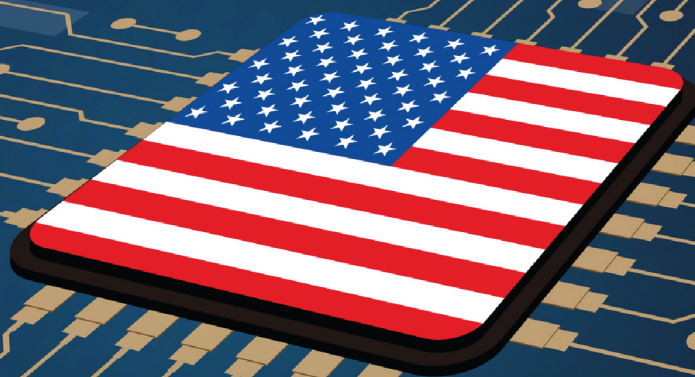


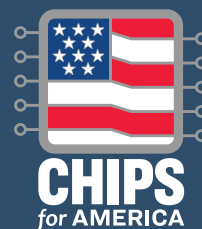
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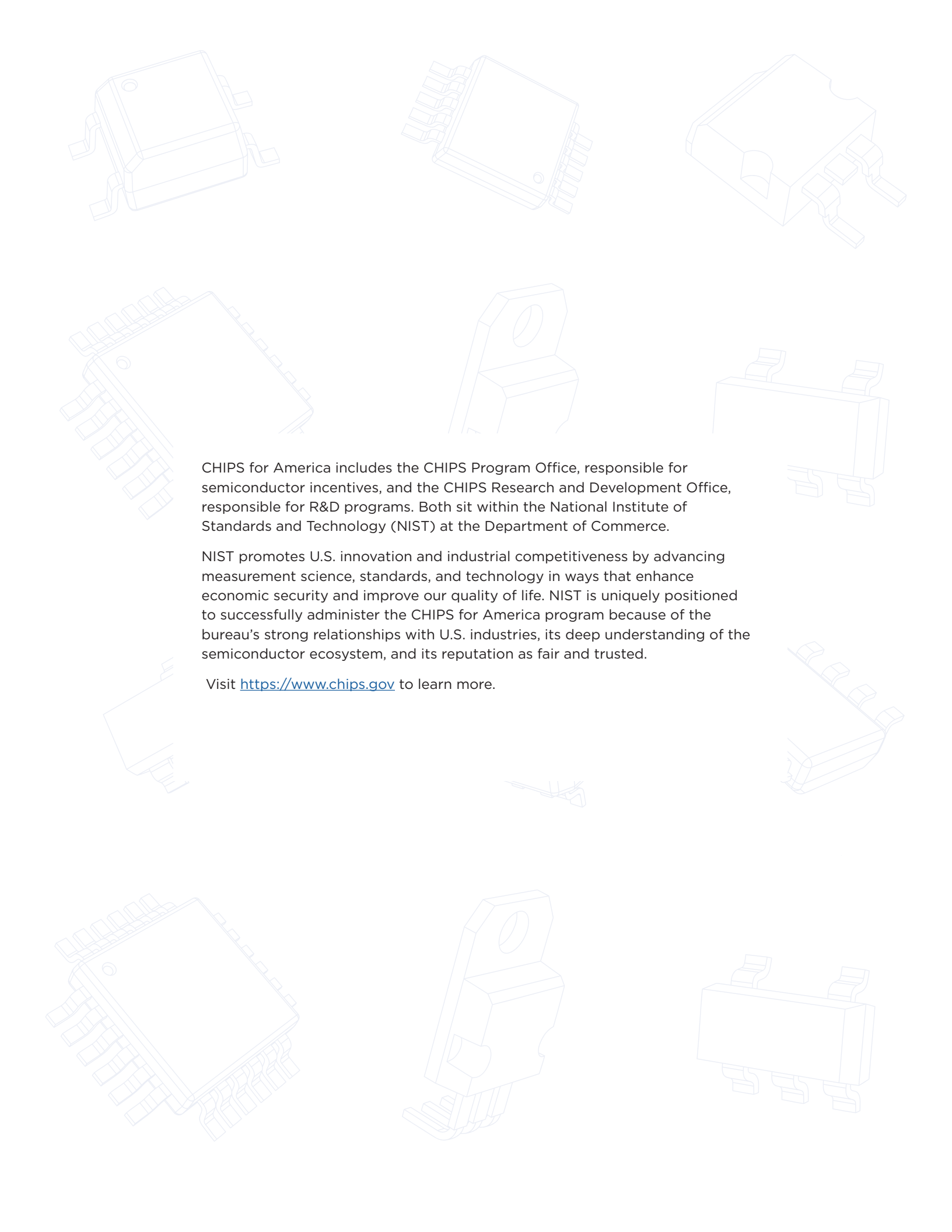
VISION FOR SUCCESS: Facilities for Semiconductor Materials and Manufacturing Equipment

CHIPS Incentives Program

June 23, 2023



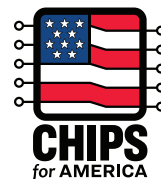
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NIST promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST is uniquely positioned to successfully administer the CHIPS for America program because of the bureau's strong relationships with U.S. industries, its deep understanding of the semiconductor ecosystem, and its reputation as fair and trusted.

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Vision for Success: Facilities for Semiconductor Materials and Manufacturing Equipment

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EXECUTIVE SUMMARY

The semiconductor supply chain is global, specialized, and interconnected. Chipmakers do business with thousands of individual suppliers that provide the highly complex materials and tools used to produce semiconductors. Often, even the biggest chipmakers lack full visibility into their entire supply chain.

The United States and its allies and partners produce nearly all of the world's most advanced semiconductor materials and manufacturing equipment. But as suppliers have expanded overseas, the United States has also grown vulnerable to risks stemming from the geographic concentration of critical suppliers, as well as from threats to supply chain security and integrity. At the same time, the CHIPS Incentives Program presents a unique opportunity to strengthen the U.S. supplier ecosystem as a historic expansion of U.S. chipmaking capacity boosts domestic demand for semiconductor materials and tools.

Against this backdrop, the U.S. Department of Commerce's CHIPS Program Office is releasing two funding opportunities for the semiconductor supply chain. The first, released in June 2023, expands the funding opportunity released in February 2023 to accept applications for the construction, expansion, or modernization of semiconductor materials and manufacturing equipment facilities for which the total capital investment equals or exceeds \$300 million. The second, to be released in the fall of 2023, will cover semiconductor materials and manufacturing equipment facilities with total capital investments under \$300 million. This document lays out the CHIPS Program Office's "Vision for Success" for both funding opportunities across three categories: strengthening supply chain resilience, advancing U.S. technology leadership, and supporting vibrant U.S. fab clusters.

The CHIPS Program Office aims to work with industry, U.S. partners and allies, U.S. government agencies, state and local entities, labor unions, workforce development organizations, career and technical education providers, economic development organizations, and institutions of higher education to achieve the following goals by the end of this decade:

Strengthening supply chain resilience. The CHIPS Program Office will invest, in coordination with other U.S. government agencies, to reduce chokepoint risks flowing from geographic concentration. Meanwhile, U.S. semiconductor supply chain participants will improve the transparency of demand and supply to reduce the risks of production disruptions due to chronic shortages of critical supply chain inputs.

Advancing U.S. technology leadership. Major U.S. semiconductor manufacturing equipment and materials suppliers will increase their footprints in the United States, reinforcing American technology leadership in the supply chain. In addition, non-U.S. suppliers of the world's most advanced semiconductor manufacturing equipment, materials, and subsystems will establish large-scale footprints in the United States for the first time, contributing to and benefiting from the domestic innovation ecosystem and bringing new strategic capabilities and know-how to the United States.

Supporting vibrant U.S. fab clusters. Each CHIPS-funded fab cluster in the United States will be supported by dozens of suppliers, including many that will be investing in the United States for the first time to close critical gaps in the U.S. supplier ecosystem. The CHIPS Program Office will encourage state and local entities to facilitate the expansion of these ecosystems and to support both domestic suppliers growing their U.S. presence and non-U.S. suppliers expanding in the United States for the first time.

In pursuit of these objectives, the CHIPS Program Office will be guided by the nine cross-cutting themes detailed in the "Vision for Success: Commercial Fabrication Facilities" released on February 28, 2023. These include catalyzing private investment, encouraging customer demand, engaging with U.S. partners and allies, building a skilled and diverse workforce, reducing time-to-build, reducing costs through innovation, promoting operational security, supply chain security, and cybersecurity; spurring regional economic development and inclusive economic growth; and enforcing guardrails. These themes apply across the CHIPS Program Office's varied investments.

Continued U.S. leadership in semiconductor materials and manufacturing equipment supply chains is critical to establishing a vibrant U.S. manufacturing sector, which is in turn core to America's economic and national security. The CHIPS Program Office will reserve a significant majority of its investments for the commercial fabrication facilities that will bring semiconductor manufacturing back to the United States. But targeted investments in semiconductor materials and manufacturing equipment will help address important vulnerabilities and capitalize on existing U.S. strengths in one of the world's most important supply chains.

INTRODUCTION

In February 2023, the CHIPS Program Office within the Department of Commerce released its first funding opportunity 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).¹ Alongside the funding opportunity, the CHIPS Program Office released a “Vision for Success,” outlining how investments in commercial fabrication facilities can revitalize the U.S. semiconductor ecosystem and advance U.S. economic and national security.²

Building on that report, this document outlines the CHIPS Program Office’s “Vision for Success” for a second set of investments, this time in the semiconductor supply chain. This vision will guide implementation of two funding opportunities. The first, released June 2023, expands the funding opportunity from February to accept applications for the construction, expansion, or modernization of semiconductor materials and manufacturing equipment facilities for which the total capital investment equals or exceeds \$300 million. The second, to be released in the fall of 2023, will cover semiconductor materials and manufacturing equipment facilities with total capital investments under \$300 million.

The CHIPS Program Office will subsequently release a separate funding opportunity for research and development facilities, which will seek to complement investments by the CHIPS Research and Development Office in the National Semiconductor Technology Center, the National Advanced Packaging Manufacturing Program, one or more Manufacturing USA institutes, and the NIST metrology program under Section 9906 of the CHIPS Act.³

Transforming raw silicon into a finished chip involves one of the world’s largest and most complex supply chains. Chip manufacturers do business with thousands of individual suppliers that provide the often highly complex materials and tools needed throughout the production process.⁴ Adding to the complexity: suppliers have their own supply chains to manage, and even the biggest chipmakers and their suppliers often lack full visibility into their entire supply chain.⁵

In the early days of semiconductor manufacturing, the American chipmakers who founded the industry developed and manufactured many of their manufacturing tools and materials in-house. Over time, companies were spun out to service the growing diversity of mostly

U.S.-based chipmakers, spawning many increasingly specialized suppliers largely based in the United States.⁶

In the last forty years, however, as semiconductor manufacturing has shifted abroad, the supply chain has expanded overseas as well.⁷ The United States continues to produce many of the world’s most advanced semiconductor manufacturing tools, subsystems, and materials, and its allies and partners have produced remarkable technological advances that have benefited the United States and the entire global ecosystem.⁸ But the transformation of the supply chain has also come with risks. U.S.-based chipmakers have been buffeted by disruptions and shortages in recent years—partly because of vulnerabilities associated with the geographic concentration of highly specialized suppliers; the lack of visibility into demand, supply, and security risks in the supply chain; and the months- or even years-long lead times required to qualify new suppliers in the event of disruptions.⁹

At the same time, the CHIPS Incentives Program presents a unique opportunity to build on U.S. strengths in the supply chain, as a historic expansion of U.S. chipmaking capacity boosts domestic demand for semiconductor manufacturing inputs. If successful, the CHIPS Incentives Program will not only address supply chain vulnerabilities but also accelerate U.S. innovation in manufacturing equipment and materials and grow the supplier ecosystems supporting new clusters of U.S. fabs.

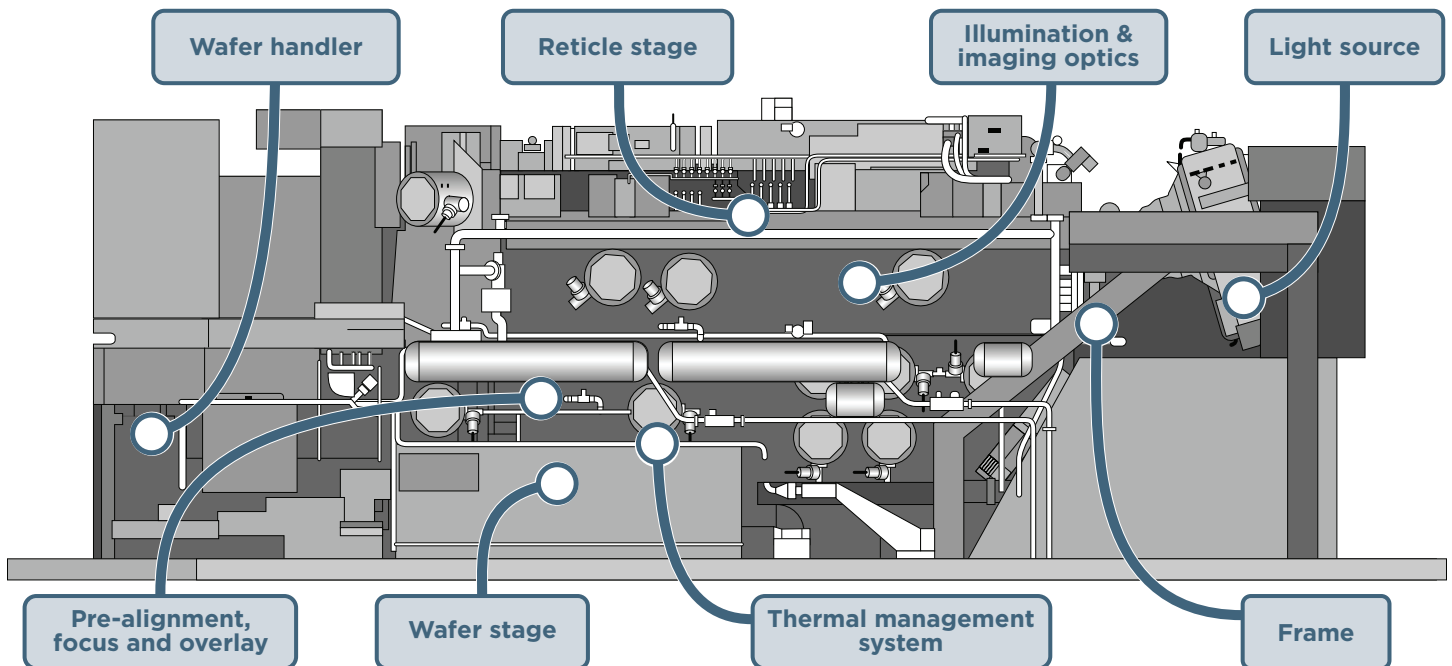
To guide its supply chain investments, the CHIPS Program Office has developed a “Vision for Success” focused on strengthening supply chain resilience, advancing U.S. technology leadership, and supporting vibrant fab clusters.¹⁰ In pursuit of these objectives, the CHIPS Program Office will be guided by the nine cross-cutting themes detailed in the “Vision for Success: Commercial Fabrication Facilities” released on February 28, 2023.¹¹ These include catalyzing private investment, encouraging customer demand, engaging with U.S. partners and allies, building a skilled and diverse workforce, reducing time-to-build, reducing costs through innovation, promoting operational security, supply chain security, and cybersecurity; spurring regional economic development and inclusive economic growth; and enforcing guardrails. These themes apply across the CHIPS Program Office’s varied investments.

One such theme—engaging with U.S. partners and allies—will be especially critical to strengthening supply chain resilience. The United States does not seek to create a self-sufficient semiconductor supply chain. The United States will continue to depend on advanced materials and tools produced overseas, and through bilateral and

multilateral dialogues and business-to-business and government-to-business forums, the CHIPS Program Office and other government departments and agencies will work with like-minded partners to diversify the global semiconductor supply chain.

This Vision for Success will guide the CHIPS Program Office as it assesses the trade offs between worthy supply chain projects and other types of projects across the CHIPS Incentives Program. The CHIPS Program Office will reserve a significant majority of its investments

for the commercial fabrication facilities that will bring semiconductor manufacturing back to the United States. But targeted investments in semiconductor materials and manufacturing equipment—investments focused on projects that would not happen without CHIPS Incentives Program funding—will help address important vulnerabilities and capitalize on existing U.S. strengths in one of the world’s most important supply chains.



Subsystems of a photolithography machine. A single photolithography machine incorporates many subsystems that are often sourced from highly specialized suppliers who have many suppliers of their own. The proliferation of suppliers at tier 2 and above—subsystems and materials suppliers that chipmakers often have no direct relationship with—makes it difficult for any one company to have full supply-chain visibility.

STRENGTHENING SUPPLY CHAIN RESILIENCE

Without access to the wide array of materials and tools needed for semiconductor manufacturing, chipmakers would struggle to produce the devices that are critical to U.S. economic and national security. Even isolated supply chain disruptions can be damaging. In 1993, for example, the explosion of a Sumitomo Chemical factory in Japan caused spot prices for dynamic random-access memory chips in the United States to more than double.¹²

Unfortunately, many supply chain inputs are geographically concentrated. Ukraine produced roughly half of the global supply of neon in 2022, for example, and

the United States depends on the People’s Republic of China for a variety of upstream inputs such as rare earths and gallium.¹³ Meanwhile, certain inputs face chronic shortages simply because U.S. production is limited in quality and quantity. For example, ultra-high purity chemicals such as hydrofluoric acid and isopropyl alcohol are required for wafer manufacturing and are often in short supply.¹⁴ Promoting supply chain traceability, recovering chemicals and metals, identifying alternative raw materials sources in low-risk geographies, and increasing the domestic production of shortage-prone materials will all help prevent supply disruptions such as those the United States experienced during the COVID-19 pandemic.

The CHIPS Program Office has set the following objectives to strengthen supply chain resilience:

The CHIPS Program Office will invest, in coordination with other U.S. government agencies, to reduce chokepoint risks flowing from geographic concentration.

The CHIPS Program Office will focus especially on inputs that are highly specialized for semiconductor production and that are not being addressed by other U.S. government agencies. Pressure from chipmakers, their investors, and U.S. allies and partners will also help to diversify supplier procurement. These efforts will ensure that the world continues to benefit from innovations across a globalized supply chain, while also mitigating the risks that flow from geographic concentration. The United States does not seek a self-sufficient semiconductor supply chain and will continue to collaborate with allies and partners to fill critical gaps in advanced materials and manufacturing equipment.

U.S. semiconductor supply chain participants will improve transparency of demand and supply to reduce the risks of production disruptions due to chronic shortages of critical supply chain inputs. Applicants to the CHIPS Program Office's funding opportunity for commercial fabrication facilities and large-scale semiconductor materials and manufacturing equipment facilities must list and map all key suppliers and address techniques used to manage supply chain risk, such as conducting supply chain stress test analyses and regular supply chain mapping into second-tier and further suppliers.¹⁵ In most cases, the CHIPS Program Office expects chipmakers as well as their suppliers and end customers to manage shortage risks without CHIPS incentives. Industry stakeholders should also work to establish secure venues and best practices for cross-industry supply chain information sharing. In rare cases where industry is unable to address a given supply-chain risk, targeted CHIPS Incentives Program funding may be necessary to ensure the supply keeps pace with rising U.S. and global demand.

ADVANCING U.S. TECHNOLOGY LEADERSHIP

American companies produce many of the world's most technologically sophisticated semiconductor manufacturing tools and materials. The United States is home to three of the top five semiconductor manufacturing equipment companies by revenue, and U.S. equipment manufacturers are the leading suppliers of many tools needed to make the most advanced chips.¹⁶ The United States is also a major supplier of semiconductor materials, from electronic gases and

wet chemicals to deposition and chemical mechanical planarization materials.¹⁷

Sustaining and building upon these pre-existing strengths will be critical to the overall success of the CHIPS program and will help the American innovation ecosystem attract continued investment from both chipmakers and their suppliers. Innovations in semiconductor process technology benefit from close collaboration between chipmakers and suppliers.¹⁸ Developing extreme ultraviolet (EUV) photolithography tools, for example, required co-optimization of reticles, photoresists, and electronic design automation software, as well as years of testing and feedback from leading-edge chipmakers.¹⁹ U.S. leadership in one part of the supply chain can thus reinforce and accelerate leadership in other parts, further advancing U.S. strategic capabilities.

Recognizing the symbiotic relationship between chipmakers and suppliers, the CHIPS Program Office aims to incentivize U.S. manufacturing equipment and materials firms to build capacity in the United States. At the same time, the CHIPS Program Office also welcomes and encourages investment from leading non-U.S. suppliers, especially since non-U.S. firms produce many critical manufacturing inputs.

The CHIPS Program Office has set the following objectives for sustaining and growing U.S. technology leadership:

Major U.S. semiconductor manufacturing equipment and materials suppliers will increase their footprints in the United States, reinforcing American technology leadership in the supply chain.

The United States must remain a world leader in technologies like deposition, etch, inspection, metrology, process control, and other critical equipment inputs. In addition, to ensure the long-term sustainability of manufacturing in the United States, equipment firms will improve the productivity of their manufacturing processes.

Non-U.S. suppliers of the world's most advanced semiconductor manufacturing equipment, materials, and subsystems will establish large-scale footprints in the United States for the first time.

Such suppliers will benefit from and contribute to the U.S. innovation ecosystem and bring new strategic capabilities and know-how to the United States. At the same time, the contributions of U.S.-based engineers will drive faster progress in advanced equipment and materials, benefiting the many industries that rely on continued progress in semiconductor technology.

SUPPORTING VIBRANT FAB CLUSTERS

Chipmakers prefer to—and in some cases must—domestically source many materials and manufacturing equipment, as illustrated by the rise in semiconductor supply chain investments around recently-announced fab locations.²⁰ Recent supply chain shortages have also highlighted the need for establishing local materials production facilities.²¹ Sourcing these materials domestically and taking steps to recover chemicals and metals for further use can help lower shipping costs and reduce the risk of shipping delays, allowing clusters to become more efficient and productive.

Investments to support vibrant fab clusters will overlap with, but are distinct from, investments to strengthen supply chain resilience. The CHIPS Program Office expects the latter investments to focus on inputs that face acute chokepoint or shortage risks. By contrast, supporting vibrant fab clusters involves making the United States as attractive as possible to chipmakers to ensure continued investment in the United States.

State and local entities will be critical partners for CHIPS Program Office investments through the provision of both public investments and non-financial services and resources to support suppliers. Especially valuable are efforts that benefit a wide set of firms, such as streamlining permitting, investing in a strong and diverse workforce, and building critical infrastructure like electric or water utilities.

Of course, as fabs are established in the United States thanks to the CHIPS Act, many suppliers will move here organically to secure business from the new facilities. The CHIPS Program Office aims to reserve its investments for the rare cases where suppliers would be unwilling or unable to move to the United States in the absence of CHIPS Incentives Program funding.

The CHIPS Program Office has set the following objectives for supporting vibrant fab clusters:

Each CHIPS-funded fab cluster in the United States will be supported by dozens of suppliers, including many that will be investing in the United States for the first time to close critical gaps in the U.S. supplier ecosystem.

Initial investments in each cluster will create a flywheel effect that helps the cluster expand over many years, attracting new investments and driving continuous improvements in cluster productivity. While the CHIPS Program Office will fund projects to strengthen these supplier ecosystems, it expects that many suppliers will not require CHIPS Incentives Program funding because they will expand here naturally in response to the demand signal from new U.S. fabs.

The CHIPS Program Office will encourage state and local entities to facilitate the expansion of these ecosystems and support both domestic suppliers growing their U.S. presence and non-U.S. suppliers expanding in the United States for the first time. In particular, state and local entities should consider establishing science parks or regional one-stop shops to facilitate investments in infrastructure, land, and workforce development as well as to guide critical suppliers through the complexities of permitting and identifying additional U.S. customers. The Department is also dedicating staff to support the formation of clusters, including by helping communities and businesses access resources critical to cluster growth, such as those related to permitting, infrastructure, workforce development, and others.

CONCLUSION

The CHIPS Incentives Program is an unprecedented effort to reestablish U.S. leadership in manufacturing the semiconductors that power the global economy and undergird U.S. economic and national security. Building off the vision for success for investments in the front- and back-end fabrication of leading-edge, current-generation, and mature-node semiconductors, this document presents a complementary vision for success for investments in semiconductor materials and manufacturing equipment. Investments to strengthen supply chain resilience, advance U.S. technology leadership, and support vibrant U.S. fab clusters are essential to the broader success of the CHIPS Incentives Program and ultimately to U.S. economic and national security.

ENDNOTES

¹ 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. 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 the CHIPS Act. Of that \$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. See CHIPS Act of 2022, Pub. L. No. 117-167, Div. A, § 102, 136 Stat. 1372 (2022) (“CHIPS Act of 2022”).

² U.S. Department of Commerce, “Vision for Success: Commercial Fabrication Facilities,” February 2023.

³ In addition to the \$39 billion being administered by the CHIPS Program Office, the Department of Commerce is also responsible for administering \$11 billion for research and development pursuant to Section 9906 of the CHIPS Act. Section 9906 funding will be administered by the CHIPS Research and Development Office.

⁴ To take just two examples, both Intel and Taiwan Semiconductor Manufacturing Company (TSMC) do business with more than 1,000 suppliers. Intel, “2020-21 Corporate Responsibility Report,” June 2021, 3, <https://csrreportbuilder.intel.com/pdfbuilder/pdfs/CSR-2020-21-Full-Report.pdf>; TSMC, “Supplier Sustainability Management,” 2021, 1, <https://esg.tsmc.com/download/file/2019-csr-report/english/pdf/e-5-issue-1.pdf>.

⁵ Vishal Gaur, Nicolay Osadchiy, Maximiliano Udenio, “Research: Why It’s So Hard to Map Global Supply Chains,” Harvard Business Review, October 31, 2022, <https://hbr.org/2022/10/research-why-its-so-hard-to-map-global-supply-chains>.

⁶ Unni Pillai, “The Emergence of Tools Suppliers in the Semiconductor Industry,” SUNY Polytechnic Institute, January 2017, 2-3.

⁷ Akhil Thadani and Gregory C. Allen, “Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region,” Center for Strategic International Studies, May 2023, 11, <https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-role-indo-pacific-region>; Henry Wai-Chung Yeung, “Explaining Geographic Shifts of Chip Making Towards East Asia and Market Dynamics in Semiconductor Global Production Networks,” Economic Geography, Vol. 98, No. 3, 2022, 273.

⁸ Semiconductor Industry Association (SIA)/Boston Consulting Group (BCG), “Strengthening the Global Semiconductor Supply Chain in an Uncertain Era,” April 2021, 31, <https://www.bcg.com/publications/2021/strengthening-the-global-semiconductor-supply-chain>.

⁹ Wall Street Journal, “Biden Orders Broad Supply-Chain Review Amid Chip Shortages,” February 2021, <https://www.wsj.com/articles/biden-to-address-chip-shortages-supply-chain-problems-with-executive-action-11614160803>; SIA/BCG, “Strengthening the Global Semiconductor Supply Chain”; David Simchi-Levi, Feng Zhu, and Matthew Loy, “Fixing the U.S. Semiconductor Supply Chain,” Harvard Business Review, October 2022, <https://hbr.org/2022/10/fixing-the-u-s-semiconductor-supply-chain>.

¹⁰ The CHIPS Program Office defines clusters as 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. See Department of Commerce, “Vision for Success: Commercial Fabrication Facilities,” at 1, 5. As outlined in this first “Vision for Success,” the CHIPS Program Office aims by the end of the decade for each CHIPS-funded fab to be supported by an ecosystem of reliable suppliers committed to operating and innovating in the United States. See id. at 6.

¹¹ See Department of Commerce, “Vision for Success: Commercial Fabrication Facilities,” at 7-8.

¹² David Thurber, “Semiconductor Industry Faces Problems After Resin Plant Explosion,” AP News, August 4, 1993, <https://apnews.com/article/8fe2925b68d34d33f19a53e4892c74a2>.

¹³ Alexandra Alper, “Exclusive: Russia’s Attack on Ukraine Halts Half of World’s Neon Output for Chips,” Reuters, March 2022, <https://www.reuters.com/technology/exclusive-ukraine-halts-half-worlds-neon-output-chips-clouding-outlook-2022-03-11/>; White House, “Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100- Day Reviews under Executive Order 14017,” June 2021, 7, 45, 156. The examples in this sentence are for illustrative purposes only. The Department will evaluate the merits of each proposal on a case-by-case basis.

¹⁴ Shannon Davis, “Shortage Threat to Semiconductor Materials from US Chip Expansion Plans,” Semiconductor Digest, July 8, 2021. The examples in this sentence are for illustrative purposes only. The Department will evaluate the merits of each proposal on a case-by-case basis.

¹⁵ See Department of Commerce, “Notice of Funding Opportunity (NOFO): CHIPS Incentives Program – Commercial Fabrication Facilities,” February 28, 2023, at 42.

¹⁶ Congressional Research Service, “Semiconductors: U.S. Industry, Global Competition, and Federal Policy,” 15-16, <https://crsreports.congress.gov/product/pdf/R/R46581>.

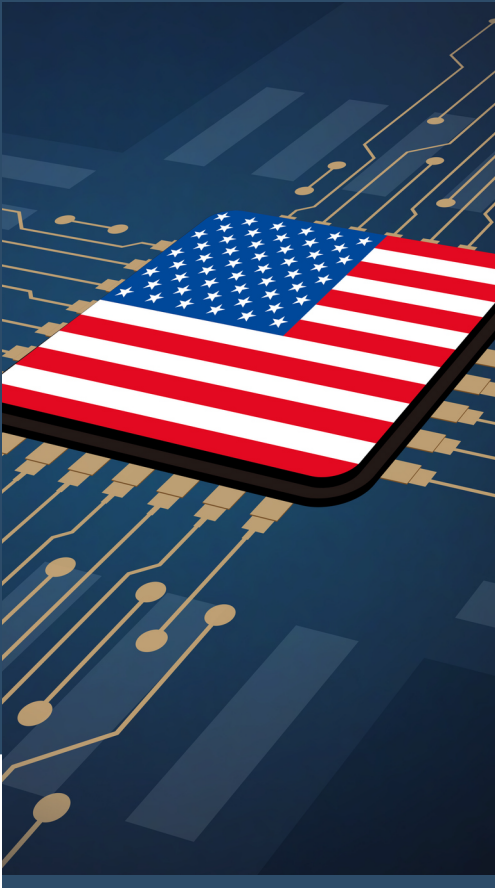
¹⁷ Saif M. Khan, Alexander Mann, and Dahlia Peterson, “The Semiconductor Supply Chain: Assessing National Competitiveness,” Center for Security and Emerging Technology, June 6, 2023, <https://cset.georgetown.edu/publication/the-semiconductor-supply-chain/>.

¹⁸ Sujai Shivakumar, Charles Wessner, and Tom Howell, “Can Semiconductor Reshoring Prime a U.S. Manufacturing Renaissance?” Center for Strategic & International Studies, September 2022, <https://www.csis.org/analysis/can-semiconductor-reshoring-prime-us-manufacturing-renaissance>.

¹⁹ Sander Hofman, “Making EUV: From Lab to Fab,” ASML, March 2022, <https://www.asml.com/en/news/stories/2022/making-euv-lab-to-fab>.

²⁰ Shivakumar, Wessner, and Howell, “Can Semiconductor Reshoring Prime a U.S. Manufacturing Renaissance?”

²¹ Shannon Davis, “U.S. Chip Expansions Squeezed by Shortages of Specialty Materials,” Semiconductor Digest, August 2022, <https://www.semiconductor-digest.com/u-s-chip-expansions-squeezed-by-shortages-of-specialty-materials/>.



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