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UNITED STATES OF AMERICA

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April 5, 2021

The Honorable Gina Raimondo
Secretary
U.S. Department of Commerce
1401 Constitution Avenue, NW
Washington, DC 20230

Re: Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain; 86 FR 14308; Docket No. BIS-2021-0011

Dear Secretary Raimondo:

The U.S. Chamber of Commerce (Chamber) is submitting this letter in response to the U.S. Department of Commerce's (Department) request for comments regarding risks in the semiconductor manufacturing and advanced packaging supply chain. The Chamber welcomes this review as part of the Biden Administration's Executive Order 14017 on America's Supply Chains (EO), and we appreciate the Administration's efforts to engage closely with the private sector as it identifies policy recommendations and priorities.

Semiconductors arguably represent the world's most important industry as they are the foundation of a wide array of products and services. They enable advancements in artificial intelligence (AI), high-performance computing (HPC), 5G, Wi-Fi, Open RAN, and autonomous systems and importantly power the digital infrastructure needed for remote learning, telehealth, and work-from home. The Chamber's membership includes the entire semiconductor ecosystem (leading edge and mature semiconductor manufacturers, designers, and equipment makers), information and communications technology companies, and a whole host of semiconductor end-users in the healthcare, finance, manufacturing, automotive and agricultural sectors. Our comments are informed by this broad perspective and underscore the criticality of semiconductor technology.

Here are our comments on the specific policy objectives in the EO:

I. Critical and Essential Goods and Materials Underlying the Semiconductor Manufacturing and Advanced Packaging Supply Chain

The industries consuming and producing semiconductors in the U.S. and our allies would be more competitive with the option to choose manufacturers based in the U.S. with local end-to-end supply chain capabilities. The expansions of U.S.- and ally-based facilities announced to date are for wafer production only despite shortages of substrate, packaging, and testing – and a majority of these supply bases are located outside of the country. We encourage the federal government to support a surety of supply of an end-to-end supply chain within the US to support critical industries like defense, healthcare, automotive, and communications.

II. Manufacturing and Other Capabilities Necessary to Produce Semiconductors, Including Electronic Design Automation Software and Advanced Integrated Circuit Packaging Techniques and Capabilities.

In addition to ensuring a robust supply chain of the goods and materials supporting semiconductor manufacturing, the federal government should work with the private sector to diversify its sources of semiconductor manufacturing and to increase capacity in the U.S., and ensure that the U.S. continues to be a global leader in semiconductor research and development. Revitalizing manufacturing, research, development and prototyping of leading edge semiconductors and investing in large-scale missions—like ushering in a silicon manufacturing renaissance—would restore American leadership in advanced manufacturing, secure these vital supply chains, grow well-paying jobs, and ensure our technological long-term national security and economic competitiveness.

The U.S. semiconductor industry has long been the global leader, consistently accounting for 45% to 50% of global revenues, however, the U.S. share of semiconductor manufacturing capacity has dropped precipitously from 37% in 1990 to 12% today. Today, East Asia controls 75% of the global capacity while only 6% of new global capacity is expected to be located in the United States.[1] The concentration of manufacturing capacity in East Asia is no accident. As the United States decreased support for semiconductor manufacturing facilities and basic research development funding, others have been investing heavily. The result is the ten-year total cost of ownership of a new semiconductor fabrication facility (fab) located in the U.S. is approximately 30% higher than in Taiwan, South Korea, or Singapore, and 50% higher than in China—an enormous cost disadvantage considering that the ten-year cost of a state-of-the-art fab ranges between $10 billion and $40 billion, depending on the type of product. As much as 40% to 70% of that cost differential is directly attributable to government incentives.[2]

Such trends will have significant repercussions and demonstrate that maintaining domestic manufacturing capabilities is essential to ensure the U.S. semiconductor industry has a highly resilient, geographically diversified supply chain. Manufacturing and research and development (R&D) are optimized when done in close proximity and will help the U.S. stay at the forefront of further advances in manufacturing-processing technology, architectures, and materials critical for developing the next generations of semiconductors that will make artificial intelligence, quantum computing, and other technological advances possible.

To help increase domestic production capacity, the federal government should provide economic incentives – including grants and tax incentives – to help the U.S. become a globally competitive destination for semiconductor investment, particularly for the most advanced

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[1] Varas, Antonio, Varadarajan, Raj, Goodrich, Jimmy, & Yinug, Falan, *Government Incentives and U.S. Competitiveness in Semiconductor Manufacturing.* September 2020, page 1. https://www.semiconductors.org/wp-content/uploads/2020/09/Government-Incentives-and-US-Competitiveness-in-Semiconductor-Manufacturing-Sep-2020.pdf

[2] *Ibid. Pg. 1.*

technologies that are the foundation for future technology superiority. There are a limited number of companies – including Intel, Micron, Taiwan Semiconductor Manufacturing Company (TSMC), and Samsung – that are at the leading edge of manufacturing semiconductors and focusing on attracting investment from these three will be important. Their semiconductors are foundational to the success of the U.S. technology industry, and expanding their capacity in the U.S. will benefit U.S. consumers, strengthen U.S. national security, create thousands of new high-wage jobs (direct and indirect), and bolster state and federal tax revenues.

In order to manufacture at the leading edge, the U.S. should implement an integrated, collaborative capability between industry, academia, and government in advanced development, prototyping and packaging. This capability exists in Europe and Asia, but not in the U.S., creating a substantial supply chain vulnerability. The National Semiconductor Technology Center (NSTC), as included in the FY21 NDAA, could address this problem for both national security and commercial needs.

Investments should be prioritized at the leading edge of semiconductor technology, while also recognizing the importance of building resiliency of supply of legacy/mature forms of chip architectures. For example, while many semiconductor technologies have migrated to 300mm (12”) wafers to support higher end processing performance, some power management integrated circuits (PMICs) and other semiconductors that are still manufactured using 200mm (8”) wafers. These older fabs support a variety of mixed signal chipsets still in use today, yet there has been no investment in domestic tooling or manufacturing capacity for these nodes in many years. U.S. investment in semiconductor manufacturing should support these wafers as well to enhance manufacturing resiliency across the full portfolio of chipsets used today. There is also a need to explore module package substrate capacity investments, as this also presents one of the leading manufacturing challenges today. It should be part of any investment strategy to coordinate with our foreign allies and other democratic nations to multilaterally advance manufacturing resiliency.

III. The availability of the key skill sets and personnel necessary to sustain a competitive U.S. semiconductor ecosystem, including the domestic education and manufacturing workforce skills needed for semiconductor manufacturing; the skills gaps therein, and any opportunities to meet future workforce needs

The semiconductor industry relies on a highly skilled workforce. It is critical for the federal government to recognize that the United States is behind on both research progress and number of engineers needed to execute developing and maintaining semiconductor manufacturing capabilities. The United States must develop and attract talent in science, technology, engineering, and mathematics (STEM) fields and particularly in semiconductor-adjacent areas, such as electrical engineering, materials science, solid-state physics, and computer science programs. There are currently thousands of job openings throughout the entire semiconductor industry, and at all levels - from technicians to design engineers. Immigration policy will play a key role in maintaining a skilled and robust workforce in the near term.

IV. Risks or Contingencies that may Disrupt the Semiconductor Supply Chain (Including Defense, Intelligence, Cyber, Homeland Security, Health, Climate, Environmental, Natural, Market, Economic, Geopolitical, Human-Rights or Forced Labor Risks):

a. Risks Posed by Reliance on Digital Products that May be Vulnerable to Failures or Exploitation

The semiconductor supply chain is one of the world's most complex, representing over half a trillion dollars in value. The production of a single computer chip often requires more than 1,000 steps passing through international borders 70 or more times before reaching an end customer.[3] Semiconductor supply chains include research and development, production, production inputs and distribution for end use. R&D underpins all production and its inputs.[4] Semiconductor design is the first and foundational step in the supply chain because design involves specification (how the chips operates in the final system), logic design, physical design, and validation and verification.[5] If the semiconductor design is compromised, the semiconductors and all subsequent associated hardware and software will be compromised as well.

b. Risks Resulting from Lack of or Failure to Develop Domestic Manufacturing Capabilities, Including Emerging Capabilities

The United States faces risks presented by the challenge in a validating modern, complex circuit designs. The Biden administration should work with Congress to increase funding and support for programs such as the Rapid Assured Microelectronics Prototypes (RAMP) using Advanced Commercial Capabilities program managed by the U.S. Navy that seeks to ensure access and integrity to advanced commercial semiconductors using quantifiable assurance techniques. Investment should also be placed in developing software supply chain tools that improve the federal government and industry's ability to verify the security of circuit design software, as well as the firmware and software run by these components.

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[3] Syed Alam, Timothy Chu, Shrikant Lohokare, Shungo Saito, and McKinley Baker, "Globality and Complexity of the Semiconductor Ecosystem" (Accenture and Global Semiconductor Alliance, 2020), https://www.accenture.com/_acnmedia/PDF119/Accenture-Globality-Semiconductor-Industry.pdf.
[4] Saif Khan, Alexander Mann, Dahlia Peterson, "The Semiconductor Supply Chain: Assessing National Competitiveness " (Georgetown Center for Security and Emerging Technology, 2021), https://cset.georgetown.edu/wp-content/uploads/The-Semiconductor-Supply-Chain-Issue-Brief.pdf
[5] ibid

V. The resilience and capacity of the semiconductor supply chain to support national and economic security and emergency preparedness, including: (a) manufacturing or other needed capacities (including ability to modernize to meet future needs); (b) gaps in manufacturing capabilities, including nonexistent, threatened, or single-point-of-failure capabilities, or single or dual suppliers; (c) location of key manufacturing and production assets, and risks posed by these assets' physical location; (d) exclusive or dominant supply of critical or essential goods and materials by or through nations that are, or may become, unfriendly or unstable; (e) availability of substitutes or alternative sources for critical or essential goods and materials; (f) need for research and development capacity to sustain leadership in the development of goods and materials critical or essential to semiconductor manufacturing; (g) current domestic education and manufacturing workforce skills and any identified gaps, opportunities and potential best practices; (h) risks posed by climate change to the availability, production, or transportation of goods and materials critical to semiconductor manufacturing; and (i) role of transportation systems in supporting the semiconductor supply chain and risks associated with these transportation systems.

In addition to the supply chain issues discussed above (i.e., general issues with U.S. capacity, research, and security, among others) there are additional areas of supply chain concern of the semiconductor industry.

First, there is an expectation that fabrication capacity won't be able to keep up with customer demand in the near term. Overall semiconductor capacity is projected to have a 6% compound annual growth rate (CAGR) over the next five years. However, demand for semiconductors is expected to have double digit CAGR during that same period.[6] This demand is expected to be principally driven by new and emerging technologies, including AI, 5G, next generation Wi-Fi, cloud platforms, automotive and various consumer electronics categories. Additionally, there is not currently a balanced investment by industry between 8" wafer capacity and 12" wafer capacity. Currently, it is expected that there will be an 8% growth in the foundry capacity for producing 12" wafers over the next five years.[7] However, it is expected that there will be little to no capacity build out for 8" wafers over that same period. These 8" wafers are necessary to produce certain critical components of integrated devices, including power management integrated circuits and metal–oxide–semiconductor field-effect transistors, which could potentially lead to stabilizing or even reducing prices for downstream consumers.

There are additional challenges in the older fabs, including the financial reality that legacy manufacturing typically sees quick depreciation of the assets with low revenue returns for legacy chips. This creates additional challenges to increasing capacity of legacy chip manufacturing despite the expected demand. According to Accenture, "over the past few years, foundries have focused their investments in leading nodes such as 7nm and 5nm because they typically command the best price and are in demand from larger high-tech companies. This has led to relatively lower investment in the older nodes needed by other sectors such as automotive. Thus, when the capacity shortage

[6] IC Insight, "Global Wafer Capacity 2021-2025."
[7] Ibid.

occurred, the impact on older nodes was even greater and difficult to solve by simply moving production to another fab."[8]

Second, the current semiconductor capacity is dependent on a few countries – notably, Korea, Taiwan, and Japan. Further, China continues to build its own capacity – in both semiconductor and raw material production. That said, within these semiconductor-producing countries, there exists foreign availability for chip making, equipment, and materials in the semiconductor industry. However, it is worth noting that in a situation in which there is a disruption, an immediate switch to another location cannot occur. The origin of manufacture of 12" wafers can be segregated by the type of component part:

- Wafers for logic chips (e.g., central processing units (CPUs), graphics processing units (GPUs), etc.) are primarily manufactured in Taiwan, which has the major share of the market (approximately 30%). This market share is largely driven by the Taiwan Semiconductor Manufacturing Company, upon which domestic device manufacturers are highly dependent.

- Wafers for dynamic random-access memory (DRAM) are primarily manufactured in Korea and Taiwan, which collectively have a 70% share of the market. China currently has a market share of approximately 15%. This is predominantly driven by Korean players (e.g., SK Hynix) setting up manufacturing facilities in China. While local Chinese players are emerging on the back of state funds, it remains unclear how these players will navigate technology and intellectual property barrier to further grow. Wafers for NAND chips are principally manufactured in Korea, Japan, and Singapore, which collectively have an approximately 80% share of the market. It is expected that China's share of the market will grow with the emergence of local Chinese suppliers and investment by Korean companies.

The manufacture of 8" wafers is more fragmented, generally due to the presence of smaller scale suppliers in various geographic locations. The largest manufacturing capacity for these chips resides in Taiwan, which has a market share of approximately 20%, and China, which has a market share of approximately 15%. The United States supports a smaller segment, largely driven by foundries owned and operated by Texas Instruments, NXP, Jazz Semiconductor, Skywater Technology, and On Semiconductor.

Third, printed circuit boards (PCBs) – another critical component to the production of electronic products – also have geo diversification challenges. Currently, 80% of the worldwide capacity of PCBs resides in China. Diversification of the PCB production is important but challenging given its environmental impact. Mandating the use of domestic PCBs when there is insufficient supply can be harmful and have unintended consequences. Here, encouraging a move over time to diversified sourcing including allied nations is appropriate.

Fourth, we urge the Biden administration to focus on supporting R&D investments. While in 2019, private sector funding for semiconductor R&D totaled nearly $40 billion, the federal

[8] Alam, Syed, "Chip Shortages Impact for Supply Chain Resiliency." Accenture, March 12, 2021. https://www.accenture.com/us-en/blogs/high-tech/chip-shortages-impact-for-supply-chain-resiliency

government spent only $1.7 billion on core, semiconductor specific R&D (along with an additional $4.3 billion in research in semiconductor related fields).[9] Federal R&D investment is important for our continued competitiveness and economic growth as evidenced by each federal dollar invested into semiconductor research has shown to increase overall U.S. GDP by $16.50.[10] Therefore, we urge the administration to expand R&D incentives to sustain US semiconductor design leadership, including working with Congress to fully fund the CHIPS Act.

Overall, given the challenges noted above, there is a significant need for the Biden administration to develop policies and incentive programs to increase domestic semiconductor and unique raw material capacity and to develop technologies needed to secure U.S. market position in this sector.

VI. Potential impact of the failure to sustain or develop elements of the semiconductor supply chain in the United States on other key downstream capabilities, including but not limited to food resources, energy grids, public utilities, information communications technology (ICT), aerospace applications, artificial intelligence applications, 5G infrastructure, quantum computing, supercomputer development, and election security. Also, the potential impact of purchases of semi-conductor finished products by downstream customers, including volume and price, product generation and alternate inputs.

The potential impact to downstream capabilities if there is a failure to sustain or develop elements of the semiconductor supply chain cannot be overstated. Among other things, critical domestic industries and capabilities are highly dependent on the production of semiconductors, including food production and agriculture, energy and utilities, information communications technology, aerospace, home appliances, artificial intelligence, infrastructure, medical, transportation, and national security and elections, among others.

Given the current concentration of suppliers in a limited number of countries, the United States faces an existential threat to its safety, the health of its citizens, its democratic process, and its ability to support commerce if access to the limited number of foreign production centers is diminished or restricted. Microsoft serves as a case for the potential impact of a supply disruption. Consider the period shortly after widespread lockdowns due to the COVID-19 pandemic. As just one example, at the end of March 2021, for instance, Microsoft Teams set a new daily record of 2.7 billion meeting minutes in one day, up from 900 million minutes just two weeks earlier. In April, that number climbed to 4.1 billion meeting minutes in a single day. Microsoft went to a 24-hour schedule to deploy new hardware to meet this surge in demand. Today, 95 percent of Fortune 500 companies, governments worldwide, and critical infrastructure operators like the power grid and hospitals, all rely on Azure for business continuity. A disruption to the semiconductor supply chain would impact services in these critical sectors.

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[9] SIA Sparking Innovation, https://www.semiconductors.org/wp-content/uploads/2020/06/SIA_Sparking-Innovation2020.pdf

[10] Ibid.

VII. Policy recommendations or suggested executive, legislative, regulatory changes, or actions to ensure a resilient supply chain for semiconductors (e.g., reshoring, nearshoring, or developing domestic suppliers, cooperation with allies to identify or develop alternative supply chains, building redundancy into supply chains, ways to address risks due to vulnerabilities in digital products or climate change).

To ensure a resilient supply chain of trusted and assured semiconductors, Sections 9902, 9903, and 9906 of the William M (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (FY21 NDAA) should be fully funded. Sections 9902 and 9903 are based on the CHIPS for America Act and would establish funds within the Department of Commerce and the Department of Defense (DoD) to onshore the design and manufacturing of semiconductors and to provide critical research, development, prototyping and packaging support for these efforts. While these incentives were authorized in the FY21 NDAA, no appropriations were provided to allow for their execution. These semiconductor incentive programs should be funded in this year's appropriation cycle to begin the process of establishing a domestic trusted and assured semiconductor manufacturing base. Not only will developing a secure supply of semiconductors in the United State address national security concerns, but it will also create highly skilled jobs and encourage the development of a domestic supply chain to support design and manufacturing activities.

Further, the semiconductor industry operates across global supply chains. Export controls are best used strategically, in a manner that is integrated in a unified strategy with other tools of national policy, narrowly tailored to address specific national security concerns and implemented multilaterally with all semiconductor-producing countries. Additionally, the administration should ensure there is adequate funding available to support DoD's Rapid Assured Microelectronics Prototype using Advanced Commercial Capabilities (RAMP) Project for improving DoD assured access to advanced commercial microelectronics technology, particularly those efforts that focus on leading edge semiconductors.

Improving federal coordination for the permitting and environmental review processes to extract and produce minerals fundamental to producing semiconductors – like rare earth elements – is also important. The federal and state permitting process can take up to 10 years and reducing this timeline will help meet the supply that will be necessary for the expected market demand. Bottom line, it is important for the federal government to make timely permitting decisions and ensure appropriate environmental protections, for ore extraction activities under programs like the National Environmental Policy Act.

Finally, tax incentive programs and credits should be considered to attract U.S. companies to make the large capital commitments necessary to enable large-scale domestic manufacturing efforts and the ecosystem that support those efforts, including R&D and design. Offering tax incentives would allow the U.S. to compete against the robust incentive structures offered by other nations to the semiconductor industry to establish a domestic ecosystem. This will further help to quickly close the cost gap and provide certainty for investments in new and expanded fabs, creating thousands of jobs and reversing the decline in America's share of global semiconductor manufacturing.

Conclusion

Thank you for the opportunity to comment on this review. The Chamber welcomes the Biden administration's focus on U.S. supply chain resiliency as the American public should never suffer from shortages of essential goods due to supply chain issues. We can mitigate risks to our supply chains by working with key international partners to diversify our supply chains and stockpiling select products – and we trust that the administration will engage closely with the private sector to ensure that any policy recommendations reject punitive approaches, new trade barriers, and one-size-fits-all solutions.

Sincerely,

Christopher D. Roberti

John Drake