IEEE-USA

POSITION STATEMENT

STRENGTHENING THE DEFENSE MICROELECTRONICS INDUSTRIAL BASE

Adopted by the IEEE-USA Board of Directors (June 2024)

IEEE-USA strongly supports the strengthening of the defense semiconductor microelectronics industrial base.

Semiconductor microelectronics and computers are ubiquitous and essential to economic security and national defense. Microelectronic chips are critical components in defense command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) and weapon systems, as well as civil and defense infrastructure systems. The nation, and particularly the Department of Defense (DoD), needs to have an assured supply of advanced microelectronic chips, in peacetime and wartime. DoD depends entirely on the private semiconductor industry for this supply. The semiconductor industry, although originally established by the DoD, for several decades has gradually moved offshore to mostly Asian countries, including for fabrication, testing, and packaging. The offshoring of semiconductor manufacturing, together with geopolitical instability, presents serious risks in the microelectronics supply chain. To mitigate the risks in the supply chain and to secure the supply of defense microelectronics, it is necessary to rebuild and strengthen the defense microelectronics industrial base to sustain legacy components, form a domestic capacity for advanced nanometer chips, and innovate for future advanced capability needs.

In addition to the recommendations in the Federal Support for Advanced Microelectronics Manufacturing, Research & Development Position Statement, IEEE-USA recommends all the stakeholders in defense microelectronics work together to:

1. Develop and implement a strategy to mitigate the risks in the microelectronics supply chain, including semiconductor materials and chips, to secure the supply of defense microelectronics.

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2. Streamline regulatory processes to facilitate the timely development and deployment of new microelectronics technologies and provide regulatory clarity and guidance to companies involved in microelectronics R&D and manufacturing.

3. Enhance cybersecurity measures to protect intellectual property and sensitive information related to microelectronics and strengthen enforcement of intellectual property laws to prevent theft and counterfeiting of semiconductor designs and technologies.

4. Foster collaboration with like-minded nations to address global challenges in the microelectronics industry, such as supply chain resilience and standards development.

5. Support semiconductor workforce development through competitive scholarships and other incentives for U.S. citizen STEM students interested in defense microelectronics careers, including honorably discharged veterans who have been exposed to defense microelectronics technology. Provide reasonable assurances that suitable jobs will be available for these students after graduation.

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BACKGROUND

Semiconductor microelectronics and computers are essential to economic competitiveness and national security. Microelectronic chips are critical components in defense C4ISR and weapon systems, as well as civil and defense infrastructure systems. The Department of Defense (DoD) needs to have an assured supply of advanced microelectronics chips, in peacetime and wartime. DoD depends entirely on the semiconductor industry to produce the needed chips. DoD uses a variety of chips: digital processors, memories, EO/R, DSP, analog, RF, FPGA, ASIC, and SoC. Many of these semiconductor microelectronics chips are commercial-off-the-shelf (COTS) chips that are adapted to military applications.

Military commercial off the shelf (m-COTS) chips have different requirements than commercial chips. Chips for defense must operate at a wider temperature range from -55ºC to +125ºC, whereas commercial chips are specified to operate from 0ºC to +75ºC. Military COTS chips and the packages require vibration resistance and corrosion resistance and high reliability and radiation hardening. Most importantly, military chips must be trusted and must be compliant with Zero Trust. In addition to m-COTS chips, there are defense-unique and classified chips, made by specialized defense microelectronics manufacturers. There are also legacy chips with older, mature technologies (for example, chips made at greater than the 130nm node). Defense chips must have long shelf life, as long as more than 40 years.

In the past several decades, the U.S. semiconductor industry, although originally created by DoD, has gradually moved offshore, including fabrication, testing, and packaging. The U.S. market share of global semiconductor manufacturing capacity has fallen from about 37% in 1990 to 12% in 2020 (Ref. 1). According to Forbes, Taiwan Semiconductor Manufacturing Company (TSMC) is the world's largest semiconductor chip manufacturer, supplying 92% of the world's leading edge advanced chips. The U.S. is dependent on TSMC to produce the most advanced microelectronic chips, in both the commercial and military sectors. Political instabilities in the Taiwan region could cause serious disruptions in the supply of advanced microchips.

Concerned about the supply chain risks in the U.S. industrial base, President Biden issued Executive Order (EO) 14017 (Ref. 2), which directed each department in the administration to assess potential supply-chain risks within its jurisdiction and develop strategies to mitigate or overcome them. The initial assessment focused on four critical products: semiconductors and advanced packaging; high-capacity batteries, including electric-vehicle batteries; critical minerals and materials, including rare earth elements; and pharmaceuticals and active pharmaceutical ingredients (APIs). The reviews provided recommendations to strengthen supply chain resilience and mitigate future disruptions across five broad categories (including microelectronics): (1) rebuild domestic production and innovation capabilities; (2) support the

development of markets that invest in workers, sustainability, and quality; (3) leverage the Federal government's role as a purchaser of and investor in critical goods; (4) strengthen international trade rules and trade enforcement mechanisms; and (5) work with allies and partners to decrease vulnerabilities in global supply chains.

To re-shore semiconductor manufacturing to the U.S., Congress passed the **Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022** (CHIPS Act) and the President signed it into law on August 9, 2022. The CHIPS Act authorized more than $280B, and immediately appropriated $52.7B, in federal funding to promote domestic semiconductor manufacturing production, research and development, and workforce training.

The supply chain also lacks a sufficient STEM workforce, particularly in semiconductor microelectronics. According to the Semiconductor Industry Association, there will be a semiconductor technical workforce gap of 67,100 by 2030 (Ref. 7). Approximately 26,400 of these jobs will be in technician occupations, 27,300 jobs in engineering occupations, and 13,400 jobs in computer science. Semiconductor microelectronics worker shortage, particularly in the defense sector due to low number of U.S. citizens studying microelectronics because of concerns on available jobs. Changing that perception will require an innovative approach that involves collaboration among various stakeholders, such as government, industry, not-for-profits, and academic with funding and guarantees that the jobs will be filled by U.S. citizens.

In response to EO 14017, DoD assessed the supply-chain risks in several technology areas, including kinetic weapons, energy storage and batteries, castings and forgings, and microelectronics (Ref. 4). DoD found that indeed there are significant risks in the microelectronics supply-chain, due to low U.S. domestic manufacturing capacities (Figure 1). In 2020, the U.S. market share of global semiconductor manufacturing capacity was only 12% and is projected to decline to <10% by 2030 (Ref. 5). Furthermore, 88% of the production, and 98% of the assembly, packaging, and testing, of microelectronics is performed overseas, primarily in Taiwan, South Korea, and China. The migration of semiconductor manufacturing to the Asia-Pacific region, and the subsequent decline in domestic manufacturing, represents significant risks in the microelectronics supply chain.

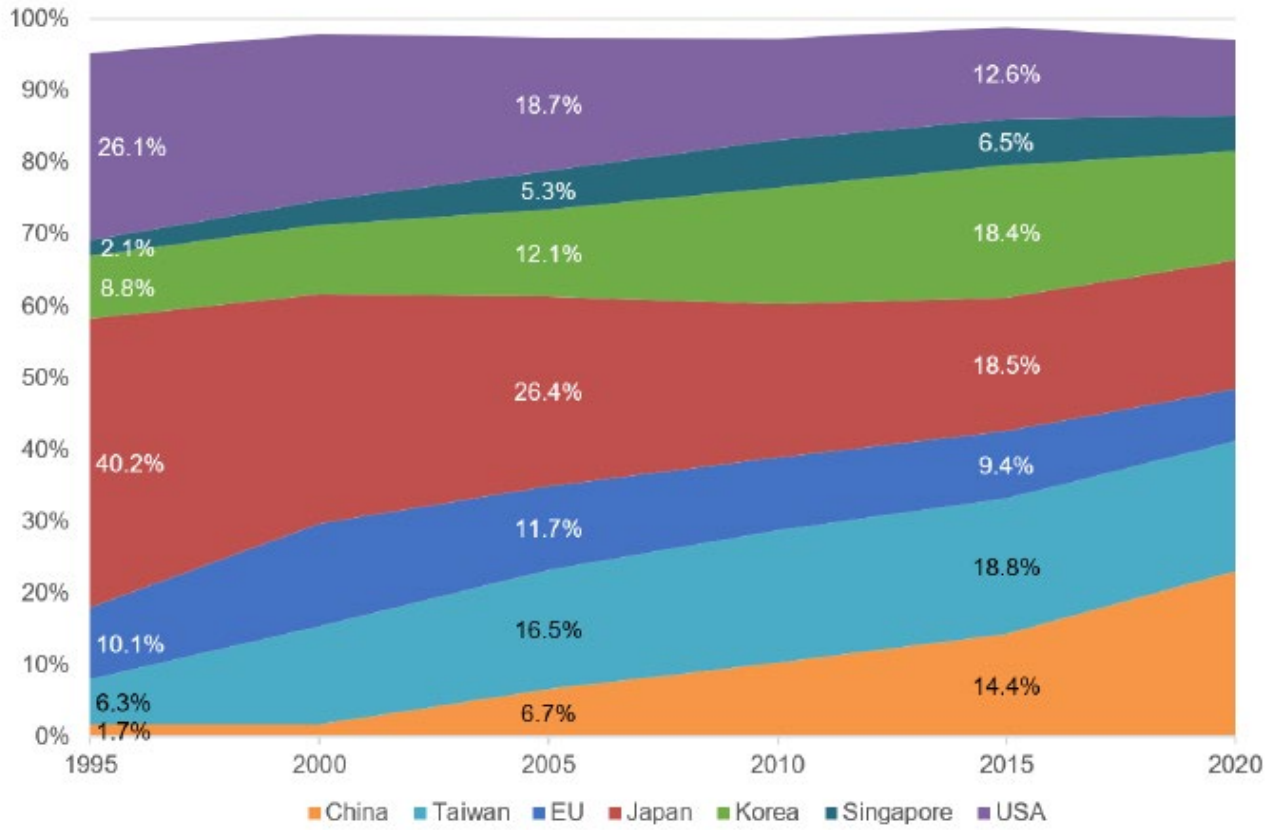

Figure 1 World Wafer Fab Capacity by Country/Region (source: European Semiconductor Industry Association, "Trends in worldwide semiconductor production capacity, 17 June 2021)

Disruption in the microchip supply chain has tremendous impact on the U.S. economy and national security. In 2022, when there was a shortage of chips due to the COVID pandemic, several automobile plants were shut down. The war in Ukraine, with U.S. supplying some defense weapon systems, is placing strain on the microchips in the U.S. inventory. Chip supply can also be disrupted due to pandemics, natural disasters, and geopolitical events. In the escalating technology war with China, the U.S. imposed sanctions of artificial intelligence (AI) chips and export control of advanced semiconductor manufacturing equipment. Almost all the most advanced AI chips, including those produced by Nvidia, AMD, and Qualcomm, are fabricated by TSMC at the latest nanometer technology node. This presents a significant risk in the supply of high-performance AI chips if China invades Taiwan. Secured supply of AI chips is necessary to meet the mandate in the President's Executive Order (Ref. 8) on “Safe, Secured, and Trustworthy Development and Use of Artificial Intelligence.”

In retaliation for the U.S. sanctions, China banned the export of gallium (Ga) and germanium (Ge). Ga and Ge are widely used semiconductor materials. China produces a staggering 98% of the world's supply of raw gallium and 60% of germanium. Shortage of these semiconductor materials would place the microelectronics supply chain at risk. Onshoring microelectronics production, packaging, and testing capability, although challenging and expensive, is the only way to mitigate the supply chain risks and threats to national security.

As a part of the CHIPS Act, DoD allocated $2B to launch the Microelectronics Commons initiative. DoD selected eight regional innovations hubs that include many members in the semiconductor microelectronics industrial base. The objective of these hubs, called "lab to fab," is to speed up the transition of microelectronics from research to prototyping to production. In addition to the Microelectronics Commons innovation hubs, DoD is also developing a strategy to mitigate the microelectronics supply chain risks (Ref. 6). The strategy includes motivating the DoD program offices and their primes to modernize and exploit the most capable microelectronics; leveraging tools, policies, and enforcement to reduce or eliminate costly sustainment issues; increasing microelectronics discovery and innovation and accelerating transition to defense systems; and cultivating a semiconductor microelectronics workforce with the right capacity and the right skills at the right place and the right time. The strategy aims to rebuild and strengthen the defense microelectronics industrial base to mitigate the supply chain risks.

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This statement was developed by the IEEE-USA R&D Policy Committee and represents the considered judgment of a group of U.S. IEEE members with expertise in the subject field. IEEE-USA advances the public good and promotes the careers and public policy interests of the over 180,000 engineering, computing and allied professionals who are U.S. members of the IEEE. The positions taken by IEEE-USA do not necessarily reflect the views of IEEE, or its other organizational units.

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