ITI Submission to the Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain

April 5, 2021

The Information Technology Industry Council (ITI) appreciates the opportunity to submit comments to the U.S. Department of Commerce on Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain. ITI is the premier global advocate for technology, representing the world's most innovative companies, including companies directly involved in the semiconductor manufacturing and packaging supply chain as well as downstream consumers and users of microelectronics technology. Founded in 1916, ITI is an international trade association with a team of professionals on four continents. We promote public policies and industry standards that advance competition and innovation worldwide. Our diverse membership and expert staff provide policymakers the broadest perspective and thought leadership from technology, hardware, software, services, and related industries.

While ITI represents the breadth of the technology sector and counts several leading global semiconductor manufacturers amongst our membership, our response is informed by an end-user perspective on the importance of semiconductors to our industry. Semiconductors represent the foundational building blocks of – and serve as a fundamental enabler of – information and communications technology (ICT) products and services across our industry, products and services which in turn are integral to driving economic and innovative activity across most industries and sectors.

We welcome President Biden's *Executive Order on America's Supply Chains* and the Commerce Department's efforts to consult with industry to identify risks in the semiconductor manufacturing and advanced packaging supply chains. Semiconductors are vital to U.S. economic competitiveness and national security, as are many of the technologies that rely on a secure supply of chips, such as 5G, Internet of Things (IoT), Artificial Intelligence (AI), quantum computing, and supercomputer development. During the pandemic, semiconductors have been particularly vital in powering the ICT products and services necessary to drive healthcare and the government's response to COVID-19, as well as enabling millions of students and workers to learn and work remotely. ITI and its members strongly believe that for the U.S. to maintain its technology leadership, we must make investments to promote a strong, skilled advanced manufacturing workforce and strengthen and diversify the semiconductor supply chain, in particular by building U.S. manufacturing capacity. As a start, we welcome President Biden's recent announcement in the infrastructure package calling for $50 billion to fund the *Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Act* provisions to incentivize the domestic manufacturing, research, and design capacity needed to ensure resilient supply chains and sufficient chip supply to power the U.S. economy. We also strongly urge the Administration to cooperate with allies and partners to secure and diversify semiconductor supply chains globally. We stand ready to support these efforts by responding to the request for comment (RFC) and offering our industry's expertise.

Below, we structure our comments into an Executive Summary of our inputs and general recommendations followed by specific responses to the RFC's seven areas of inquiry. Note in our specific response section, we lead with our response to question #7, which asks for our policy

Global Headquarters
700 K Street NW, Suite 600
Washington, D.C. 20001, USA
+1 202-737-8888

Europe Office
Rue de la Loi 227
Brussels - 1040, Belgium
+32 (0)2-321-10-90

info@itic.org
www.itic.org
@iti_techtweets

recommendations.

Executive Summary of ITI Recommendations

- **Strengthen U.S. Semiconductor Leadership to Enhance Economic Competitiveness and Bolster National Security.** Revitalizing high-tech manufacturing of semiconductors in the United States has the potential to drive innovation across many different sectors for decades to come. Semiconductors enable a range of advancements including in AI, quantum computing, medical technologies, and 5G. 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.
- **Provide Funding and Incentives to Enhance Domestic Semiconductor Ecosystem.** ITI encourages the Administration to provide meaningful incentives to increase domestic semiconductor manufacturing capacity of both leading edge and mature node semiconductors and to increase semiconductor R&D funding and prototyping. We encourage the Administration and Congress to provide robust funding for the *CHIPS for America Act* to incentivize investments in the U.S. fabrication supply chain, including key raw materials. These efforts should remain open to all multi-national chip manufacturers that meet the standards and guidelines set forth in the *CHIPS for America Act*.
- **Encourage Greater Investments in the U.S. Semiconductor Ecosystem through Tax Policy.** ITI supports investment tax credits as a critical tool to further incentivize building new and modernizing existing semiconductor manufacturing facilities in the United States. Preserving the ability to deduct R&D expenses and expanding applicability of the Advanced Research Credit (ARC) related to R&D expenses incentivizes long-term investments and enhances American semiconductor competitiveness.
- **Support Semiconductor R&D through Innovation-forward Economic Policies.** ITI encourages the Administration to pursue policies that open markets and minimize burdens on U.S. overseas sales to ensure continued robust R&D funding and market leadership.
- **Strengthen America's Technology Workforce.** Policymakers should support significant funding for science, technology, engineering, and mathematics (STEM) and computer science education, advance legislative proposals for immigration reforms, and adopt other measures that help prepare the domestic workforce and attract the best and brightest from around the world.
- **Enhance Cooperation and Ensure Stability with Global Partners.** ITI supports increased bilateral, regional, and multilateral engagement with partner economies to deepen trade and investment relationships, including efforts to organize tech-sector specific dialogues, increase digital trade partnerships, and enhance regulatory compatibility and reduce barriers to trade.
- **Address Unfair Chinese Trade Practices.** The U.S. should build upon existing workstreams to address expansive Chinese government subsidies and unfair trade practices not adequately managed by existing international trade rules, and advocate for the acceptance of updated rules capable of disciplining unfair subsidization practices.
- **Strengthen Public-Private Partnerships.** ITI encourages the Administration to work with industry to develop a coherent, streamlined and effective long-term approach to address semiconductor supply chain issues in a coordinated and holistic manner. The U.S. Department of Homeland Security (DHS) Supply Chain Risk Management Task Force provides a preeminent model in this regard.

Responses to Specific Questions

We provide answers to all of the seven questions listed in the RFC, leading with our response to question #7, which asks for our policy recommendations and suggested actions, followed by answers to the remaining questions.

7. Policy recommendations or suggested actions to ensure a resilient supply chain for semiconductors

ITI offers several policy recommendations to ensure a resilient semiconductor supply chain:

Strengthen U.S. Semiconductor Leadership to Enhance Economic Competitiveness and Bolster National Security
Revitalizing high-tech manufacturing of semiconductors and bolstering R&D in the United States has the potential to drive innovation across many different sectors for decades to come. However, the United States is "not currently a cost-competitive location for semiconductor manufacturing" and captures only 12 percent of global semiconductor manufacturing capacity – down from 37 percent in 1990.[1] For the U.S. semiconductor industry to remain competitive, and to strengthen the resilience of critical semiconductor supply chains, the Administration should prioritize incentivizing research, development, prototyping, and manufacturing of advanced semiconductors in the United States. Federal investment and incentives to boost domestic semiconductor manufacturing will level the capital expenditure playing field vis-à-vis other nations, enabling firms to build new or expand existing manufacturing capacity in the U.S versus other locations where governments heavily subsidize semiconductor manufacturing infrastructure. Incentivizing semiconductor manufacturing and R&D has the potential to drive innovation across nearly every sector of the economy and is the single most important action in the United States can take to strengthen these critical supply chains.

Fortunately, the U.S. has extensive experience spearheading the development of the most innovative and cutting-edge technologies, and federal support has been critical in setting up the U.S. as a global leader. Other economies have learned lessons from the U.S. and have pursued policies to support and incentivize their own domestic manufacturing industry including through grants, tax credits, and pragmatic investments in the semiconductor space, resulting in concentrated semiconductor manufacturing and the accompanying ecosystem in those regions — notably in South Korea, Taiwan, Japan, and China. Others, like Singapore, Israel, and the European Union are also providing robust incentives to try to attract investments in this strategic sector. They have recognized that leading-edge semiconductors are an expensive, yet critical, technology that will drive their competitiveness in the economy of the future. The current incentive structure in the United States is limited to a patchwork of state-level incentives, which are not cost-competitive.

In addition to supporting the increased production of the final semiconductor product, it is critical to ensure that procurement of the unique key raw materials utilized in the production of semiconductors has robust domestic support as well. Critical components, such as sputtering

---

[1] *"Government Incentives and US Competitiveness in Semiconductor Manufacturing,"* Boston Consulting Group and Semiconductor Industry Association. https://www.bcg.com/en-us/publications/2020/incentives-and-competitiveness-in-semiconductor-manufacturing

targets and high purity chemicals, are a key component of the supply chain and maintaining a leading position globally is key to a robust domestic semiconductor industry. As semiconductor features pass below 10 nm use new wafer production technologies, which include cobalt and ruthenium, the U.S. must strengthen R&D investment if we are to keep pace on the world stage.

As semiconductors are foundational to technologies used in national security contexts, the U.S. needs to ensure a consistent domestic supply that is sufficiently insulated from external shocks to the supply chain, including unique raw materials. Augmenting domestic production of semiconductors, coupled with ensuring the continuity of necessary global supply chains, would make America's semiconductor supply chains more resilient to future crises and ensure the U.S. can supply the advanced chips needed for defense and critical infrastructure.

Provide Incentives to Enhance Domestic Semiconductor Ecosystem

In order to boost domestic production of semiconductors and address long-term supply concerns, and to compete globally in designing and producing increasingly complex state-of-the-art semiconductor components, the U.S. must invest in the semiconductor ecosystem overall. ITI encourages the Administration to work with Congress to prioritize robust funding for the programs and initiatives authorized under the *CHIPS for America Act*, enacted as part of the *FY2021 National Defense Authorization Act* (NDAA). In particular, the *CHIPS for America Act* authorized programs to promote U.S. semiconductor research, design, packaging, prototyping, and manufacturing – each of which plays a fundamental role in strengthening U.S. semiconductor supply chain capacity and global leadership in the semiconductor industry. ITI encourages the Administration and Congress to collaborate to fully fund the *CHIPS for America Act* at the President's request of $50 billion, without distorting the incentives or the semiconductor market by favoring some sectors or applications over others, as a fundamental first step to boost the domestic semiconductor supply chain.

Further, ITI encourages the Administration to ensure the incentives as implemented are accessible to all multi-national chip manufacturers that meet the standards and guidelines set forth in the *CHIPS for America Act*. This is critical as only three companies in the world (Intel, Samsung, and TSMC) currently manufacture at the leading edge. Additionally, we encourage Congress and the Administration to advance semiconductor development through robust funding of the Endless Frontier Act and USA Telecom Act to ensure the U.S. sustains leadership in the semiconductors driving emerging technologies.

Finally, any actions taken by the Administration to address the short-term semiconductor supply chain imbalance should minimize market distortions. The government should not interfere in the market allocation of supply, even in the short-term. Picking winners or losers by prioritizing certain industries over others would undermine ongoing market efforts to build resilience into supply chains and make it more difficult for companies to adapt to meet market needs. To the extent the U.S. considers guidelines for allocation in the event of an extreme shortage, it should look to the Cybersecurity and Infrastructure Security Agency's (CISA) Guidance on Essential Critical Infrastructure Workers as a model. To address the issue long-term through a more sustainable approach, the U.S. government should adopt policies such as those above that will incentivize increased domestic chip production at all nodes to ensure all industries have ample access to semiconductors, grounded in the SECURE Technology Act's requirement that the U.S. government identify legal, regulatory, or policy levers to incentivize industry adoption of supply chain best practices.

Encourage Greater Investment in the U.S. Semiconductor Ecosystem through Tax Policy
Ensuring a competitive domestic tax environment is crucial to incentivizing semiconductor manufacturing, R&D, and securing unique raw materials in the United States. U.S.-based semiconductor industry R&D investments are roughly one-fifth of industry sales, while annual spending on new property, plant, and equipment (capital expenditures) has averaged between 8 and 20 percent of sales revenues industry-wide.

ITI supports investment tax credits (ITCs) as a critical tool to further incentivize building new and modernizing existing semiconductor manufacturing facilities in the United States. ITCs would be an immediate and measurable step the United States could take, and by providing a credit in the tax code that is open to any company that makes an investment, the U.S. would provide significant opportunity for domestic investment. Such tax incentives should be accessible to all multi-national chip manufacturers that meet the standards and guidelines set forth in the *CHIPS for America Act.*

Further, ITI encourages the Administration and Congress to ensure companies can fully expense R&D costs in the year such costs are incurred. Since 1954, companies across the industry spectrum have been able to expense R&D costs in the year they are incurred. However, beginning in 2022, companies will be required to amortize these expenses over five years, which will further detract from the United States' ability to compete for R&D dollars. In addition, the Advanced Research Credit (ARC) offers a narrowly targeted incentive for R&D efforts linked to semiconductors in the United States, better enabling companies to sustain U.S. design leadership while attracting manufacturing capacity. Preserving the ability to expense R&D costs in the year they are incurred and expanding the ARC related to R&D expenses incentivizes long-term investments in innovation and technological breakthroughs, supports high-paying U.S. jobs and American competitiveness, and ensures the U.S. remains the world leader in innovation.

Support Semiconductor R&D through Innovation-forward Economic Policies
Policies that decrease companies' global sales eliminate a major funding stream for companies' foundational R&D activities. The vast majority of demand for U.S. semiconductors is outside the United States. Approximately 80 percent of U.S. industry revenues come from sales to export markets, making semiconductors one of the nation's top exports. The ability for U.S. innovators and manufacturers to not only participate but to hold leading positions in the global marketplace is key to facilitating the cycle of private-sector R&D investments, and this leadership is significantly supported by revenues from sales to a diverse customer base in overseas markets. Unless there is a clearly articulated legitimate national security concern with a tight nexus to sales activity, preventing sales to any overseas markets, including China, undercuts U.S. R&D investments and competitiveness. ITI encourages the Administration to pursue policies that open markets and minimize burdens on U.S. overseas sales to ensure continued robust R&D funding and market leadership.

Strengthen America's Technology Workforce
The semiconductor industry requires workers with highly specialized skills. Maintaining an equipped and trained domestic workforce is key to ensuring a resilient semiconductor supply chain in the United States. While the semiconductor industry currently employs approximately 240,000 workers in various positions, ranging from manufacturing to R&D, the Bureau of Labor Statistics

anticipates that the industry will continue to face strong demand for highly skilled workers despite automation trends within the sector.[2]

The United States must prioritize investing in the domestic workforce, including ensuring that the country will have an adequate talent pool with necessary advanced manufacturing skills to meet future demand. Policymakers should support significant funding for science, technology, engineering, and mathematics (STEM) and computer science education, which should consist of technical training and new advanced hardware for teachers; expanded access to high-quality instructional materials and rigorous STEM and computer science coursework; hands-on practical experience for students; and effective regional partnerships. Moreover, policymakers must ensure that all students have access to high-caliber STEM and computer science education, including underrepresented minorities and girls. It is also imperative to support increased funding and focus on training/upskilling programs in STEM and computer science through partnerships and other initiatives to facilitate placement of U.S. workers into digitally resilient jobs, including those within the semiconductor industry. Additionally, it is important to note as manufacturing evolves so will its workforce. At the moment, manufacturing executives have identified the top skills necessary for the future advanced technological workforce to thrive, including technology/computer skills, digital skills, programming skills for robots/ automation, working with tools and an array of technology and critical thinking skills.

The Administration should also support solutions that allow companies to address their labor shortages today. Foreign talent is essential to the U.S. semiconductor industry. For instance, an estimated 40 percent of high-skilled semiconductor workers were born abroad.[3] Consequently, policymakers should support immigration reform that successfully meets the demands of a globally competitive, digital economy by updating the H-1B visa program. The Administration should support reforms that ensure that the number of available H-1B visas adjust to meet market demands; promote additional protections for nonimmigrant employees such as H-1B portability; provide funding for domestic STEM education and training programs; and support the H-4 visa program.

Furthermore, the Administration should advance legislative proposals that reform the employment-based visa program, including reforms which increase the overall number of employment-based immigrant visas available for applicants, as well as their spouses and children, such as through the recapture of unused green cards to help reduce application backlogs; eliminating arbitrary per-country caps through legislation; and exempting STEM university graduates with advanced degrees from additional employment-based visa numerical limitations.

Lastly, foreign students are essential to the competitiveness of the U.S. semiconductor industry as they account for approximately two-thirds of graduate students in electrical engineering and computer science at U.S. colleges and universities – top recruitment fields for domestic semiconductor companies. It is important to note that American student enrollment in semiconductor-related graduate programs has remained consistently at 90,000 students since 1990, while during the same period, the number of enrolled international students within these fields has tripled from 50,000 to 140,000.[4] As such, policymakers should support policies aimed at

---

[2] Semiconductors: U.S. Industry, Global Competition, and Federal Policy. October 2020. https://fas.org/sgp/crs/misc/R46581.pdf

[3] *Id*.

[4] *Id*.

ensuring these students can contribute to the U.S. economy following graduation, including the optional practical training (OPT) and STEM OPT programs.

Enhance Cooperation and Ensure Stability with Global Partners

The semiconductor supply chain – comprised of research, design, advanced development, prototyping, manufacturing, assembly, test, packing, and distribution – is complex and global. Geographic diversification has become critical to the global competitiveness of U.S. firms, as it lowers costs, promotes efficiency and productivity, enables access to top global talent and growing customer bases, and mitigates supply chain risks. Companies often spend months if not years negotiating contracts with suppliers, planning manufacturing processes in line with rigorous quality controls, packaging and testing product security and efficiency, and providing customized services to clients around the world.

The U.S. should work with partners and allies such as the EU, Japan, South Korea, Taiwan, and others in the Asia Pacific and Latin America to minimize damaging interruptions and ensure stability of the global semiconductor supply chain. Such efforts could include the convening of formal supply chain reviews with allies and building upon existing efforts to ensure that market access barriers do not present impediments to the efficient functioning and resiliency of global supply chains. Acknowledging the complexity, interconnectedness, and significant investment required to operate global semiconductor supply chains, this kind of engagement should seek to better enable firms to carefully calibrate their supply chains, maximize time-to-market, and account for other considerations that enable them to remain globally competitive. ITI strongly encourages the Administration to keep these global competitiveness considerations in mind and coordinate with foreign governments to ensure the stability of the global semiconductor supply chain, including by ensuring alignment on broader strategic objectives.

Moreover, given the fact that several Asian economies are of central importance to evolving global ICT supply chains, their roles as growing hubs for trusted supply chain partners continue to be crucial. Alongside other structural factors, recent U.S.-China trade tensions have accelerated the diversification of supply chains in the Asia Pacific region as companies have sought to move supply chains to ensure that they are not overly reliant on any one supplier or geography. ITI therefore supports increased bilateral, regional, and multilateral engagement with partner economies aimed at deepening trade and investment relationships and addressing any unintended trade barriers that restrict supply chain resilience. This engagement could include efforts to organize tech-sector specific dialogues, increase digital trade partnerships, enhance regulatory compatibility, and reduce barriers to trade.

Address Unfair Chinese Trade Practices

From China's 2014 National IC Plan, to Made in China 2025, to the September 2020 14th five-year plan's comprehensive policies to grow the third-generation semiconductor industry for self-reliance, China has systematically implemented policies aimed at fueling the rise of Chinese semiconductor companies – often times leveraging expansive industrial subsidies – to compete directly with U.S. and other leading firms based in market economies. Together, these policies amount to more than $150 billion in government subsidies intended to position China as the global leader in semiconductors. Though such spending has yielded mixed results and China still lags behind its competitors in advanced semiconductor development and production capability, subsidization has created undesirable effects for the global semiconductor supply chain and distorted fair trade and investment practices.

To encourage innovation and fair competition in the global semiconductor market, the U.S. should build upon existing workstreams to address China's unfair trade practices not adequately disciplined by existing international trade rules. Beyond expansive government subsidies and state-supported acquisitions, such practices also include broad market access and data restrictions. The U.S. has already undertaken work through trilateral engagement with the EU and Japan to facilitate agreement on necessary updates to international trade rules governing industrial subsidies and state-owned enterprises (SOEs). Moving forward, the United States should extend these efforts to ensure all government/public subsidies related to semiconductor industries are notified and terminated in cases of non-compliance with international norms. In addition, through plurilateral and multilateral engagement, alongside direct bilateral engagement with China, the U.S. should advocate for the acceptance of updated rules capable of disciplining unfair subsidization practices employed by China with the explicit aim of broadening their Chinese firms' global market share in the semiconductor and other emerging technology sectors.

U.S. policies should also be reviewed with a view to identifying market access barriers that inhibit developing domestic manufacturing capacity. Domestic manufacturing capacity will necessarily rely on globally sourced component supplies, including components on which import tariffs are currently assessed. We encourage the U.S. to establish benchmarks for the phased rollback of tariffs imposed under Section 301, prioritizing removal of all tariffs on semiconductor components, which disincentivize the creation of a sustained American manufacturing base.

Strengthen Public-Private Partnerships
Public-private partnerships and other multistakeholder approaches are essential to protect the semiconductor supply chain. We believe government and industry must work together to achieve the trusted, secure, and reliable global semiconductor supply chains that are paramount to protecting national security and supporting innovation and economic growth. In particular, the U.S. DHS/CISA ICT Supply Chain Risk Management Task Force provides a preeminent model for a public-private partnership vehicle. It serves as the center of gravity for all U.S. stakeholders, allowing for a holistic view of supply chain risk and convening industry expertise alongside government experts to offer policy recommendations for strengthening U.S. supply chain security. ITI welcomes the Commerce Department's role in undertaking an analysis of the semiconductor supply chain as a part of its broader effort to undertake, with DHS, a strategic review of the ICT industrial base supply chain and encourages the Administration to work with industry to develop a coherent, streamlined, holistic, coordinated long-term approach to address ICT supply chain security, which will ultimately prove most effective in addressing both national security and U.S. competitiveness. Additionally, we appreciate Section 9903 of the FY2021 NDAA, which directs the U.S. Department of Defense (DoD) to establish a public-private partnership consortium to secure microelectronics manufacturing and R&D facilities.

1. ***Critical and essential goods and materials underlying the semiconductor manufacturing and advanced packaging supply chains***

ITI supports the U.S. government's exploration of options to secure supply chains for materials and inputs necessary for the production of semiconductor wafers, such as substrate materials and photoresist chemicals, where production is concentrated in Asia. In particular, many photomask-makers are not U.S.-based. While there are some U.S.-based options, they are either seen as less capable or otherwise very expensive. For metal layers, some ITI members rely on a steady supply of gold, platinum, and tungsten. For substrates, some ITI members rely on gallium and indium, especially from Japan.

U.S. electronics industrials who both consume and produce semiconductors in the U.S., would like the ability to choose between U.S. manufacturers with end-to-end supply chain capabilities locally. Expansions announced to date are wafer only. Substrate and package/test are still in short supply and a majority of the supply base is located outside of the United States. Building the surety of supply of an end-to-end supply chain within the United States would support U.S. industrial companies in supporting critical areas like defense, fire, medical, auto and communications.

2. ***Manufacturing and other capabilities necessary to produce semiconductors, including electronic design automation software and advanced integrated circuit packaging techniques and capabilities***

The United States leads the world in activities that are more R&D-intensive such as chip design and advanced manufacturing equipment. Fabrication, however, is currently led by East Asian manufacturers due in large part to significant government incentives that U.S. domestic manufacturers do not have access to. For example, the advanced node foundry leadership in the U.S. has declined over the last decade. GLOBALFOUNDRIES announced in 2018 that they would stop investing in state of the art (SOTA) FinFET nodes, leaving only three companies to pursue SOTA nodes and associated manufacturing capabilities. If the United States is to compete globally in this highly competitive industry, government support through incentivization is going to be critical.

Additionally, the cost of semiconductor manufacturing has grown exponentially over the past several years, significantly increasing the amount of resources it takes to maintain leadership in this space. Successfully developing and manufacturing a leading edge fabrication facility in the United States is estimated to cost at least $12 billion and as much as $35 billion.[5]

We also encourage the Administration to address growing capacity and capability shortfalls in U.S. radiation testing infrastructure by increasing and stabilizing funding for maintaining and upgrading proton and heavy-ion accelerator facilities to restore resilience in national testing capabilities. In 2017, a Presidential Determination[6] identified radiation-hardened microelectronics and radiation test and qualification facilities as assets central to national defense and the U.S. space industrial base. Please see ITI's detailed responses for the capacity and capabilities shortfalls impact on the space industrial base in question 6 below.

We have seen adversarial nation-states providing significant funding and/or subsidizing the semiconductor industry, which serves to offset private investment and creates an unlevel playing field for investments in building semiconductor capacity in the United States. We addressed this issue and provided further suggestions in our policy recommendations in response to question 7.

3. ***The availability of key skill sets and personnel necessary to sustain a competitive U.S. semiconductor ecosystem***

There are several risks in the area of personnel and skill sets. First, designing chips is one of the most complex scientific processes and it requires engineers and scientists with deep knowledge in

[5] Electronics Weekly.com. TSMC Said to be Planning $35 bn Arizona Gigafab. March 2021.
[6] Presidential Determination No. 2017–08 of June 13, 2017

material science, applied physics, computer science and electrical engineering. The advanced level of education required places a major constraint on workforce development and availability within the U.S. Second, there are constraints on the ability to employ talent globally, including overly broad export controls that slow down license processing and immigration rules that make it difficult to put globally skilled individuals to work in U.S. facilities. While there has been investment in the U.S. microelectronics industry through DoD, no corresponding program to grow talented semiconductor manufacturing professionals has been developed and adding the workforce piece under this DoD program is critical. A path is needed for top engineering students to continue to excel and apply their degrees at U.S.-based microelectronics and semiconductor companies. There are creative ways to increase visibility of the semiconductor industry to undergraduate STEM students, such as an advertising program that highlights the semiconductor industry as a strong career path. ITI provided further suggestions regarding this topic in our policy recommendations in response to question 7.

4. 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):

In general, diversified production and supply chains are often a source of resilience for firms in an adverse environment. Companies with diversified supply chains are better able to adjust to external supply chain shocks to keep production and shipments online. However, the semiconductor supply chain is vulnerable to some specific weaknesses as a result of industry consolidation and specialization, which has led to more concentrated groups of upstream suppliers (equipment and materials) selling to more concentrated groups of customers (chip producers). We encourage the U.S. government to work with global partners to strengthen supply chain resilience and mitigate risk. Below are a few top-of-mind risks and contingencies that can disrupt the semiconductor supply chain:

- **Climate/Environment.** Semiconductor fabs require unique and specialized resources to continue operating at capacity and meet the national security and consumer demands of semiconductor and electronics around the world. Availability and cost of essential resources such as electricity and water can significantly impact semiconductor production. Energy grids across the U.S. and around the world are increasingly vulnerable to severe weather events caused by climate change. This was recently demonstrated in Texas, where unprecedented weather conditions impacted electricity production and forced the shutdown of several chip manufacturing plants in the Austin area. This exacerbated an already existing automotive supply chain shortage. The risk of grid failure and any rising cost of electricity or water is a challenge facing U.S. chip manufacturers.
- **Natural Disasters.** There are a number of historical examples of natural disasters impacting semiconductor supply chains and chip production. These include single factory failures due to fires or flooding (e.g., 1993 Sumitomo Chemical factory explosion that impacted 60 percent of global supply of epoxy resin) or larger natural disasters such as earthquakes, hurricanes, or tsunamis. The Japanese earthquake/tsunami in 2011 impacted 25 percent of worldwide production of silicon wafers and 75 percent of the global supply of hydrogen peroxide.
- **Health.** At the beginning of the COVID-19 pandemic, governments around the world closed borders, implemented quarantines, suspended non-essential activities, and imposed

restrictions on movement. This caused a number of supply chain disruptions and supply/demand imbalances that are continuing to contribute to significant supply shortages.

- **Geopolitical**. Semiconductor companies are facing increasing risks of supply chain disruption resulting from geopolitical conflict and trade tensions. Geopolitical risks include unilateral tariffs, non-national security-based export restrictions, or trade blockades as a result of conflict or war. The impacts emerging from these types of risks include 1) high costs of shifting production and investment to alternative locations to reduce vulnerability to punitive policies that competitors in other regions do not face; 2) an inability to access essential goods or materials for production; 3) loss of sales to global competitors that do not face similar restrictions; and 4) loss of market leadership as U.S.-based companies are "designed out" of supply chains as device-makers proactively diversify suppliers to reduce exposure.

- **Regulatory.** The U.S. regulatory efforts that place constraints on the semiconductor supply chain or result in barriers that discourage foreign companies from pursuing opportunities with technology companies in the United States, such as the Securing the Information and Communications Technology and Services (ICTS) Supply Chain Interim Final Rule, can amplify risks of supply chain disruptions particularly where non-U.S. companies with even the most tenuous ties to "foreign adversaries" will face significant uncertainty in pursing transactions in the United States where there is a risk the transaction could be unwound.

a. Risks posed by reliance on digital products that may be vulnerable to failures or exploitation;

There are a variety of risks that stem from reliance on digital products that may be vulnerable to failures and/or exploitation.

The reports developed by the ICT Supply Chain Risk Management Task Force Working Group 2 focused on Threat Evaluation identified a wide range of supplier-related threats in year one, and catalogued threats related to ICT products and services in year two. These reports may serve as a helpful resource to the Commerce Department as it undertakes its analysis of the semiconductor and advanced packaging supply chains.[7] The Working Group bucketed these threats into a series of threat categories related to the ICT supply chain, including suppliers, products, and services, and proposed mitigating measures to address identified threats.

We encourage the Commerce Department to consider all of the threat categories identified in the report, which looks at threats from a variety of vantage points and which all touch upon the risk of relying upon products that may be subject to failure and/or exploitation. The insertion of counterfeit parts, for example, could have a significant impact on products and services provided to downstream customers, especially if a trusted or qualified component is replaced with a counterfeit product from an untrusted or unqualified source. Such exploitation can result in several different outcomes, ranging from creating an unwanted function to inserting compromised components into organizational systems to embedding hardware or software threats into a product. Adversaries may also be able to leverage compromised components to launch an external attack on systems, gain

[7] ICT Supply Chain Risk Management Task Force Threat Evaluation Working Group: Threat Scenarios. January 2021. https://www.cisa.gov/sites/default/files/publications/ict-scrm-task-force-threat-scenarios-report-v2.pdf

unauthorized access to equipment or systems, or otherwise exploit such vulnerabilities to exfiltrate information and/or data.

b. *Risks resulting from lack of or failure to develop domestic manufacturing capabilities, including emerging capabilities;*

There are also risks associated with a lack of or failure to develop domestic manufacturing capabilities, including – most particularly – that the failure to diversify and add resilient capacity to the current supply chain, particularly at the advanced node level, increases the vulnerabilities of supply chains to disruption from a whole range of risk factors, including natural and geopolitical. In addition, there are other risks or contingencies that may disrupt the semiconductor supply chain. Below, we elaborate on risks in several areas:

- ***Chip Design and Verification.*** Presently, design and verification are only made possible by electronic design automation (EDA) software, which is at the heart of the microelectronics. EDA software has enabled "virtual" design, modeling, and verification of microelectronics chips for the last 35+ years. See above for additional information that may be useful for Commerce to consider in the context of this software, particularly specific threats that may jeopardize the security of this software and/or the complex methodologies required to use the software.

  The United States also faces risks presented by the challenge in validating modern, complex circuit designs. To combat this risk, the U.S. government should ensure increase funding and support for programs such as the Rapid Assured Microelectronics Prototypes (RAMP-C) 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 U.S. government and industry's ability to verify the security of circuit design software, as well as the firmware and software run by these components.

- ***Mask Creation.*** This is where the virtual design starts to become physical. There are quality and security risks that may emerge during this phase of design. When design and verification are complete, the design is advanced to mask creation. Masks are used in lithography to transfer design intent on to a wafer by physically locating and specifying the exact shapes (polygons) of the various materials that are used for semiconductor production. The first step in mask creation is the post-tape out flow (PTOF), however, malicious cyber-attack could occur in the PTOF undetected, and the malicious circuit would be transferred to the mask. There is a need for comprehensive security solutions to be applied to the mask process, state-of-the-art (SOTA), and legacy fabs in the U.S. Trusted and assured microelectronics supply chains must eventually require more security for mask creation and usage in semiconductor fabs, which involve both EDA software, manufacturing software and cleanroom production machinery. Incentive or subsidy programs should be established to help enable these solutions.

- ***Fabrication & Lithography Systems.*** SOTA technology nodes are very costly to develop as previously mentioned. This presents risks and/or inhibits developing a strong U.S. supply chain as most of the companies investing and developing SOTA tech nodes are based outside of the United States. In addition, securing the equipment/tool needed for lithography systems and technologies that is crucial to print circuit patterns onto silicon wafers is another key. Those lithography equipment manufacturers supply to all the world's major chipmakers and play key roles in securing the semiconductor supply chain and the future of digital advancement.

- ***Packaging, Test & Validation***. For SOTA chip packaging with very high density, only one integrated device manufacturer (IDM) and none of the top 25 outsourced semiconductor assembly and test (OSAT) manufacturers do their manufacturing in the United States. Much of the globe's packaging capacity is located in the Asia Pacific region. There are additional security risks in packaging that should be considered, especially in multi-chip packaging (very tight integration of multiple chips into a single "package"). Packaging and integration substrates like silicon interposers and other organic substrate materials with very dense metal line/space capabilities are needed. Ultra-precision assembly machines and capabilities are also needed.

  Configuration/program software, integration and testing, and operations and maintenance are system-focused areas that are also of concern. As the microelectronic devices developed above are configured and integrated into their final products or otherwise introduced into operation by their customers, there are risks associated with each of these areas.

- ***Raw Material Supply – Sputtering Targets and High Purity Etching Chemicals (SOTA).*** SOTA nodes require highly precise and engineered sputtering targets that are only produced by a limited set of manufacturers, of which there is only one domestic producer remaining. Ensuring that there is a robust program for continued investment in R&D and manufacturing to advance the development of next generation nodes is critical to maintain a resilient and robust supply chain.

  Additionally, the requirements of high purity etching chemicals continue to increase as SOTA nodes become ever smaller. This is requiring an escalating level of investment to support the new quality requirements. Domestic production is limited and at risk due to the high investment costs. Ensuring that there is adequate support for the necessary investments to maintain domestic supply is critical to ensure a fully robust supply chain.

- ***Geographic Location.*** Some ITI members' critical partners are situated in the Silicon Valley/Bay area in California. There is a large variability of earthquake hardiness. Also, some precious metals are largely available from nations that might be perceived as unfriendly to the United States. Substitutes are impossible in some cases (e.g., the need for a particular metal is driven by the reality of pure physics so switching to another metal is not possible), therefore posing a challenge to the United States.

5. The resilience and capacity of the semiconductor supply chain to support national and economic security and emergency preparedness, under which there are a series of questions related to manufacturing capacity, gaps in manufacturing capabilities, location of key manufacturing and production assets, exclusive of dominant supply of critical or essential goods from unfriendly nations, availability of substitutes, need for R&D, the role of domestic education and transport systems, and risks posed by climate change

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

- **Growing Customer Demand**. There is an expectation that fabrication capacity will not be able to keep up with customer demand in the near-term. Overall semiconductor capacity is projected to have a 6 percent 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.[8] This demand is expected to be driven by emerging technologies, including 5G, cloud, automotive and various consumer electronics. Additionally, currently there is not a balanced investment by industry between 8-inch wafer capacity and 12-inch wafer capacity. It is expected that there will be significant growth in the foundry capacity for producing 12-inch wafers over the next five years,[9] and there will be little to no capacity build out for 8-inch wafers over that same period. These 8-inch wafers are necessary to produce certain critical components of integrated devices, including power management integrated circuits and metal–oxide–semiconductor field-effect transistors.

- **High Dependency on East Asia**. As noted elsewhere, the current semiconductor capacity and key raw materials is dependent on a few countries – notably, South Korea, Taiwan, and Japan for certain manufacturing as well as some equipment and materials. At the same time, China continues to build its own capacity. Looking specifically at wafers, the origin of manufacture of 12-inch wafers can be segregated by the type of component part including: 1) wafers for logic chips (e.g., central processing units (CPUs) and graphics processing units (GPUs)) are primarily manufactured in Taiwan, which has the major share of the market; 2) wafers for dynamic random-access memory (DRAM) are primarily manufactured in South Korea and Taiwan, which collectively have a 70 percent share of the market. China currently has a market share of approximately 15 percent. 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; 3) wafers for NAND chips are principally manufactured in South Korea, Japan, and Singapore, which collectively have an approximately 80 percent share of the market. It is expected that China's share of the market will grow with the emergence of local Chinese suppliers and foreign investments. The manufacture of 8-inch 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 percent, and China, which has a market share of approximately 15 percent. 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; 4) printed circuit boards (PCB) – another critical component besides silicon to the production of semiconductors – also have geographic diversification challenges. Currently, 80 percent 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.

- **Supply of Legacy Nodes.** A U.S. semiconductor strategy should prioritize leading-edge semiconductor technology, while also recognizing the importance of building resiliency of supply of less sophisticated forms of chip architectures. For example, while some

[8] Source: IC Insight, "Global Wafer Capacity 2021-2025."
[9] Ibid.

semiconductor technologies have migrated to 300mm (12-inch) wafers to support higher-end processing performance, there are a variety of power management integrated circuits (PMICs) and other semiconductors that are still manufactured using 200mm (8-inch) nodes. 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 nodes 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. Additionally, the Cyberspace Solarium Commission recommended that the U.S. be able to meet a "minimal viable manufacturing capacity" for national and economic security and resilience. Semiconductors manufactured in advanced process nodes that are no longer state of the art remain vital to the U.S. microelectronics supply chain, but manufacturing capacity for these nodes is heavily concentrated outside the U.S. The U.S. government should coordinate with allies to multilaterally encourage the resiliency of the supply chain across the spectrum of semiconductors from mature to the state of the art.

- **Definition for Resiliency.** ITI believes the Administration would benefit from further engagement with industry and other stakeholders to develop a working definition for "resiliency" as it relates to the semiconductor supply chain. If the Administration is seeking to improve resiliency in the semiconductor supply chain, we must first understand what resiliency looks like, especially as it relates to the different stages of the semiconductor lifecycle. The EO reiterates the need for "resilient, diverse, and secure supply chains." Perhaps most importantly, it is critical to recognize that a more resilient supply chain does not inherently mean a supply chain that is entirely located inside the United States. Instead, the COVID-19 pandemic has further demonstrated that – as noted in the EO – resiliency requires the deployment of multiple, ongoing initiatives that provide for coverage in times of uncertainty but do not introduce new requirements that reduce global competitiveness. However, the opportunity to further build out strength in the domestic supply chain would add to the resiliency of the overall network. As mentioned earlier, much of the supply chain for semiconductor manufacturing is currently out of Asia. The Administration should find ways to encourage domestic production where reasonable of key sputtering targets and high purity chemicals which are unique in their capacity in the United States and are essential to semiconductor production. ITI's comment opens with this sentiment and it bears repeating: the ability for U.S. innovators and manufacturers to participate in the global marketplace is key to facilitating the cycle of private-sector R&D investments, which is made possible by revenues from sales to a diverse customer base in overseas markets. Therefore, any action taken to provide for more resilient supply chains must consistently bear in mind the potential impacts on the ability of firms operating in the United States to engage with global markets, reinvest in R&D, design, and manufacturing capacity, and compete globally.

6. 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 of semiconductor to downstream capabilities if there is a failure to sustain or develop elements of the semiconductor supply chain cannot be overstated. Most, if not all, electronic items use and rely upon semiconductors. This reliance on chips underscores the need to proceed cautiously when the effect of a certain policy will be to remove or impair global capacity. Among other things, critical domestic industries and capabilities are highly dependent on the production of semiconductors, including food production and agriculture, energy and utilities, ICT, aerospace, AI, infrastructure, medical, transportation, 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. A disruption to the semiconductor supply chain would impact services in these critical sectors. Below, ITI includes one example for the space sector:

- **Space Innovation.** We have observed that in the past few years there were capacity and capability shortfall of domestic radiation testing facilities, especially proton and heavy ion testing. Increasing and stabilizing funding for maintaining and upgrading proton and heavy-ion accelerator facilities to restore resilience in national testing capabilities is essential to empower U.S. innovation and capability in space. Existing U.S. heavy ion radiation test facilities required to test radiation-hardened semiconductor chips cannot meet current or future "single event effects" (SEE) test demand: "There are fewer than half a dozen accelerator laboratories that can produce ion beams with sufficient ion species and energies to meet the needs of SEE testing. These facilities are heavily used because they serve the nuclear physics research community, and the entire U.S. governmental SEE testing community (including the National Aeronautics and Space Administration (NASA), DoD, the Department of Energy (DOE), and other government agencies), and an increasing number of commercial enterprises eager to take advantage of business opportunities offered by access to space. With the many users competing for time, it is usually necessary to book beam time well in advance, with wait times."[10] Current heavy ion accelerators for SEE testing at U.S. universities and DOE labs have limited capacity and capability, and the supply and demand gap is expected to grow more acute over the near-term horizon. Unpredictable funding creates unstable operations at test facilities, which has national security implications. Increasing and stabilizing funding for maintaining and upgrading proton and heavy-ion accelerator facilities to restore resilience in national testing capabilities is essential to empower U.S. innovation and capability in space.

[10] Testing at the Speed of Light: The State of U.S. Electronic Parts Space Radiation Testing Infrastructure (2018), National Academies of Sciences, Engineering, and Medicine 2018. https://www.nap.edu/catalog/24993/testing-at-the-speed-of-light-the-state-of-us