chips occurs in East Asia, but this is a recent development.[13] East Asian chipmakers have surpassed the United States in both process technology—the manufacturing methods that allow engineers to fit more transistors and other electronic components onto a single chip—and scale, attracting a broad customer base that has supported their continued expansion and innovation. This is in part due to the "pure-play foundry" business model pioneered by East Asian firms. Unlike integrated device manufacturers, which design and manufacture their own chips, pure-play foundries manufacture chip designs from a variety of customers on a contract basis. As a result, many American firms have become "fabless," leading the world in semiconductor design while outsourcing manufacturing to East Asian foundries.[14]

U.S. strength in chip design is a key commercial and strategic asset, but the decline in U.S. manufacturing—and subsequent geographic concentration—has created supply chain vulnerabilities. It has also eroded U.S. technology leadership: Without fabs, it is difficult to build the domestic manufacturing know-how that helps spur innovations in process technology and related advancements in chip design. A core priority for the CHIPS Program Office is to help the United States once again produce the most advanced chips at competitive scale on a sustainable basis, either through the pure-play foundry model or alternative models that allow companies to manufacture chips at scale.

Accordingly, the CHIPS Program Office has set the following objectives:

By the end of the decade, the United States will have at least two new large-scale clusters of leading-edge logic fabs. For this purpose, the CHIPS Program Office defines a cluster as a geographically compact area with multiple commercial-scale fabs owned and operated by one or more companies; a large, diverse, and skilled workforce; nearby suppliers to the semiconductor industry; R&D facilities; utilities; and specialized infrastructure, such as chemical processing and water treatment facilities. Given the importance of continued U.S. capability in logic chip production and the rapidly changing competitive landscape in advanced logic chip production, relying on a single cluster presents serious risks. The CHIPS Program Office thus expects to focus its leading-edge logic investments on at least two clusters where companies are manufacturing highly advanced chips in the United States.

Each leading-edge cluster will have the scale, infrastructure, and other competitive advantages required to ensure that chipmakers view continued expansion in the United States as economically attractive and core to their business models, even



in the absence of future funding from the CHIPS Program Office. The CHIPS Program Office will evaluate applications based on the extent to which the applicant makes credible commercial commitments to ongoing private investment in the United States. The CHIPS Program Office will also aim to ensure that each U.S. cluster has sufficient scale to drive down the cost of future capacity expansions and strongly encourages applicants to explore other innovative ways of driving down costs in the long term. In addition, the CHIPS Program Office will encourage fabless firms and original equipment manufacturers to prioritize supply chain security by increasing their demand for domestically produced chips.

U.S.-based workers will develop and scale the process technologies underlying future generations of logic chips. Applicants will be asked to submit strategies for their continued reinvestment in the U.S. semiconductor industry, and the CHIPS Program Office will prioritize applicants that credibly commit to investing in R&D in the United States, such as by building domestic R&D fabs or other domestic R&D facilities.[15] Conducting R&D within the United States will facilitate the transfer of new leading-edge process technologies to high-volume production and signal chipmakers' intent to invest in the United States over the long term.

Each CHIPS-funded fab will be supported by an ecosystem of reliable suppliers committed to operating and innovating in the United States. The CHIPS Program Office encourages applicants to take steps to attract associated suppliers, such as by identifying plans for key suppliers to locate in the same area, identifying infrastructure that can benefit the applicant as well as material or manufacturing equipment suppliers, or incorporating these suppliers into the applicant's workforce development or R&D commitments. The CHIPS Program Office will also release a separate funding opportunity for materials and manufacturing equipment facilities in late spring 2023.

The U.S. Department of Defense and national security community will have access to secure leading-edge logic chip manufacturing in a commercial production environment in the United States. The U.S. military is currently unable to source leading-edge chips from an onshore facility, leaving critical military systems vulnerable to supply disruptions.[16] Producing secure chips in the United States is thus a strategic priority.

Advanced Packaging

Assembly, test, and packaging (ATP) are the final steps of semiconductor production. These steps are generally performed in specialized facilities and have been historically labor intensive.[17] Today, most packaging capacity resides in East and Southeast Asia, where ATP facilities can be located near the companies performing electronic assembly.[18] The United States currently has limited ATP capacity.[19] This shortfall represents a strategic vulnerability, as bolstering front-end fabrication capacity without investing in packaging will limit supply-chain resiliency.

The industry distinguishes between two categories of packaging: conventional and advanced. Although the United States must on-shore some conventional packaging for national security purposes, it will generally be difficult to build economically competitive conventional packaging facilities in the United States. For conventional packaging, the CHIPS Program Office, in coordination with other departments and agencies, will support ongoing work with allies and partners, including countries in the Americas and those participating in the Indo-Pacific Economic Framework for Prosperity, to ensure the adequacy of global capacity and guarantee supply outside countries of concern.[20]

At the same time, the CHIPS Program Office will invest in projects that support U.S. leadership in advanced packaging—a subset of packaging technologies that uses novel techniques and materials to increase the performance, power, modularity, and/or durability of an integrated circuit. Chipmakers increasingly view progress in advanced packaging as critical to remaining at the leading edge of logic and memory chip production. Indeed, advanced packaging is poised to play a major role in the development of chips for artificial intelligence, cloud computing, and medical applications, among many other next-generation technologies.[21]

The CHIPS Program Office has therefore set the following objectives for advanced packaging:

By the end of the decade, the United States will be home to multiple high-volume advanced packaging facilities. Consistent with the importance of advanced packaging to leading-edge logic and memory

CROSS-CUTTING THEMES

Elaborating on the CHIPS Act implementation priorities identified in Executive Order 14080, the CHIPS Program Office has identified nine themes that will be critical to success across each category highlighted in this report. Alongside the Notice of Funding Opportunity for Commercial Fabrication Facilities, the CHIPS Program Office will release fact sheets and other materials on https://www.chips.gov expanding on the themes listed below.

1. **Catalyzing private investment**. The CHIPS Program Office aims to support a virtuous cycle of private investment in large-scale U.S.-based production and R&D, as well as throughout the supply chain, attracting both existing and new private investors to the U.S. semiconductor ecosystem and encouraging innovative approaches to funding industry growth. This will help ensure that semiconductor firms and their investors continue to invest in the United States long after CHIPS funding has ended. In addition, the first funding opportunity requires applicants to demonstrate how the requested funding will incentivize them to make investments in facilities and equipment in the United States that would not occur in the absence of the incentives.

2. **Encouraging customer demand**. As part of ensuring a project's overall financial feasibility, applicants for CHIPS funding will be encouraged to secure purchase commitments across the supply chain to clarify future demand and mitigate the risk of future chip shortages or oversupply. In addition, the CHIPS Program Office will encourage customers to increase the resiliency of their supply chains by increasing demand for U.S.-produced chips. The CHIPS Program Office urges customers to think creatively about how they can make purchase commitments or take other actions to support semiconductor manufacturing in the United States.

3. **Engaging with U.S. partners and allies**. While the CHIPS Program Office aims to build domestic manufacturing capacity to advance U.S. economic and national security, the United States does not seek to become self-sufficient in semiconductor manufacturing. Alongside other agencies, the Department of Commerce will engage with U.S. allies and partners to coordinate government incentive programs, build resilient cross-border semiconductor supply chains, promote knowledge exchange and collaboration in developing next-generation technologies, and implement safeguards to protect national security.

4. **Building a skilled and diverse workforce**. The CHIPS Program Office expects applicants and their partners to develop strategies to recruit, train, and retain a diverse and skilled set of workers to fill the good jobs created by the CHIPS Act. The CHIPS Program Office will work with applicants and their partners to deploy best practices from within and outside the semiconductor industry to help scale evidence-informed models and partnerships to meet workforce demands. Applicants will be required to detail their engagement with workforce partners—such as educational institutions, labor unions, workforce development organizations, and career and technical education programs—in formulating their workforce plans. Sectoral partnerships will play an integral role in the development and implementation of high-quality, equitable workforce development strategies. Moreover, to create a self-sustaining domestic semiconductor ecosystem the United States must train the next generation of scientists, engineers, and technicians.

5. **Reducing time-to-build**. To create and maintain competitive advantage, the United States needs to be able to build semiconductor manufacturing facilities much more rapidly. This will require efficient

and transparent permitting processes. The CHIPS Program Office intends to prioritize applications that demonstrate a clear path to meeting permitting requirements in a timely manner, such as by securing agreements from state and local permitting authorities to ensure projects stay on schedule while remaining safe, environmentally friendly, and otherwise compliant with relevant laws.

6. **Reducing costs through innovation**. To sustain a vibrant U.S. semiconductor ecosystem over the long term, companies will need to innovate to reduce operating costs and increase net productivity. Companies should focus on (1) reducing the unit cost of new capacity, including by investing in next-generation manufacturing processes and developing more modular, upgradeable, and effective tools; (2) leveraging existing capacity to streamline fab operations, such as by utilizing new technologies to improve demand forecasting, production planning, yield, and tool uptime; and (3) enhancing value for customers, including by making use of advanced packaging, chiplet-based products, and new materials and substrates with unique performance properties. Such innovation will require close collaboration with other market participants, including customers and companies specializing in construction, software, equipment, and materials.

7. **Promoting operational security, supply chain security, and cybersecurity**. The CHIPS Program Office will assess applications based on the quality of an applicant's strategy for mitigating key risks to operational security, supply chain security, and cybersecurity. This assessment will consider the likelihood that the applicant will protect semiconductor production and use for national security purposes from insider threats and external interference, if applicable; the likelihood that the applicant can effectively establish the security of intellectual property and government assets; the comprehensiveness and maturity of the applicant's cybersecurity and cyber-supply chain risk management plans and activities; and the extent to which the applicant has identified and mitigated any risks or vulnerabilities associated with dependence on foreign-owned or sourced inputs, equipment, facilities, personnel, or subsequent manufacturing steps.

8. **Spurring regional economic development and inclusive economic growth**. The CHIPS Program Office is committed to building strong communities that participate in the prosperity of the semiconductor industry, as well as ensuring that taxpayer investments maximize benefits for the U.S. economy. In particular, the CHIPS Program Office will assess applicants' commitments to future investment in the U.S. semiconductor industry; their support for CHIPS R&D programs; their efforts to create inclusive opportunities for businesses; their commitments to climate and environmental responsibility; and their commitments to community investments, such as financing or building affordable housing, financially supporting research institutes, investing in K-12 schools and community colleges, and aligning their efforts with other federal programs.

9. **Enforcing guardrails**. The CHIPS Act allows the Department of Commerce to recover the full amount of an award if an applicant knowingly engages in any joint research or technology licensing effort with a foreign entity of concern that relates to a technology or product that raises national security concerns. In addition, the CHIPS Act requires awardees to enter into an agreement to refrain from engaging in any significant transaction involving the material expansion of semiconductor manufacturing capacity in countries of concern for ten years after receiving funding. Further, awardees cannot spend CHIPS dollars on stock buybacks or dividends, and the CHIPS Program Office will give preference to applicants that commit to making long-term investments in the United States. The CHIPS Program Office will monitor award recipients to ensure compliance with award terms and protection of taxpayer resources and take enforcement steps as necessary.

manufacturing, the CHIPS Program Office encourages applicants to invest in advanced packaging in addition to wafer fabrication. The CHIPS Program Office welcomes applications from both outsourced assembly and test firms, as well as from integrated device manufacturers and foundries that have in-house advanced packaging capabilities.

The United States will be a global technology leader in commercial-scale advanced packaging for both logic and memory chips. The CHIPS R&D Office has established the National Advanced Packaging Manufacturing Program, which will leverage some of its funding to generate rapid advances in advanced packaging over the coming decade, accelerating progress in strategic industries such as artificial intelligence, cloud computing, and next-generation telecommunications. The CHIPS Program Office aims to build on this progress by ensuring that the latest advanced packaging technologies are brought to commercial scale here in the United States.

Semiconductors produced by CHIPS-funded fabs will have multiple options for packaging services, including from both U.S.-based facilities and other facilities in diverse locations outside countries of concern. In addition, the United States and its allies and partners will be substantially less reliant on countries of concern for conventional packaging. In conjunction with the Department of State, the Department of Commerce will engage with U.S. allies and partners to help them attract investments in conventional packaging facilities. For applicants seeking funding for front-end fabrication facilities, the CHIPS Program Office will consider the national security risks of the location of any upstream and downstream steps in the manufacturing process.

Leading-Edge Memory

Memory chips are a critical component of all computational systems, ranging from supercomputers to smartphones, and account for a significant portion of the overall global semiconductor market.[22] Although the United States was once a leader in memory production, cost competition and market consolidation led most U.S. companies to exit the memory business in the 1980s and 1990s.[23] Most manufacturing—even by fabs operated by U.S.-based firms—now takes place in East Asia.[24] Investments in U.S. leading-edge memory production will therefore advance American technology leadership and geographically diversify global supply.

Unlike logic chips, memory products are standardized and often interoperable: A memory chip from one company can typically substitute for a memory chip from another.[25] These features generally increase the resiliency of the memory market, as memory customers willing to pay the prevailing market price can often source their products from any memory producer in the market. Memory chipmakers must thus compete largely on price and operate at lower margins relative to logic chipmakers.[26] U.S. memory producers will therefore need to reach sufficient scale to benefit from the economies of scale enjoyed by larger clusters in East Asia.

The CHIPS Program Office has set the following objectives for memory chips:

By the end of the decade, U.S.-based fabs will produce high-volume leading-edge dynamic random-access memory (DRAM) chips on economically competitive terms. The CHIPS Program Office welcomes applications from memory companies to build advanced memory capacity in the United States, especially those that identify innovative ways to drive down the costs of U.S.-based production. Applicants for funding should demonstrate that their U.S. memory facilities will be economically competitive and sustained through continuous upgrades after the conclusion of the CHIPS Incentives Program, and the CHIPS Program Office encourages applicants to explore innovative ways of driving down costs in the long term.

R&D for next-generation memory technologies critical to supercomputing and other applications will be conducted in the United States. DRAM will be key to supercomputing and other advanced technologies. Moreover, with innovations in advanced packaging, memory and logic technologies will work together to enable advanced computing, and eventually both logic and memory functions will be more deeply integrated on a single or co-packaged chip.

Current-Generation and Mature-Node Semiconductors

A resilient supply of current-generation and mature-node chips is critical to U.S. economic and national security. These chips are in a wide range of modern

technologies, including automobiles, aerospace and defense systems, medical devices, and critical infrastructure. But over the past several years, the COVID-19 pandemic and associated economic impacts have exposed the underlying fragility of these supply chains. Between 2020 and 2021, demand skyrocketed for semiconductors related to computing, communications, and consumer and industrial goods.[27] When the industry struggled to ramp up supply, the resulting shortages exacerbated ongoing supply-demand imbalances and contributed to delays in the production of a range of goods, including automobiles and medical equipment.

While COVID-19 was unprecedented, it revealed structural problems with semiconductor supply-chain management that will endure unless actively addressed. Firms both upstream and downstream of chipmakers typically have limited visibility into their supply chains, often having knowledge of only their immediate customers and suppliers. Purchasing often involves the use of third-party distributors and short-term purchase contracts. These features make it difficult for companies to assess supply chain risks and to diagnose and address shortages as they arise. In addition, current-generation and mature-node production is geographically concentrated, with East Asia accounting for the majority of global capacity in the legacy space and the Chinese government actively subsidizing additional investment in legacy production.[28]

Such challenges are further compounded by the limited interoperability of chips manufactured by different suppliers or made to different specifications.[29] If one chipmaker has an unexpected shortage, others struggle to fill the gap. These issues are particularly pronounced for the long tail of legacy chips used in the defense industrial base.[30]

With these challenges in mind, the CHIPS Program Office will invest in current-generation and mature production consistent with the following objectives.[31]

By the end of the decade, the United States will have increased its production for the current-generation and mature-node chips most vital to U.S. economic and national security. This includes, for example, certain semiconductors used in automobiles, aerospace and defense, medical devices, or other U.S critical infrastructure sectors. The CHIPS Program Office believes that developing new capacity across a range of current-generation and mature nodes can advance U.S. economic and national security, and applicants seeking funding for projects at specific nodes will be asked to make the case for how their proposed approach would advance this objective. In addition, the CHIPS Program Office encourages applicants to explore innovative ways of driving down costs in the long term. It also plans to engage semiconductor customers, including fabless firms and original equipment manufacturers, to increase demand for U.S.-origin chips and improve the resiliency of their own supply.

The United States will increase production of and maintain technology leadership in compound semiconductors and other specialty chips. Innovation in semiconductor manufacturing is not confined to reducing the size of the features on logic and memory chips. For example, semiconductors made from compound materials such as Silicon Carbide or Gallium Nitride will be increasingly central to defense applications, electric vehicles, and next-generation communications infrastructure. Specialty process technologies such as Fully Depleted Silicon-On-Insulator are also critical for defense applications, and specialty chips will be key inputs to emerging technologies such as quantum information systems. The CHIPS Program Office does not seek to displace the private capital that is already being invested into these technologies but encourages applications for CHIPS funding where appropriate.

The United States will coordinate with allies and partners to ensure resilient production of and access to current-generation and mature-node chips. The United States does not seek to become self-sufficient in chip manufacturing and expects that U.S. allies and partners will also increase their chip production to reduce the global concentration of current-generation and mature-node chips. International coordination will help mitigate the risk of overproduction and fill known gaps in the allied and partner ecosystem.

Chipmakers will be able to respond more nimbly to supply and demand shocks. If a given chipmaker cannot meet customer demand, other chipmakers should be positioned to fill the gap without months- or years-long delays. In evaluating proposals for current-generation and mature-node facilities, the CHIPS Program Office will consider the extent to which the proposed manufacturing processes can easily be converted to produce different types of semiconductors in times of disruption.

CONCLUSION

The CHIPS Program Office is embarking on a once-in-a-generation investment in American industry. This document presents a vision for success for investments in the front- and back-end fabrication of leading-edge, current-generation, and mature-node semiconductors. It will guide how the Department of Commerce approaches implementation, with an eye toward advancing U.S. economic and national security, enhancing global supply chain resilience, and cementing U.S. leadership in designing and building the technologies that will define our future.

SUPPLY CHAINS AND R&D FACILITIES

The CHIPS Program Office will release two additional funding opportunities in the coming months: one for materials and equipment facilities in late spring 2023, and one for R&D facilities in the fall. Although suppliers and R&D facilities are not yet eligible for funding, encouraging the development of supply chain and R&D ecosystems is nonetheless an important focus of the first funding opportunity.

Supply Chains. The CHIPS Program Office recognizes the benefits of collaboration between the fabrication facilities that are eligible under the first funding opportunity and the material or manufacturing equipment facilities that will be eligible under the funding opportunity to be released in the spring. The CHIPS Program Office encourages applicants for the first round of funding to take steps to attract suppliers, thereby creating a more productive, efficient, and self-sustaining semiconductor ecosystem. Fabrication facilities could, for example, identify plans for key suppliers to locate in the same area, identify mutually beneficial infrastructure, or incorporate suppliers into workforce development and R&D commitments.

R&D. The CHIPS Program Office will prioritize applicants in this first round of funding who credibly commit to investing in R&D in the United States, such as by building domestic R&D fabs or other domestic R&D facilities. In addition, each applicant will be asked to participate in the National Semiconductor Technology Center (NSTC), which will conduct research and prototyping of advanced semiconductor technology; and, if applicable, to engage, support, and collaborate with projects funded by the National Advanced Packaging Manufacturing Program (NAPMP), which will strengthen capabilities for semiconductor advanced test, assembly, and packaging in the domestic ecosystem. Applicants will furthermore be asked to propose commitments to support these or other CHIPS R&D efforts, such as by rotating project technical staff to the NSTC or NAPMP or by making mature-node process design kits available under an open-source license to further strengthen the domestic electronic design automation industry and improve foundry interoperability.

Beyond these efforts by the CHIPS Program Office, the CHIPS Research and Development Office is also responsible for administering $11 billion in CHIPS funding to support R&D and infrastructure investments, including in the NSTC and NAPMP and not more than three new Manufacturing USA Institutes focused on semiconductor manufacturing. The CHIPS Research and Development Office will soon release a strategy for its implementation of the NSTC. The CHIPS Act also establishes the Department of Defense Microelectronics Commons, which will enable domestic lab-to-fab transition of microelectronics innovations.

ENDNOTES

1 See CHIPS Act of 2022, Pub. L. No. 117-167, Div. A, § 102, 136 Stat. 1372 (2022) ("CHIPS Act of 2022").

2 Pub. L. No. 116-283, tit. XCIX, § 9902 (2021) (codified at 15 U.S.C. § 4652). The Department of Commerce is also responsible for administering $11 billion for research and development pursuant to Section 9906, including for the National Semiconductor Technology Center, the National Advanced Packaging Manufacturing Program, NIST metrology research, and not more than three Manufacturing USA Institutes focused on semiconductors. 15 U.S.C. § 4656. Section 9906 funding will be administered by the CHIPS Research and Development Office. The CHIPS Act of 2022 also provides $2 billion for the CHIPS for America Defense Fund, administered by the U.S. Department of Defense; $500 million for the CHIPS for America International Technology Security and Innovation Fund, administered by the U.S. Department of State; and $200 million for the CHIPS for America Workforce and Education Fund, administered by the National Science Foundation. See CHIPS Act of 2022, § 102(b), (c), (d).

3 This strategy will be released by the CHIPS Research and Development Office within the National Institute of Standards and Technology.

4 Semiconductor Industry Association and Oxford Economics, "Chipping In: The Positive Impact of the Semiconductor Industry on the American Workforce and How Federal Incentives Will Increase Domestic Jobs," May 2021, 4, 6.

5 See Chris Miller, Chip War (New York: Scribner, 2022), 3-32.

6 Miller, Chip War, 19-22, 29-31.

7 The White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews under Executive Order 14017," June 2021, 9, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

8 White House, "Building Resilient Supply Chains," 38-39; Brian Shirley, "Don't Forget About Memory," Potomac Institute for Policy Studies, July 2022, 2.

9 See, e.g., Dylan Walsh, "How auto companies are adapting to the global chip shortage," Massachusetts Institute of Technology, June 2022, https://mitsloan.mit.edu/ideas-made-to-matter/how-auto-companies-are-adapting-to-global-chip-shortage; "Medical Device Shortages During the COVID-19 Public Health Emergency," U.S. Food and Drug Administration, last modified December 2022, https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/medical-device-shortages-during-covid-19-public-health-emergency.

10 The White House, "Building Resilient Supply Chains," 21-80.

11 U.S. Department of Commerce, "Results from Semiconductor Supply Chain Request for Information," January 2022, https://www.commerce.gov/news/blog/2022/01/results-semiconductor-supply-chain-request-information.

12 U.S. Department of Commerce, "A Strategy for the CHIPS for America Fund," September 2022, https://www.nist.gov/system/files/documents/2022/09/13/CHIPS-for-America-Strategy%20%28Sept%206%2C%202022%29.pdf.

13 White House, "Building Resilient Supply Chains," 38-39. Industry participants also noted the shift in production to East Asia in comments submitted in response to the Department of Commerce's Request for Information (RFI) on the semiconductor supply chain. See, e.g., DOC-2022-0001-0171 (citing U.S. Department of Defense report referencing "[t]he migration of semiconductor manufacturing to the Asia-Pacific region").

14 The majority of the top 10 fabless semiconductor design firms, by revenue, are headquartered in the United States. See Congressional Research Service, "Semiconductors: U.S. Industry, Global Competition, and Federal Policy," October 2020, 12.

15 The CHIPS Program Office will also be releasing a Notice of Funding Opportunity for R&D facilities in fall 2023

16 White House, "Building Resilient Supply Chains," 56 ("With no leading-edge semiconductor manufacturers in the United States . . . the DoD is currently unable to ensure its access to secure supply chains.").

17 Congressional Research Service, "Semiconductors: U.S. Industry, Global Competition, and Federal Policy,"

18 Of the more than 500 assembly and test facilities tracked by SEMI, more than 210 outsourced semiconductor assembly and test facilities are in China and Taiwan, while only approximately 45 are in the Americas. In addition, more than 50 integrated device manufacturer packaging facilities are in Southeast Asia, and around 25 are in China. See SEMI, "Worldwide Assembly & Test Facility Database," 2022.

19 John VerWey, "Betting the House: Leveraging the CHIPS and Science Act to Increase U.S. Microelectronics Supply Chain Resilience," Center for Security and Emerging Technology, January 2023, 13 ("U.S.-based ATP capacity is roughly 3 percent of total global capacity, and no U.S. firms lead in the supply of packaging materials."). See also DOC-2022-0001-0073 (noting, in response to the Department of Commerce's Request for Information, that "North America's share of global packaging production is a mere 3 percent").

20 The CHIPS Act defines "foreign country of concern" as "a country that is a covered nation (as defined in section 4872(b) of title 10 United States Code)" and "any country that the Secretary, in consultation with the Secretary of Defense, the Secretary of State, and the Director of National Intelligence, determines to be engaged in conduct that is detrimental to the national security or foreign policy of the United States." 15 U.S.C. § 4651(7).

21 See, e.g., IEEE Electronics Packaging Society, "Heterogeneous Integration Roadmap," October 2019, 5.

22 Shirley, "Don't Forget About Memory," 2 ("The memory industry accounts for $154 billion in sales in 2021, compromises 28% of the global $556 billion semiconductor market, and is equivalent in size to the entire category of logic.").

23 Miller, Chip War, 207; Shirley, "Don't Forget About Memory," 4 ("The 1980s saw the memory market become both international and commoditized, with the rise of the personal computer (PC) and DRAM manufacturing by several well-funded Japanese companies driving cost competition. By the end of the decade, companies such as Toshiba, NEC, and Hitachi dominated the DRAM market, forcing out most US suppliers.").

24 Will Hunt, "Sustaining U.S. Competitiveness in Semiconductor Manufacturing," Center for Security and Emerging Technology, January 2022, 29-30.

25 Congressional Research Service, "Semiconductors: U.S. Industry, Global Competition, and Federal Policy," 9 (noting that "memory chips are considered commodities with little differentiation among them").

26 Id. (noting that memory chips "typically [operate] with smaller profit margins than microprocessors").

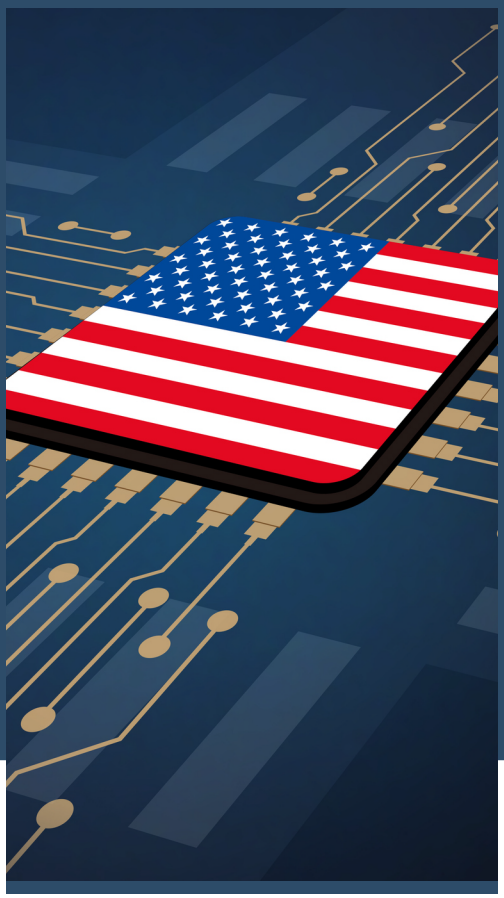
27 Semiconductor Industry Association, "Global Semiconductor Sales Increase 24% Year-to-Year in October; Annual Sales Projected to Increase 26% in 2021, Exceed $600 Billion in 2022," December 2021.

28 Hunt, "Sustaining U.S. Competitiveness," 2; U.S. Department of Commerce, "A Strategy for the CHIPS for America Fund," 7.

29 World Economic Forum, "When the chips are down: How the semiconductor industry is dealing with a worldwide shortage," February 2022 (noting that "[s]witching to a different manufacturer typically adds [a] year or more because the chip's design requires alterations to match the specific manufacturing processes of the new partner").

30 Sujai Shivakumar and Charles Wessner, "Semiconductors and National Defense: What are the Stakes?" Center for Strategic and International Studies, June 2022, https://www.csis.org/analysis/semiconductors-and-national-defense-what-are-stakes.

31 Of the $39 billion appropriated for section 9902 of the CHIPS Act, $2 billion is set aside for equipment and fabrication facilities used to produce semiconductors at mature technology nodes. See CHIPS Act of 2022, § 102(a)(3). The CHIPS Program Office views this number as a floor, not a ceiling.



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