Chapter 13: Microelectronics

Blueprint for Action

Regaining microelectronics leadership requires meeting an explicit objective: Stay at least two generations ahead of China in state-of-the-art microelectronics and maintain multiple sources of cutting-edge microelectronics fabrication in the United States. To do this, the Executive Branch must prepare and implement a National Microelectronics Strategy while Congress simultaneously institutes new tax credits, subsidizes the construction of semiconductor manufacturing facilities, and grows federal microelectronics R&D and infrastructure funding. Achieving this goal will require roughly $30 billion in additional federal funding, but these funds should attract more than five times as much private-sector investment. Additional federal funding on this scale will likely boost economic activity domestically and could add more than $100 billion to U.S. gross domestic product (GDP).[1] Inside the U.S. government, agencies must also expand access to trustworthy, high-performance microelectronic components by shifting from serial to concurrent development of hardware and software to catch up to the commercial sector and make use of new microelectronics produced in the United States.

Five-Year Microelectronics Funding

Category	Amount
Federal Grants for Microelectronics Manufacturing*	$3 billion per project ($15 billion total)
Microelectronics R&D	$12 billion
Microelectronics Infrastructure	$7 billion
DoD Trusted & Assured Microelectronics	$0.5 billion
Total	**$35 billion**

Recommendation: Issue an Executive Order on Microelectronics Strategy and Leadership

Recommendation

The United States needs a National Microelectronics Strategy to coordinate semiconductor policy, funding, and incentives within the Executive Branch and externally with industry and academia.

Actions for the President:

- **Issue an Executive Order on Microelectronics National Strategy and Leadership.**
    - The first step in rebuilding microelectronics leadership is clearly stating that it is a Presidential priority to stay at least two generations ahead and maintain multiple sources of cutting-edge microelectronics fabrication in the United States. The Administration should also highlight the importance of the legislatively required National Microelectronics Strategy and create a durable structure for its development, implementation, and revision by issuing an Executive Order requiring the National Defense Authorization Act (NDAA)-mandated Subcommittee on Microelectronics Leadership to lead a process to develop a clear federal strategy for microelectronics leadership. Draft text to inform the development of an Executive Order for this purpose is included as an Annex to this Blueprint for Action.

Recommendation: Revitalize Domestic Microelectronics Fabrication

Recommendation

Existing U.S. incentives offset the cost of semiconductor foundry construction attributable to capital expenses, operating expenses, and taxes by 10% to 15%.[2] Yet additional tax credits and subsidies are needed to make the United States a globally competitive market for semiconductor manufacturing, especially leading-edge logic facilities. Other leading semiconductor manufacturing nations such as South Korea, Taiwan, and Singapore offer 25% to 30% cost reduction, roughly double what the United States currently offers.[3] This gap in incentives is one driving factor behind the lack of an advanced logic merchant foundry in the United States. Closing the gap will encourage U.S. firms to construct facilities domestically while also attracting foreign firms. In fact, a program of the size described here is projected to attract roughly 14 new fabs in the United States over 10 years.[4] Additionally, increasing demand in the United States for high-end semiconductor manufacturing equipment (SME) will create new business opportunities for SME manufacturers from allied countries, particularly Japan and the Netherlands, which could increase their governments' willingness to align their export control policies with U.S. policies prohibiting the export of such equipment to China.[5] A refundable investment tax credit should be instituted in combination with funding for federal grants for the expansion, construction, and modernization of SME authorized in the NDAA.[6]

Action for Congress:

- **Create a 40% refundable investment tax credit for domestic semiconductor manufacturing.**

  - Congress should pass legislation establishing a 40% refundable federal investment tax credit for semiconductor manufacturing facilities and equipment required to produce state-of-the-art logic chips. This incentive would reduce a semiconductor firm's tax bill by 40% on SME and facilities through 2024, followed by reduced tax credit rates of 30% and 20%, respectively, through 2025 and 2026. Although introduced as part of the Creating Helpful Incentives to Produce Semiconductors for America Act (CHIPS for America Act), Congress has not yet passed legislation establishing this credit.[7]

- **Appropriate funding authorized in the FY 2021 NDAA for domestic semiconductor manufacturing incentives, including matching funds for semiconductor fabrication facilities.**

  - The FY 2021 NDAA authorizes the Secretary of Commerce to establish a Federal financial assistance program to incentivize investment in facilities and equipment in the United States for semiconductor fabrication, assembly, testing, advanced packaging, or R&D. Under the program, the Secretary may authorize up to $3 billion per project to finance the construction, expansion, or modernization of facilities and equipment for semiconductor manufacturing. Larger subsidies are also permitted if the project significantly increases the proportion of semiconductors relevant for national security and economic competitiveness that can be met through reliable domestic production. However, this judgment requires the concurrence of the Secretary of Defense and Director of National Intelligence.

  - Although authorized in the FY 2021 NDAA, funds have not yet been appropriated toward this program. Congress should appropriate at least $15 billion to subsidize several facilities in the United States to meet the end goal of multiple state-of-the-art sources for domestic fabrication.

Recommendation

Recommendation: Double Down on Funding for Research and Infrastructure to Lead the Next Generation of Microelectronics

Four research arms of the U.S. government focused on medium- and long-term microelectronics breakthroughs through engagement with academia and industry are the Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), the National Science Foundation (NSF), and the Department of Commerce. Their suite of existing programs, such as DARPA's Electronics Resurgence Initiative (ERI), are targeting the right research areas but must be expanded by an order of magnitude to achieve the necessary breakthroughs to maintain U.S. competitiveness. Additional funding should support not only research projects, but also the capital-intensive infrastructure for microelectronics development, including the National Semiconductor Technology Center and advanced packaging prototyping programs authorized in the FY 2021 NDAA. In line with the existing focus areas of these programs and the Commission's prior recommendations, funding should pursue breakthroughs in promising technologies such as 3D chip stacking, photonics, carbon nanotubes, gallium nitride transistors, domain-specific hardware architectures, electronic design automation, and cryogenic computing. In particular, funding should prioritize the development of manufacturing equipment and tools to reach 3nm and beyond at production scale. However, this funding should not solely be directed to classical computing technologies. The U.S. government should also support efforts to research and develop hybrid quantum-classical techniques that

leverage noisy intermediate-scale quantum computers. The Commission offers detailed recommendations on this subject in Chapter 16 of this report.

Action for Congress:

- **Appropriate $1.1 billion for semiconductor R&D in FY 2022 and continue increasing funding over the next five years for a total of $12 billion**
    - Congress should appropriate an additional $1.1 billion in FY 2022. Consistent with the amounts in the CHIPS for America Act, this funding should include $400 million for DARPA ERI, $300 million for NSF semiconductor research, and $400 million for DOE semiconductor research. These funding levels should be grown over the following five years to roughly $7 billion per year and $12 billion total. Recognizing it will take time to build capacity among agencies to administer programs at the necessary scale, these amounts should start at funding levels that can be absorbed by agencies and ramped up over time.
- **Appropriate $1 billion in FY 2022 and $5 billion total over five years for the Advanced Packaging National Manufacturing Program.**
    - Novel packaging techniques such as heterogeneous integration and 3D stacking—combined with domain-specific architectures—will be critical to the development of artificial intelligence (AI) as traditional architectures of silicon-based chipsets encounter diminishing marginal performance improvements. Congress should also appropriate $1 billion in initial FY 2022 funding to establish the Advanced Packaging National Manufacturing Program led by the National Institute of Standards and Technology (NIST), as authorized by the FY 2021 NDAA.[8] This funding should be continued through FY 2027 for a total of $5 billion.
- **Appropriate $100 million in FY 2022 and $2 billion over five years to establish the National Semiconductor Technology Center.**
    - A National Semiconductor Technology Center would serve as a microelectronics research hub while also conducting prototyping of advanced semiconductors in partnership with the private sector. Early-stage semiconductor startups currently face difficulties scaling due to the high costs of microelectronics design and fabrication. The incubator component of the center could provide resources to promising, early-stage microelectronics startups while also giving them access to fabrication facilities, design tools, and shared intellectual property (IP) to assist with early-stage development costs. It could also partner with the U.S. International Development Finance Corporation (DFC) to provide loan guarantees to microelectronics firms if DFC's authorities are expanded and extended to rebuild domestic supply chains for a broader range of strategic emerging technologies.[9] This laboratory could grow into a center of expertise in high-performing, trusted microelectronics, ensuring continued U.S. leadership in this field over the ensuing years.

Recommendation

Recommendation: Continue DoD's Trusted Microelectronics Program and Adopt Agile Hardware Development

Semiconductor manufacturing has moved offshore, expanding threat vectors to hardware security and leaving the U.S. government unable to trust sensitive electronic components it needs for defense systems. And while the U.S. government is now recognizing that it

must take steps to adopt modern software practices, there has been less attention on incorporating hardware into the agile development process. Both issues require attention from the Department of Defense (DoD) and other government agencies. The U.S. government needs to inject security and agility into its microelectronics acquisition and development process to leverage the best technology possible for defense systems.

Actions for the Department of Defense:

- **Continue growing the Trusted & Assured Microelectronics Program to include AI-enabling hardware.**
    - DoD's Trusted and Assured Microelectronics research, development, test, and evaluation (RDT&E) funding has grown to more than $500 million annually for advanced component development and prototyping and system development and demonstration.[10] These programs improve access to advanced packaging and testing; support the development of quantifiable assurance and secure design; develop foundry access standards; expand access to non-complementary metal oxide semiconductor state-of-the-art microelectronics; support disruptive R&D; and promote education and workforce development. These are foundational microelectronics capabilities that will also enable the development and application of AI and machine learning (ML) capabilities across national security mission areas. In FY 2021 and beyond, USD(R&E) should expand the program to focus on developing AI-enabling capabilities and apply $50 million of funding toward developing AI multi-chip packages.
- **Shift to a more agile approach to hardware development and procurement.**
    - Just as agile development has transformed software, there is an opportunity to bring agile hardware design practices to speed development cycles, lower costs, and increase performance. Rather than designing through a serial process, the commercial sector has developed best practices to integrate hardware and software development processes concurrently. While DoD has made strides in agile software development, it remains behind the commercial sector in applying these lessons to hardware. Broader adoption of hardware emulation and moving to a common and secure design environment for the chip, package, and board would also accelerate system development and improve security. This requires the combined efforts of USD(R&E) and USD(A&S) to continue improving software acquisition and development practices to incorporate hardware.

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[1] *Sparking Innovation: How Federal Investment in Semiconductor R&D Spurs U.S. Economic Growth and Job Creation*, Semiconductor Industry Association at 2 (June 2020), https://www.semiconductors.org/wp-content/uploads/2020/06/SIA_Sparking-Innovation2020.pdf; *Semiconductor Incentives*, Semiconductor Industry Association at 2 (Oct. 9, 2020), https://www.semiconductors.org/wp-content/uploads/2020/10/Incentives-Infographic-2020.pdf.

[2] Antonio Varas, et al., *Government Incentives and US Competitiveness in Semiconductor Manufacturing*, Boston Consulting Group and Semiconductor Industry Association at 19 (Sept. 2020), https://web-assets.bcg.com/27/cf/9fa28eeb43649ef8674fe764726d/bcg-government-incentives-and-us-competitiveness-in-semiconductor-manufacturing-sep-2020.pdf.

[3] *Id.*

[4] *Id.*

[5] See Chapter 14 of this report for additional details regarding export controls on SME.

[6] Total matching funding will vary based on the number of projects approved but should have a ceiling of at least $10 billion to $15 billion.

[7] S. 3933, 116th Cong. (2020); H.R. 7178, 116th Cong. (2020).

[8] Pub. L. 116-283, sec. 9906, William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, 134 Stat. 3388 (2021).

[9] See the Chapter 16 Blueprint for Action for further details on extending and expanding DFC's loan guarantee program through executive action.

[10] Pub. L. 116-260, Division C, Department of Defense Appropriations Act (2021), https://docs.house.gov/billsthisweek/20201221/BILLS-116RCP68-JES-DIVISION-C.pdf.

Chapter 13 Annex: Executive Order on Microelectronics Strategy

By the authority vested in me as President by the Constitution and the laws of the United States of America, including section 9906 of the National Defense Authorization Act (NDAA) for Fiscal Year 2021 (Public Law 116-283), it is hereby ordered as follows:

Section 1. Findings. The United States relies heavily on imports of certain microelectronics that are vital to the Nation's security and economic prosperity. This dependency on semiconductor imports creates strategic economic and military vulnerabilities to supply chain disruptions for electronics, including adverse foreign government actions and natural disasters. Despite tremendous expertise in microelectronics research, development, and innovation across the country, the United States is limited by a lack of domestically located semiconductor fabrication facilities, especially for state-of-the-art semiconductors. This limitation compounds the risk that the United States may be outpaced in microelectronics design and fabrication. Focusing the efforts of the United States Government, industry, and academia to develop domestic microelectronics fabrication facilities will reduce the Nation's dependence on imports, preserve U.S. leadership in technological innovation, support job creation, strengthen national security and balance of trade, and enhance the technological superiority and readiness of the Armed Forces, which are important consumers of advanced microelectronics.

Section 2. Policy. To maintain the Nation's security and economic prosperity, it shall be the policy of the United States to stay at least two generations ahead of potential adversaries in state-of-the-art microelectronics and maintain multiple sources of cutting-edge microelectronics fabrication in the United States.

Section 3. Establishment of Subcommittee on Microelectronics Leadership.

(a) There is hereby established in the National Science and Technology Council a subcommittee on matters relating to leadership and competitiveness of the United States in microelectronics technology and innovation to be named the Subcommittee on Microelectronics Leadership (Subcommittee).

(b) The Subcommittee shall be composed of the following members:

(i) The Secretary of Commerce, who shall be Chair of the Subcommittee;

(ii) The Secretary of State;

(iii) The Secretary of Defense;

(iv) The Secretary of Energy;

(v) The Secretary of Homeland Security;

(vi) The Director of the Office of Management and Budget;

(vii) The United States Trade Representative;

(viii) The Director of National Intelligence;

(ix) The Director of the National Science Foundation;

(x) The Assistant to the President for Science and Technology;

(xi) The Assistant to the President for Technology Competitiveness;

(xii) The Assistant to the President for National Security Affairs;

(xiii) The Assistant to the President for Economic Policy;

(xiv) The Assistant to the President for Domestic Policy; and

(xv) The heads of other executive departments and agencies and other senior officials within the Executive Office of the President, as determined by the Chair.

(c) Sunset. The Subcommittee shall terminate on January 1, 2031.

Section 4. Functions of the Subcommittee on Microelectronics Leadership. Consistent with applicable law, the Subcommittee shall:

(a) advise the President on matters involving policy affecting microelectronics;

(b) develop, within 270 days of the date of this order, and no less than once every five years thereafter, a National Strategy on Microelectronics Research, Development, Manufacturing, and Supply Chain Security (Strategy), which shall address the following elements:

(i) methods to accelerate the domestic development and production of microelectronics and strengthen the domestic microelectronics workforce;

(ii) methods to ensure that the United States is a global leader in the field of microelectronics research and development;

(iii) activities that may be carried out to strengthen engagement and outreach between Federal agencies and industry, academia, and international partners of the United States on issues relating to microelectronics;

(iv) priorities for research and development to accelerate the advancement and adoption of innovative microelectronics and new uses of microelectronics and components;

(v) the role of diplomacy and trade in maintaining the position of the United States as a global leader in the field of microelectronics;

(vi) the potential role of a Federal laboratory, center, or incubator exclusively focused on the research and development of microelectronics, as described in section 231(b)(15) of the NDAA for Fiscal Year 2017 (as added by section 276 of the NDAA for Fiscal Year 2021) in carrying out the Strategy; and

(vii) such other activities as the Subcommittee determines may be appropriate to overcome future challenges to the innovation, competitiveness, and supply chain integrity of the United States in the field of microelectronics; and

(c) coordinate the policymaking process with respect to microelectronics-related research, development, manufacturing, and supply chain security activities and budgets of Federal agencies and ensure such activities are consistent with the Strategy required by this section.

Section 5. General Provisions. (a) If any provision of this order or the application of such provision is held to be invalid, the remainder of this order and other dissimilar applications of such provision shall not be affected.

(b) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

(c) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(d) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.