Semiconductor Industry Association (SIA)
Comments to the
National Institute of Standards and Technology on
"Current and Future Workforce Needs to Support a
Strong Domestic Semiconductor Industry"

83 Fed. Reg. 32842 (July 16, 2018)

Submitted August 15, 2018

The Semiconductor Industry Association (SIA) is pleased to submit these comments on the National Institute of Standards and Technology (NIST) Request for Information (RFI) on "Current and Future Workforce Needs to Support a Strong Domestic Semiconductor Industry."

Basic Information – Background on the U.S. Semiconductor Industry Workforce

SIA is the trade association representing leading U.S. companies engaged in the research, design, and manufacture of semiconductors. Semiconductors are the fundamental enabling technology of modern electronics that has transformed virtually all aspects of our economy, ranging from information technology, telecommunications, health care, transportation, energy, and national defense. The U.S. is the global leader in the semiconductor industry, and continued U.S. leadership in semiconductor technology is essential to America's continued global economic leadership. More information about SIA and the semiconductor industry is available at www.semiconductors.org.

As an industry association, SIA is not directly engaged in the recruitment, hiring, and training of the semiconductor workforce. Accordingly, our responses to the questions in the RFI are from an industry-wide perspective and generally reflect our member companies' experience with the semiconductor workforce.

Workforce Challenges and Needs

> *RFI Question 1. When hiring technical staff, for what types of positions do you encounter the most difficulty in finding qualified employees? (a.) Have you been able to identify any causes for these recruitment difficulties (lack of appropriate educational programs, lack of collaboration between industry and educational institutions, competition within your industry, competition for talent from outside your industry, etc.)*

There are currently several thousand open technical positions in the U.S. semiconductor industry. Many of these positions have been open for months or longer.

Our member companies experience challenges finding enough qualified U.S. workers with the advanced graduate level education, skills, and expertise needed to compete in this global economy. These include advanced technical areas such as artificial intelligence/machine learning, advanced silicon design, advance manufacturing engineering and process development, software architecture, and quantum computing, and firmware engineering. These positions include Design Engineers at the Master's and PhD levels in fields such as Electrical and Computer Engineering, Process Engineers at the Master's and PhD levels in fields such as Chemical or Materials Engineering, and Software Engineers at the Master's and PhD levels in fields such as Computer Science or Computer Engineering.

Firms face a host of challenges as they attempt to fill these positions. There are a variety of reasons for the thin pipeline of qualified and available talent for the semiconductor workforce.

- **Lack of a sufficient supply of U.S. workers with the advanced education, skills and expertise required for high skilled semiconductor positions.** The problem is demonstrated by U.S. university graduation statistics. Today, about half of the graduate students in the physical sciences in U.S. universities are foreign nationals, and that percentage increases the higher the degree and the more prestigious the school. The most recent data from the National Center for Education Statistics (NCES) Integrated Post-Secondary Education Data System (IPEDS) underscores the lack of U.S. workers who choose to pursue advanced degrees in key engineering areas:

2016 National Center for Education Statistics (NCES) Integrated Post-Secondary Education Data System (IPEDS)		**All Graduates**	
Discipline		**Master's degree**	**Doctor's degree**
Computer Science/Information Technology	Nonresident Total	29,231	1,386
	Percent Foreign Nationals	63.0%	56.5%
	Total Graduates	46,419	2,415
Electrical, Electronics and Communications Engineering/ Computer Engineering/Microelectronics	Nonresident Total	10,651	1,537
	Percent Foreign Nationals	75.8%	68.9%
	Total Graduates	14,048	2,231

Material Science/Material Engineering	Nonresident Total	762	506
	Percent Foreign Nationals	50.2	52.0%
	Total Graduates	1,517	973

Figure 1 – advanced degrees awarded to foreign nationals (available at https://nces.ed.gov/ipeds/)

A recent report by Stuart Anderson of the National Foundation for American Policy, "The Importance of International Students To American Science and Engineering" (2017), relies on different data sets, including the National Science Foundation's Survey of Graduate Students and Postdoctorates, to further document the scarcity of U.S. worker graduate students in STEM fields. As discussed further below, because of our outdated immigration system, the semiconductor industry is unable to hire and retain many of these graduates who are foreign nationals for employment in the U.S.

- **Lack of Academic Programs Supporting Emerging Technologies:** Educational institutions have yet to develop curriculum for some emerging technologies which are critical to the future of the semiconductor industry, such as Artificial Intelligence, Autonomous Driving, and Data Science. The absence of such programs to support the development of high skilled workers contributes to the absence of skilled workers.

- **Competition among high tech industry for qualified high skilled workers.** There is very intensive competition for workers with advanced technical skills, especially in the areas of data science and artificial intelligence. This is exacerbated by intense competition for these skillsets in a wide variety of industries that have recently begun to hire for these skills.

- **Industry awareness and brand recognition are low among target populations of graduate students in engineering and computer science.** With the rise of "new tech" companies over the past two decades, many STEM students today have a low awareness of the important role of semiconductors in the economy and as a driver of technology. Thus, many of these students end up specializing in areas that are not relevant to a career in the semiconductor industry. Firms work to varying degrees to boost recognition through targeted engagement with college and university campuses on curriculum development and awareness building efforts. However, the degree of engagement is often limited by both the size of the firm, and thus the resources they have available to bring to bear on workforce development, and the profit margins available in their targeted market sectors. In addition, many graduates are hesitant to relocate outside major metropolitan areas where many of these tech firms are predominantly located, whereas semiconductor companies may be in need of talent in various locations around the country.

- **New recruits often lack the skills to "hit the ground running."** According to SIA member companies, many students graduating from U.S. colleges and universities with excellent general engineering or computer science skillsets often lack industry specific skills and the broader set of "soft skills" required to work effectively as part of a team in an industrial setting.

- **The broader STEM pipeline, including the U.S. semiconductor workforce, lacks sufficient diversity.** Representation of women and underrepresented minorities in STEM, and especially in the physical sciences and engineering, has been persistently well below the demographics of the country and enrollment in institutions of higher education overall. Many SIA firms have undertaken targeted diversity initiatives to improve their workforce diversity profile to match or exceed diversity within the pool of available talent.[1] Firms both small and large have shown that through targeted approaches that include focused mentorship, bias training in hiring, and workforce cultural changes, they can improve representation of women and underrepresented minorities within their workforce. According to one SIA member, their most recent survey found that their workforce was more diverse than the most recent data on the graduating classes of relevant fields of study. Despite efforts of SIA member companies, however, the diversity in the STEM and semiconductor talent pools remains insufficient.

- **The culture differences between younger workers and the existing semiconductor workforce present challenges for retention.** SIA member companies reported that they have needed to modify both human resources behavior and company branding and mission focus to appeal to younger engineers. For example, one company reports recently moving to a system that provides opportunities for advancement every six months to meet expectations of younger workers. They also report providing regular opportunities to switch projects and job functions to provide more rapid change and diverse challenges. Several SIA companies also report increasing efforts to highlight the company's social mission, especially in communications with employees, often highlighting awards for sustainability and ethical behavior. While these and other similar

[1] For example, see: 2017 Intel Diversity & Inclusion Report (2018, March 27). Retrieved from https://newsroom.intel.com/editorials/2017-diversity-inclusion-annual-report-approaching-first-leg-intelsjourney/, Diversity and Inclusion - Texas Instruments. Retrieved from http://www.ti.com/corp/docs/company/tidiversity-ebook-print.pdf.

efforts attempt to address the needs of younger workers, other initiatives are needed to respond to the changing workforce.

RFI Question 2. Are there specific educational levels that are needed for your current workforce?

The semiconductor industry in the U.S. accounts for roughly a quarter of a million direct jobs, and each semiconductor industry job creates nearly 5 additional jobs in the broader economy, on average. As a result, the industry creates more than 1 million jobs across the economy.[2] These jobs are split across a range of occupations, with the largest two segments being production occupations – such as factory technicians and line workers – at 38 percent and engineering occupations – such as electronics and electrical engineers and chip design engineers – at 26 percent.

Given this employment profile, the semiconductor industry requires talented and qualified workers throughout the educational spectrum. In the research and design stages of the process, the industry requires the best and brightest scientists and engineers with advanced degrees in the STEM fields. Engineers with such education remain in short supply in the U.S. workforce. Engineers without such education cannot acquire it by on-the-job training, or by a short course in a vocational setting. The skills can only be acquired in the course of a multi-year, structured academic program that, in turn, relies upon the engineer-to-be already having the requisite math and physics academic building blocks. Access to these highly educated engineers is critical to the development of our future generation of products and technology and to our ability to maintain the US semiconductor industry as the global leader.

As noted in response to Question 1, an increasing percentage of graduate students in these fields at U.S. colleges and universities are from foreign countries. In electrical engineering and computer science graduate degree programs at U.S. colleges and universities, the National Science Foundation indicates that approximately 80 percent of the students are international students, and this trend is increasing rapidly. (See figure 2.)

[2] 2017 SIA Factbook. (2017, May). Retrieved from http://go.semiconductors.org/2017-sia-factbook-0-0-0.

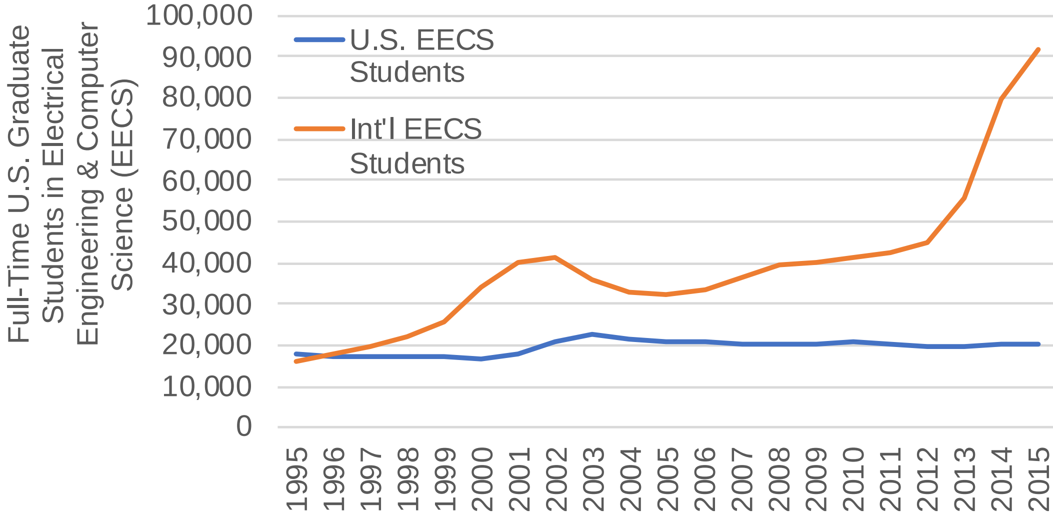

Figure 2. Full-time graduate students in Electrical Engineering and Computer Science at U.S. Institutions, based on National Science Foundation Survey of Graduate Students and Postdoctorates and National Foundation for American Policy calculations.

The semiconductor industry also requires employees with expertise in other fields, including physics, chemistry, advanced material science, artificial intelligence/machine learning, computer science, and software engineering.

In order to remain globally competitive and encourage these innovative jobs remain in the U.S., the semiconductor industry in the U.S. needs access to these students, many of which populate the top graduate programs in the country. Unfortunately, however, once these international students have their diplomas, current U.S. immigration policy create disincentives for these educated professionals to work, live, and contribute to the American economy. Similarly, current U.S. policies impose per-country caps that limit the ability of highly trained engineers and scientists from countries such as India from working in the U.S. Further, the complicated regulatory landscape requires firms to invest significant capital and human resources in immigration legal services that could otherwise be used for workforce development, R&D, and other more productive investments. Accordingly, high-skilled immigration reform remains a top priority for our industry.

The semiconductor industry in the U.S. also maintains a robust manufacturing presence in our country. Half the production capacity of U.S.-based semiconductor companies continues to be located in the U.S. As a result, skilled technicians are needed to work in fabrication facilities ("fabs") and maintain and operate the complex manufacturing equipment used to produce advanced semiconductors.[3] These positions typically require at least an associates degree or other training.

[3] While the average manufacturing job salary is slightly above the national average, at nearly $65,000 in 2016, according to the U.S. Bureau of Labor Statistics, semiconductor manufacturing jobs pay on average nearly $150,000 as of 2016. These wages have been growing steadily since 2001 at an average annual growth rate of 4.4 percent.

RFI Question 3. Are there certain factors relating to workforce needs that your company or organization prioritizes when locating a new facility, for example a strong base of existing talent, a robust local educational ecosystem, etc.?

For semiconductor firms looking to establish a new fabrication facility, the availability of a well-educated local workforce capable of supporting semiconductor research, design and manufacturing is a critical factor. According to our member companies, a capable workforce can often be found in and around areas that have a robust local educational ecosystem from K-12 through the university level. Locating semiconductor facilities in such an environment allows firms to recruit top level talent from the region, as well as partner with the educational institutions to create tailored programs to help train and ready future industry workers with the necessary skills to work in the industry.

One example of locating and growing the industry in and around a highly educated workforce that supports the industry is the growth of “Tech Valley” in New York State.[4] Over the course of several decades and differing governors, New York has both built up its Capital Region’s educational institutions and created policies to attract the semiconductor industry such that the industry has grown and benefited from the highly educated workforce and powerhouse educational institutions around it.

The Tech Valley success story provides numerous examples of how the surrounding workforce and educational institutions have benefitted the semiconductor industry:

1) Four-year Institutions – the science and engineering departments of local universities, especially SUNY Albany’s College of Nanoscale Science and Engineering and those at Rensselear Polytechnic Institute (RPI), have provided the semiconductor industry a rich base of talent from which to recruit. In addition, these institutions can engage and coordinate with the industry to ensure what is being taught is relevant to the industry’s needs.

2) Community Colleges – not all semiconductor workers are engineers; in fact, the industry needs employs technicians and operators who comprise roughly two-thirds of the labor force of a typical semiconductor fabrication facility. To this end, community colleges in the Tech Valley region have coordinated closely with firms to establish curricula relevant to high-tech manufacturing.

3) K-12 Education – New York’s public education system outperforms those of many other states, and the Capital Region’s schools collectively outperform those of the state as a whole. This strong education base has been an asset

[4] For a complete history of the development of the Tech Valley in New York, please see Charles W. Wessner and Thomas R. Howell, “Partnering to Grow the New York Regional Nano-Cluster: How it was Built, Its Strategic and Economic Value, and What is Needed to Sustain it,” May 1, 2018, Georgetown University.

from which to draw graduates into the semiconductor industry. In addition, the region has worked to establish a number of model programs in the STEM area to further help develop the future workforce with relevant skills.

Additional factors include robust university-level technical education, English proficiency, labor cost, college infrastructure, proximity to customers, and other member company facilities.

RFI Question 4. How do you see the work force needs of your company or organization changing over the next 5 years, 10 years, 15 years?

Technology and accompanying skillsets rapidly change. For the near-term future (5 years), industry members anticipate continuing to hire hardware/software talent. In addition, members will focus on growth areas such as artificial intelligence, 5G, flash memory, and autonomous driving. We continue to anticipate increased need for workers with advanced degrees in hardware engineering, software engineering, computer engineering, electrical engineering, material science, physics, and chemistry. Artificial intelligence/machine learning, autonomous driving, data science, computer vision, and networking are important emerging areas.

RFI Question 5. As the industry continues to evolve and develop and integrate new technologies (e.g., new computing paradigms, new material systems, broader use of AI) are there skillsets that you see as becoming more important?

Some scholars believe that there are three primary “types” of skills needed for employment in the upcoming Artificial Intelligence (AI) era: (1) analytical, creative, and adaptive skills; (2) interpersonal and communication skills; and (3) emotional and self-confidence skills.[5] Given that K-12 education is typically focused on traditional knowledge attainment, and not skills attainment, the workers of the future are not adequately prepared for the AI world. As a result, governments should support reforms at the K-12 level, including high school career academies, project-based learning, and increased adoption of “workforce focused classes, such as business, statistics, computer science, and engineering.”[6]

In addition to providing technical curricula, colleges should focus on improving their curricula to ensure students learn practical skills that will be useful for employers, such as business-oriented writing, critical thinking skills, statistics, and computer science.[7] The recently established Harrisburg University of Science and Technology, which offers undergraduate and graduate degrees in advanced manufacturing, computer information

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[5] Manuel Trajtenberg, “AI as the next GPT: A Political-Economy Perspective,” NBER Working Paper No. 24245, January 2018, http://www.nber.org/papers/w24245.
[6] http://www2.itif.org/2018-emerging-technology-future-labor.pdf
[7] http://www2.itif.org/2018-emerging-technology-future-labor.pdf

sciences, and information systems engineering and management, among other degrees, may provide a good example for other schools to follow.[8]

Education and training will need to evolve constantly to keep pace with advances in manufacturing. As the semiconductor industry employs new processes and materials in manufacturing, there will need to be a corresponding evolution in the expertise needed to keep pace with these changes. For example, the industry will require increased expertise in managing the environmental, health, and safety challenges associated with manufacturing processes involving new chemicals and materials, including nanomaterials. To meet these challenges, the industry will need scientists and other skilled professionals to address the responsible management of these chemicals and materials in a semiconductor fabrication facility. The industry has established a research center, the Engineering Research Center for Environmentally Benign Semiconductor Manufacturing,[9] to conduct research on many of the challenges facing the industry and build the pipeline of professionals with the necessary environmental and advanced manufacturing experience. But this initiative requires increased investment to keep pace with rapid changes in the industry.

> *RFI Question 5.b. - From your experience are there types of partnerships with the federal agencies and/or educational institutions that would be helpful to prepare this workforce for the future?*

This history of the U.S. semiconductor industry is marked by close collaboration with federal research agencies. In the 1980s, the industry and government worked together to establish SEMATECH, a successful collaborative effort to support precompetitive research and development to advance semiconductor manufacturing. In the process of achieving its primary goal of enabling the U.S. semiconductor industry to regain its leadership position in the world by the early 1990s, SEMATECH also helped develop many of the best engineers and scientists working in relevant fields.

Similarly, a key part of the success of the semiconductor industry in the U.S. is close partnerships with the university community. In addition to individual company relationships with individual universities, the industry as a whole has established partnerships with leading research universities to advance semiconductor innovation. For example, in 1982, SIA member companies established the Semiconductor Research Corporation (SRC), a consortium to partner with and fund (along with federal agencies) precompetitive basic research in areas critical to the semiconductor industry. Through the SRC, the industry has collaborated on research to advance “Moore’s Law.” In addition to the important advances resulting from this research, this program has helped train the next generation of semiconductor innovators.

The experience of the Tech Valley in New York and the development of the College of Nanoscale Science and Engineering (CNSE) is another example of an intentional and forward-looking step by policymakers and industry to help better prepare the education

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8 http://harrisburgu.edu/about-hu/
9 http://www.erc.arizona.edu/

base for the needs of the local burgeoning semiconductor industry.[10] CNSE offers bachelor's, master's, and doctoral degrees in nanotechnology and nanoscience, fields which are critical to the semiconductor industry. According to CNSE's tracking, roughly one-third of its undergraduates get positions in the nanotechnology industry in the New York Capital Region and over half of its advanced degree recipients get positions in New York in the nanotechnology field.

In order to meet the current and future needs of the semiconductor workforce, these types of partnerships need to be expanded and multiplied. In addition, these partnerships need to be coordinated to improve worker recruitment and retention, especially for underserved minority groups.

> *RFI Question 6. Are there certain obstacles that you see as the biggest impediment to meeting your workforce needs? For example, a lack of aligned educational programs (including internship and apprenticeship opportunities), a lack of collaboration with such educational programs, a lack of students in science and engineering, a lack of interest in your industry, a lack of facilities with appropriate equipment to train workers (e.g., community colleges without access to fabrication equipment/facilities), or other issues? Please describe.*

As stated above, impediments to meeting the needs of the semiconductor workforce include our broken high-skilled immigration system and necessary improvements in our education system.

Another challenge is the "greying" of the workforce. One SIA member, in comparing their workforce statistics across the globe, identified that their U.S. workforce has an average age of 48-50, while sites in the Asia Pacific region have significantly younger workforces in their late 20s and early 30s on average. Figure 3 shows the older age distribution of workers in the Electronic Component and Product Manufacturing category of the U.S. Bureau of Labor Statistics data, a broad category that includes the semiconductor industry (orange hues), compared to the total workforce of the U.S. (blue hues), for the years 2011-2017. As the overall workforce has skewed to a slightly younger age distribution over the past six years, the semiconductor sector has seen a nearly 10 percent decrease in the share of workers ages 35-44 and significant increases in older age groups. Accordingly, as older workers begin to end their careers, the semiconductor industry in the U.S. faces the challenge of attracting and retaining younger workers with the necessary skills.

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[10] For more on the role of educational institutions partnering with the industry in New York, please see Charles W. Wessner and Thomas R. Howell, "Partnering to Grow the New York Regional Nano-Cluster: How it was Built, Its Strategic and Economic Value, and What is Needed to Sustain it," Chapter 8, May 1, 2018, Georgetown University.

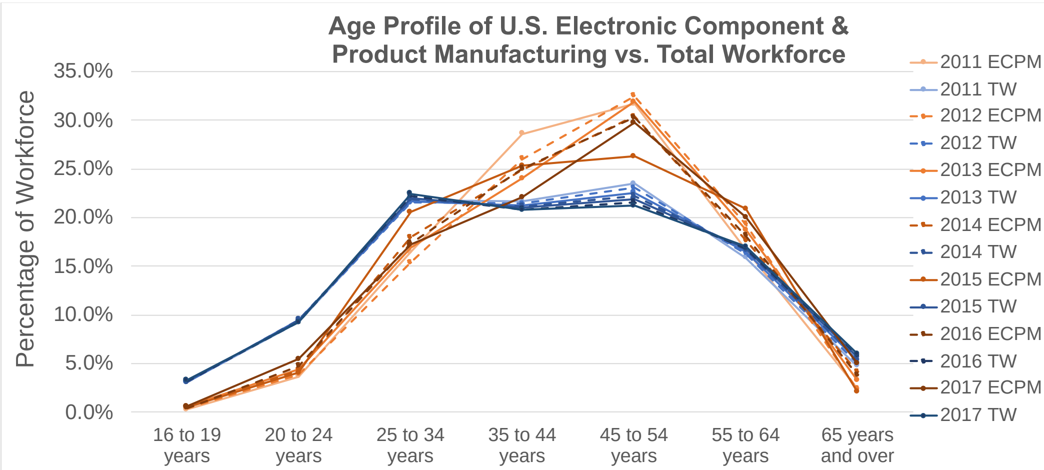

Figure 3. Age profile of workforce based on U.S. Bureau of Labor Statistics Survey information.

Another challenge is the student dropout rate for STEM programs at U.S. universities. Government and industry members can support mentoring, tutoring, and scholarship programs to encourage students to continue to pursue STEM programs at both the undergraduate and graduate level

Potential Workforce Solutions

RFI Question 7. Are there specific approaches your [member] company or organization utilizes to address [their] workforce needs? For example, tailored partnerships and curricula with regional universities and community colleges, internship or apprenticeship programs, training or retraining of displaced workers, or other approaches?

Many SIA member companies provide curriculum guides for colleges, universities, community colleges, and vocational schools. They provide internships, sponsor science competitions, and fund research grants, scholarships, and fellowships. Member companies further invest in technical upskilling programs for current workers.

RFI Question 8. Are there certain approaches or actions that would most effectively stimulate the supply of qualified workers for the semiconductor industry in the near term (e.g., targeted scholarships including internships/apprenticeships, loan repayment incentives, procurement of specialized equipment for schools and universities, immigration and visa reform, etc.)?

The highest priority change for the U.S. federal government is to stimulate the supply of qualified workers for the semiconductor industry in the near term by swiftly reforming our high-skilled immigration system to allow STEM graduates of U.S. institutions to remain in and work in the U.S. The best-and-brightest students from around the world are attracted to our world-class universities, but once they have their diplomas, current

U.S. immigration policy makes it almost impossible for these educated professionals to work, live, and contribute to the American economy. There is bipartisan support for reforming current green card policies for highly skilled immigrants, and strong government leadership is needed to make progress on this issue. The government should act swiftly to end per-country green card caps and exempt advanced STEM degree graduates of U.S. universities from existing green card caps.

From an immigration perspective, one way to increase the number of U.S. workers is to accelerate the permanent residency process for those that qualify for highly skilled immigrant visa categories (National Interest, Extraordinary Ability, Outstanding Researchers, etc.) through targeted immigrations reforms such as eliminating the per-country limit on immigrant visas coupled with recapturing unused immigrant visas from prior fiscal years. By speeding up the transition to permanent residency, highly skilled workers can switch from limited mobility work visas, such as the H-1B, and enter the unrestricted labor market as US workers.

Over the long term, the U.S. needs to develop a strategy to bolster STEM education to improve the skills of the workforce and increase the pool of available talent. This strategy should include increased funding for K-12 STEM education and scholarships and apprenticeships.

> *RFI Question 9. What approaches do you think would most effectively stimulate the supply of qualified workers for the semiconductor industry over the long term (e.g., professional development opportunities for K-12 teachers and K-12 student programs such as camps, competitions and projects in the semiconductor space)?*

Over the long-term, the federal government must do more to promote high quality STEM education both at the K-12 level and up through the higher education system. As stated above, the U.S. needs a comprehensive and coordinated STEM education strategy that includes teacher training, apprenticeships, coordinated internships, and other tools.[11]

Government and industry should also work to bring more hands-on experiences with semiconductors into more classrooms. Hands-on and work experiences contribute to better outcomes for workers over the long run and quicker returns on investment for firms that hire those workers. As the federal government works to implement Computer Science for All, hands-on experiences such as dissecting a cell phone or computer – as an analogue to biology curricula that include dissections of frogs, for example – should have a role in the curricula. While more needs to be done, SIA members are actively working on programs that bring such hands-on experiences to students.[12]

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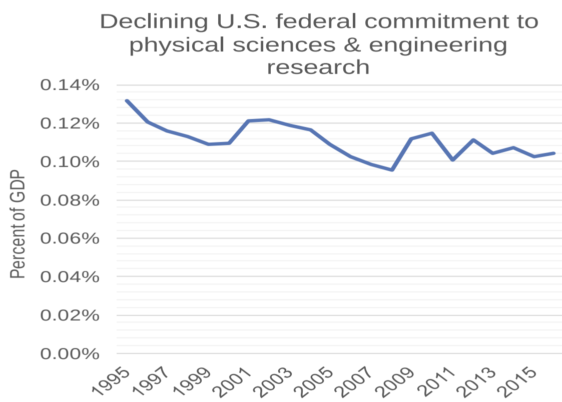
[11] Studies have shown that students who do not get interested in STEM in or before middle school are much less likely to choose a STEM education path and career. See R. Tai, C. Q. Liu, A. V. Maltese, and X. T. Fan. (2006). Planning for Early Careers in Science. Science 312(5777):1143-1144.
[12] For example, GLOBALFOUNDRIES' Robotics for Experiential & Applied Learning ("REAL") initiative aims to bring robotics into every 4th grade classroom and the SEMI Foundation's three-day career

STEM education programs should be rigorously evaluated, and funding should be allocated to scale up successful models for broader implementation. Several government funded programs, such as the Beaverworks Program at MIT funded by the Department of Defense, and industry funded programs, such as those described above, have proven positive outcomes and are ripe for larger investments to drive them to scale. However, there are currently no effective mechanisms to raise the significant funding needed to drive programs to larger regional and eventually national scale. The NSF's new INCLUDES initiative provides an initial investment in this critical area of need, but it does not itself have the necessary resources to meet the broader need. Therefore, the government should ensure funds critical for educating our future technical workforce are allocated for the short and long term through the appropriate legislation.

Finally, increased federal investment in semiconductor research is critical in addressing the future workforce in the industry. Government investment in semiconductor research provides the "pipeline" of highly educated talent that can drive innovation in the semiconductor industry for decades to come. Federally-funded projects provide learning opportunities and experience that firms cannot provide or fund on their own (e.g., Exascale program). Unfortunately, federal investment in research relevant to our industry has been flat or declining in recent years. See Figure 4.



SOURCES: National Science Foundation, Federal Funds for R&D survey and OMB, via AAAS

Figure 4 - U.S. federal research investment as a percentage of GDP

This decline in federal research investment is particularly harmful given that our global competitors are drastically increasing their commitment to funding research, which will place U.S. leadership in the semiconductor industry at risk.

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exploration known as High Tech U has provided real world experiences for thousands of students around the country. Further, IBM's P-TECH model brings industry and local governments together to develop industry relevant curricula and work experiences for students who will then graduate with a diploma and an Associate's degree.

RFI Question 10. Although apprenticeship has, in the past, been available mostly to those in the traditional trades, efforts are now underway to expand apprenticeship into new fields, including advanced manufacturing, IT, healthcare, energy supply and distribution, banking and finance and engineering (in partnership with four-year institutions). Have you considered engaging in apprenticeship training to prepare your workforce? Why or why not?

The semiconductor industry supports apprenticeship training to prepare our workforce. Government and industry should partner to develop industry-led apprenticeship models that are flexible enough to meet the rapid change in advanced manufacturing industries, including semiconductors. Studies have shown that internship or apprenticeship experiences can greatly accelerate new employees' ability to get up to speed and full productivity. The "Industry-Recognized Apprenticeship" model in consideration by the newly created federal Task Force on Apprenticeship Expansion has potential, but will require sufficient oversight to ensure the quality and relevance of the training experiences. The model must also provide an incentive, potentially in the form of federal funding, for employer participation. Some SIA members are pursuing new, industry-driven apprenticeship models to meet their needs.

RFI Question 11. Are there examples of partnerships with local educational institutions (e.g., a work-study program) that you use to support your operations?

Many SIA member companies have a long history of educational partnerships to support our long term talent needs. These include local degree programs from the community college through graduate levels, and extensive internship programs.

RFI Question 12. Are there types of support (grants, economic development incentives or other benefits) from federal, state and local government agencies that have helped enable your workforce? Of these types of support what makes them most effective?

The federal government should increase funding for semiconductor related R&D, providing a demand signal to researchers and students that this is an important area of national need. The National Science Foundation (NSF) has seen fewer research grant applicants in semiconductor related fields over the past decade, as researchers and their institutions do not see this as a growth area. Therefore, universities are not pursuing sufficient research in semiconductor science, nor are they attracting or training the students necessary to maintain U.S. innovation leadership. Increasing available funding for research in these areas would provide an important demand signal (and the crucial resources) to the science and engineering community that semiconductor research is a critical area of national need. In addition to traditional research funding opportunities, Defense Advanced Research Projects Agency (DARPA) challenges, like the Grand Challenge that stimulated production of some of the first self-driving cars, can be used to stimulate excitement, interest, and research in academia where students are trained. In addition, the new DARPA Electronics Resurgence Initiative (ERI), launched in 2017 and targeted for $1.5 billion in semiconductor R&D investment over five years, is an excellent example of the type of large-scale investment needed to fund university and company researchers needed to match the workforce and technology development challenges faced by the industry.

Additionally, federal, state, and local governments should improve and strengthen coordination on workforce development programs. Potential avenues for action include development or expansion of competency models, stackable credentials, internships, and apprenticeships.

Finally, state and local governments should actively engage with U.S. semiconductor firms to incentivize siting of new facilities and programs for workforce development. One SIA member noted that they have maintained design facilities in certain locales, even as they have shuttered co-located manufacturing operations, because of strong engagement by the state and local government to provide incentives to the company to stay and grow locally.

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SIA appreciates the opportunity to comment on this important issue and we are pleased to engage in further discussions on this topic.