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United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Research and Technology
Hearing on "Strengthening the U.S. Microelectronics Workforce"
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Dear Chairwoman Stevens, Ranking Member Feenstra and members of the Research and Technology Subcommittee:

Thank you for this opportunity to testify about the critical workforce needs of the U.S. microelectronic manufacturing sector. I hope to be of service in helping you examine current semiconductor workforce and training pipelines, exploring gaps between current and future workforce needs, and discussing strategies to expand and diversify the microelectronics workforce.

I am the Executive Director of the SEMI Foundation, which is the 501(c)(3) arm of SEMI, the global industry association representing the microelectronics manufacturing and design supply chain, connecting over 2,400 member companies and 1.3 million professionals worldwide. The SEMI Foundation was established by SEMI in 2001 to support economic opportunity for workers and the sustained growth of the microelectronics industry. The SEMI Foundation leads the association's workforce development and diversity, equity, and inclusion initiatives with a 20-year history of supporting the industry. Our work in this sector positions us to understand the workforce deficits we face today and to recommend wide-scale solutions, which are detailed below.

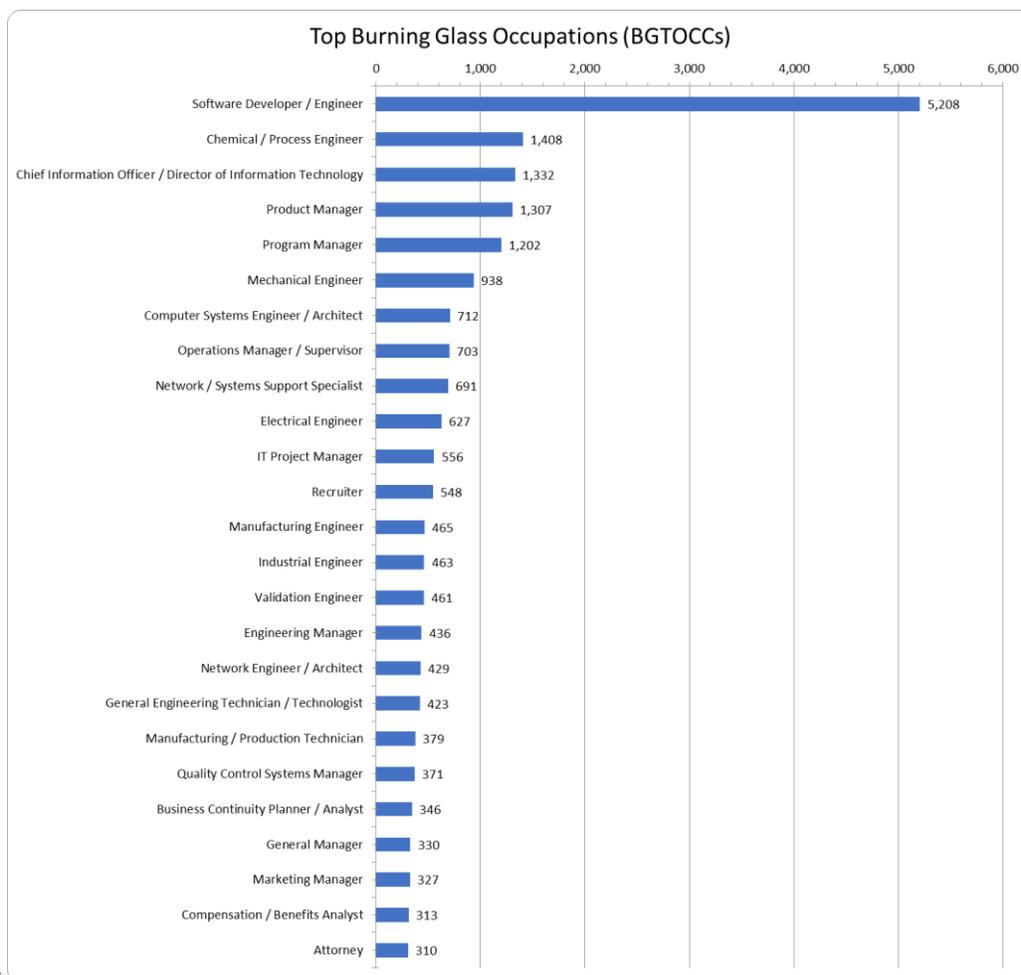**Current Workforce Needs and the Potential Impact of the CHIPS Act**

Microelectronics is an industry making frequent headlines. Supply chain disruptions and chip shortages are impacting virtually every industry and our daily lives. Yet compared to today's software and social media giants, this industry is relatively invisible to most citizens and workers. And that has made workforce development a challenge for decades.

Compounding the issue is the "Great Resignation," which has led to substantial worker churn within our member companies. The steadily declining U.S. share of global semiconductor capacity, COVID-related supply chain disruptions and an aging workforce are all important factors contributing to the current lack of qualified workers. The semiconductor industry's ability to advance and thrive faces serious challenges as it contends with an acute shortage of core skills and talent.

Yet another challenge is how to best prepare new workers for the industry, and the industry for new workers. Training programs must simultaneously be industry-led *and* worker-centric, and this process is

not simple. Industry must dictate the specific skills and competencies needed for high-demand, open jobs, even as new technologies continually emerge; and prospective workers – both students and those who need to re-skill and up-skill – must have robust support systems in place to complete training and be positioned for success in their new workplaces. Further, companies report that many workers lack the essential "soft skills": teamwork, communication, professionalism, time management, conflict resolution, etc. needed to thrive in workplaces. Finally, companies who are looking to hire a larger and more diverse workforce need to shift their workplaces toward more equitable and inclusive spaces or these new workers will not feel welcome and possibly leave those jobs or the industry entirely. Accomplishing all of the above requires significant investments at both individual and company levels.

These significant workforce challenges exist across the entire microelectronics industry. Impacted jobs range from entry-level positions in manufacturing to advanced technical jobs, as well as leadership and middle management positions. The Foundation is currently working on a project with fourteen member companies and identified in just those companies alone, there were more than 34,000 job openings in the last year. [1] Extrapolate that number to account for the more than 400 SEMI members in the U.S. alone and a clearer picture emerges of our extreme worker shortage.

Top Burning Glass Occupations (BGTOCCs)

Occupation	Count
Software Developer / Engineer	5,208
Chemical / Process Engineer	1,408
Chief Information Officer / Director of Information Technology	1,332
Product Manager	1,307
Program Manager	1,202
Mechanical Engineer	938
Computer Systems Engineer / Architect	712
Operations Manager / Supervisor	703
Network / Systems Support Specialist	691
Electrical Engineer	627
IT Project Manager	556
Recruiter	548
Manufacturing Engineer	465
Industrial Engineer	463
Validation Engineer	461
Engineering Manager	436
Network Engineer / Architect	429
General Engineering Technician / Technologist	423
Manufacturing / Production Technician	379
Quality Control Systems Manager	371
Business Continuity Planner / Analyst	346
General Manager	330
Marketing Manager	327
Compensation / Benefits Analyst	313
Attorney	310

1

This lack of skilled workers extends across the entire microelectronics supply chain. However, considering the developments in high-technology areas such as advanced transistor technology and advanced packaging, it is important to note that specialized skills, such as quantum and advanced computing, will be critical in the future. Also, in microelectronics sub-fields (fabrication, packaging, applications), the skills are highly interdisciplinary. For example, future technology innovation demands that materials and mechanical engineering disciplines, historically important in advanced packaging, will be joined by new critical skills in software and computer science, chemical engineering, electrical engineering, and systems engineering. Compounding this issue is the fact that decades-old machines are also still used in manufacturing, which means workers need to be adept in old, new, and emerging technologies.

The COMPETES Act will create growth in fab and advanced manufacturing capacity that will exponentially increase the need for skilled workers in every job function. The related growth in career opportunities will likely spark interest in new college and university graduates, but in order to meet this growing need, significant work must be done quickly to promote the image and awareness of careers within the industry. That increased awareness and improved investment in innovative training programs will start to address the many and varied skill workers need to be successful and attract them to a growing, dynamic industry.

Ability of Existing Workers/Matriculating Students to Meet Need

There are not nearly enough existing workers or matriculating students to meet the range of talent needs across the microelectronics value chain. There are no reliable workforce studies specifically about the microelectronics industry, but the industry competes with many others for STEM talent. Data on STEM jobs and workforce help us understand what we need to know for microelectronics. For example:

1. STEM jobs are projected to grow 8.8%.
Between 2017 and 2029, the number of STEM jobs will grow 8 percent, a higher rate than non-STEM jobs—with positions in computing, engineering, and advanced manufacturing leading the way.[2]

2. Specifically, software development employment is projected to grow 22%.[3]

3. Employment in STEM occupations has grown 79% since 1990.[4]

4. The average median hourly wage for STEM jobs is $38.85.

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[2] US Bureau of Labor Statistics: https://www.bls.gov/opub/btn/volume-10/why-computer-occupations-are-behind-strong-stem-employment-growth.htm#:~:text=The%20U.S.%20Bureau%20of%20Labor,3.7%20percent%20for%20all%20occupations.

[3] US Bureau of Labor Statistics: https://www.bls.gov/ooh/computer-and-information-technology/software-developers.htm

[4] Pew Research Center, 2018: https://www.pewresearch.org/social-trends/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/#:~:text=Since%201990%20STEM%20employment%20has,have%20grown%20more%20than%20others.

Compared to the median earnings for all other types of jobs in the U.S. -- $19.30 -- STEM-related jobs pay exceptionally well.[5]

5. The median annual wage of STEM occupations in 2020 was $89,780.
This is well over double of that of non-STEM occupations, where the median annual wage is $40,020.[6]

And yet:

Only 20% of US high school graduates are prepared for college-level coursework in STEM majors.
According to a 2019 *American Affairs* article, only 20% of high school graduates are ready for the rigors of STEM majors. In fact, over the past 15 years, this report also found that the U.S. produced only 10% of the world's science and engineering grads.[7]

The microelectronics industry is expected to double in size over the next decade.
Microelectronics companies do not have the name recognition or allure of companies such as Facebook, Apple, Spotify, or Google, even though our industry enables each of those technologies. The industry needs help in overcoming its image challenges and educating workers on the varied, stable, well-paying jobs available. There is not enough STEM talent to fill the jobs being opened and forecasted across every U.S. industry, but semiconductors represent the nation's "Invisible Economy". The industry plays a vital role in keeping the overall U.S. economy healthy, but we are hurt by a simple lack of awareness, understanding, and critical investments across every segment of available workers.

Addressing the Problem

The SEMI Foundation has a wide range of programs and initiatives that help address these workforce challenges, starting in grade-school classrooms and extending through re-skilling programs for older adults. The Foundation brought all these together into an Economic and Workforce Development Framework (EWDF) that provides a step-by-step path for leaders and states to engage with the industry and invest strategically so we can accelerate economic opportunity for all citizens.

Some main elements of the EWDF include:

Semiconductor Career and Awareness Network (SCAN) – Designed for the Economic Development Administration's Good Jobs Challenge opportunity, SCAN is a new Registered Apprenticeship and pre-apprenticeship program designed to address critical workforce needs within the microelectronics industry by training, supporting, and placing individuals into quality jobs at committed employers. SCAN teaches overall workplace and specialized technical skills and competencies that are in high demand for entry-level technician and professional jobs. SCAN is industry-driven, aligned with workforce needs, focuses on current and future job openings identified by employers, and worker-centric, with extensive supports to help participants succeed in the program.

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[5] Education Commission of the States:
https://ecs.secure.force.com/studies/rstempg?id=a0r0g000009TLhl
[6] US Bureau of Labor Statistics: https://www.bls.gov/emp/tables/stem-employment.htm
[7] American Affairs Volume III, Number 1 (Spring 2019):
https://americanaffairsjournal.org/2019/02/americas-stem-crisis-threatens-our-national-security/

Industry Image and Awareness Campaign - SEMI promotes the powerful story of our industry and its crucial role in the world, with upcoming campaigns reaching nearly of 50 million viewers in 2022/2023. Instructional materials and interactive content have also been created to illustrate the fascinating journey of sand to silicon that our members and educators can use to engage students. These materials have also been used at job fairs to educate students on the numerous opportunities within our industry. This full national media and education campaign has two elements: a PBS documentary with Roadtrip Nation highlighting individuals and their careers in our industry that will reach up to 60 million people and will air later this year; and an online career portal that launches in Q2 of 2022. The portal will provide skills and interest assessments, links to trainings that map to jobs, and "crosswalks" that show how to move from different industries into the microelectronics field. Additional tools include access to mentors and sponsors, demonstrations of the social good within the industry (shown to be important to today's job seekers), and a showcase of career stories from diverse individuals working in our field so people of different backgrounds can see themselves represented in the industry.

SEMI VetWorks – the SEMI Foundation established this program to help transitioning veterans enter the industry. A useful handbook, published last year, "SEMI VetWorks: A Guide to Veteran Recruitment, Hiring and Retention in the Microelectronics Industry" includes the resources, recommendations, and research that helps SEMI member companies connect with, hire, and support this vital talent pool. The SEMI Foundation also partners with the Manufacturing Institute's "Heroes Connect" program, participates in job fairs and has an ongoing communications campaign to inspire veterans to join the industry and encourage companies to hire veterans.

High Tech U – This high school STEM program connects sponsoring companies to local teachers and helps those teachers provide experiential learning for their students. Lesson plans and student experiences have clear links to our industry so students can connect their in-class learning to real-world applications. The program is also built with the flexibility to integrate with a variety of other programs.

Diversity, Equity, and Inclusion Initiatives – Last year, the SEMI Foundation published the "SEMI Roadmap to DEI and DEI Toolkit", two robust resources specifically for the microelectronics industry. These tools connect companies to the consulting, resources, trainings, webinars, articles, and thought partnership that will make the microelectronics industry more diverse, equitable, and inclusive.

<u>**SEMI Foundation, Industry, and Universities on Recruitment and Training**</u>

Mentoring Program - SEMI provides online and in-person platforms for mentoring, matching and connecting university students to established professionals. This program helps students overcome challenges, develop as leaders, and explore career opportunities.

Professional Development Seminars - SEMI organizes seminars in regional clusters, partnering with local universities to reach numerous college students and inform them of career opportunities in our industry. The seminars provide valuable, practical information that helps students plan their career trajectories, such as a day in the life of an industry professional, industry trends, and panels on skill sets sought by companies.

Workforce Development Pavilions at SEMICON events - SEMI brings students to our annual industry events – SEMICONs – to see demonstrations, attend programs, and interact with exhibitors and hiring

managers. During the day, students have tailored experiences learning about the industry and exploring various career opportunities in semiconductor manufacturing.

Industry Image and Awareness Campaign – (as described above)

Partnership with the American Semiconductor Academy (ASA) - The American Semiconductor Academy Initiative is partnering with SEMI to build a comprehensive workforce development program designed to close the microelectronics industry's widening talent gap and maintain U.S. economic competitiveness and national security. The partnership draws on the strengths of both organizations and bolsters workforce education and training programs nationwide, targeting job skills, academic degrees and continuing education to grow and diversify the talent pool for the industry, while accelerating scientific innovation and technology commercialization.

The initiative aims to connect over 200 universities and community colleges to the more than 1,500 SEMI member companies with U.S. operations. In addition to modernizing and revitalizing a comprehensive curriculum that spans multiple disciplines and credential levels, these institutions and organizations will be collaborating to provide hands-on training and apprenticeships, uniquely critical to the microelectronics industry, to students, as well as prototyping services to speed the translation of new innovations to the marketplace.

A cornerstone of the ASA and SEMI partnership is a commitment to foster equity and inclusion and to enrich the diversity of the talent pool by including minority-serving institutions and community colleges nationwide, sharing resources and best practices, and offering hands-on learning, research experiences, and internship opportunities for their students and trainees.

Hurdles to Creating Programs that Benefit Students, Employees, and Employers

The industry is focused on several significant challenges as it designs programs to meet our ongoing workforce needs.

The first challenge is the tension between the thousands of new workers needed by employers, and the support and time it can take to move one individual into a successful new career. Every career journey is unique, and every person needs an approach that meets their needs. At the same time, companies need tens of thousands of workers. In developing our microelectronics workforce, we constantly ask: how do we meet both needs?

A second challenge, as indicated in the opening of this testimony, is ensuring that programs are industry-led and truly prepare workers in both the soft and technical skills that are in high demand for currently open jobs. At the same time, programs need to be worker-centric, so students and prospective employees have the support systems they need to complete training and get set up for success in their new workplaces. This process requires the patient, thoughtful, and collaborative participation of many parties: employers, educational institutions, workforce boards, other labor organizations, support service providers, and more.

A third challenge is making sure our workplaces are truly welcoming and embrace people from all backgrounds. Employers must make *everyone* feel welcome, including groups that may not have participated in historical hiring programs such as women returning to work after absences due to family

caretaking, veterans transitioning into civilian jobs, or justice-involved individuals charting a new path. This inclusion mindset can only be accomplished with intentional diversity, equity, and inclusion practices used throughout the industry and ongoing training and education.

A final challenge is the sheer amount of information necessary to fully prepare a young person to join our industry. Four, six, or even eight years of university education is often needed for someone to contribute to a semiconductor company's research and development efforts gainfully and meaningfully. There is also a huge burden on university faculty to push their graduate students to pursue cutting-edge projects on either semiconductor devices or the materials, processes, or equipment used to make the devices. But, it is not clear how often the results for all these projects are shared or if experiments are being endlessly repeated.

There is also a great deal of specialization in our industry – much like medicine, with many branches on the semiconductor tree. Some technologies from 30 years ago are still produced (in fabs that were built 40 years ago) and perform critical functions, while at the same time, new technologies and techniques are constantly emerging. Even for entry-level jobs, it can take an extraordinary amount of time to acquaint a technician or student with all the materials, safety, equipment, process software, and other details necessary to master the working environment inside a wafer fab.

Bolstering the U.S. Microelectronics Pipeline

There are eight main areas where policymakers can help transform our industry and address widening workforce gaps quickly and effectively:

- Increase investments in semiconductor career pathways from elementary school to university to workforce (K-12).
- Continued focus and support for recruiting, supporting, and retaining underrepresented groups in STEM professions including funding for HBCUs, HSIs, and MSIs.
- Support reskilling/transition programs for veterans and current soldiers transitioning into the semiconductor industry.
- Increased investments in industry awareness and visibility programs.
- Continued support for advanced manufacturing research and student skill development programs, particularly in artificial intelligence, machine learning, cybersecurity, robotics, 3D printing, automation, and data science. These areas position the microelectronics industry at the forefront of advanced technology leadership for the U.S., but also raise the bar for all U.S. industries.
- Encourage and support current workforce development regional and national coalitions, especially those that include educators, nonprofits, trade associations, workforce development agencies, and community organizations. Help connect more local communities to these effective workforce development coalitions and their programs that are making a difference.
- Encourage organizations and coalitions to create workforce development programs that connect diversity, equity, and inclusion to their workforce development efforts.
- Fund wrap-around social, educational, and career support services for individuals transitioning into the industry.

I am grateful for the opportunity to testify at this hearing and look forward to answering your questions.