SIA Workforce Roundtable
March 16th, 2018
Summary Report

Key Challenges:

1. Current U.S. high skilled immigration policy discourages the retention of electrical engineers and computer scientists – fields for which foreign nationals make up nearly 80 percent of current graduate students at U.S. universities – in the U.S.
2. The U.S. education system is poorly aligned with the needs of high technology industries that drive the U.S. economy, including the semiconductor industry, with too few American students, especially women and underrepresented minorities, developing needed STEM skills.
3. The U.S. semiconductor labor force is greying and tightly constrained, with a relatively small number of globally distributed top firms competing amongst each other for a limited and greying supply of top talent.

Key Opportunities:

1. The U.S. federal government should act swiftly to enact high skilled immigration reforms that eliminate the existing green card backlog, by ending discriminatory per country green card caps and exempting advanced STEM degree graduates of U.S. universities from existing green card caps.
2. The U.S. federal government should increase funding for semiconductor related research & development to provide a strong demand signal that draws more STEM students into these fields.
3. The U.S. federal government should act to align education curricula and policy with U.S. workforce needs, including by incorporating more direct, hands-on work experience into educational experiences.
4. The U.S. semiconductor industry should strengthen engagements with federal, state, and local workforce development programs, including workforce development boards, apprenticeship programs, and other mechanisms.
5. Both government and industry should redouble efforts to engage populations traditionally underrepresented in STEM fields, including women, underrepresented minorities, and veterans of the armed forces.

Introduction

The U.S. semiconductor industry accounts for roughly a quarter of a million direct jobs in the U.S., which is approximately 66 percent of the total global U.S. semiconductor industry workforce. 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. In addition, each semiconductor industry job creates nearly 5 additional jobs in the broader economy, on average, meaning the industry creates more than 1 million jobs across the economy.[i]

The strong multiplicative effect of semiconductor jobs stems in part from the strong and growing wages paid to semiconductor workers. 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 (see Figure 1).[ii]

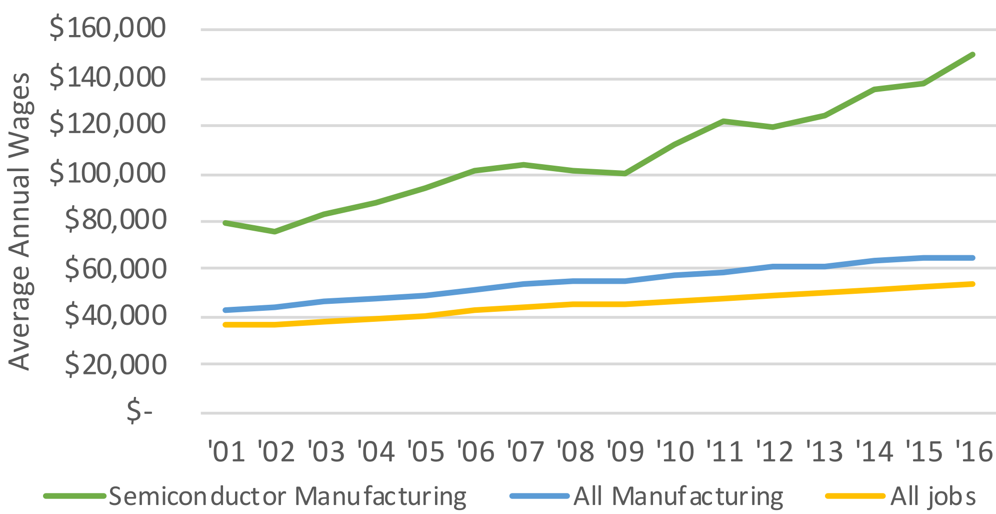

Figure 1. According to BLS statistics and SIA estimates, average annual wages for semiconductor manufacturing jobs far outpace all manufacturing and all U.S. jobs, and wages are only continuing to grow far and above wage increases for other occupations

The U.S. semiconductor industry's innovation edge rests on the efforts of scientists and engineers to develop innovative products that are better than the competition both here and abroad. One of the biggest challenges U.S. semiconductor firms face is recruiting and retaining top science and engineering talent. SIA companies are actively engaged in workforce and skills development efforts throughout the country, but a comprehensive workforce strategy is urgently needed to maintain America's technological edge. Access to the best-and-brightest scientists and engineers, *regardless of where they are born*, is critical to ensuring semiconductors remain a top U.S. export and our industry continues to be a key driver of a strong and innovative American economy.

On March 16, 2018 SIA convened industry leaders and policymakers from across the federal government to discuss the workforce challenges facing the semiconductor industry and what opportunities there are for public-private action to remediate those challenges in the short, medium, and long-terms. The following is a summary of that roundtable discussion.

Key Challenges

There are currently more than 4000 open technical positions in the U.S. among SIA's charter members, which comprise the majority of all U.S. semiconductor firms. Many of these positions have been open for months or longer. Firms face a host of challenges as they attempt to fill these positions, and the roundtable explored a wide range of policy issues and workforce development environments, from K-12 classrooms, to career and technical education, to undergraduate and graduate education, and workforce retraining. Below is a summary of the key challenges identified by participants.

1. **Current U.S. high-skilled immigration laws and regulations make it difficult to hire talented foreign nationals, who currently make up nearly 80 percent graduate students in electrical engineering and computer science programs.** The best-and-brightest students from around the world are attracted to world-class U.S. colleges and universities, and today, 80 percent of current graduate students in electrical engineering and computer science at U.S. universities are foreign nationals (See Figure 1). 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. 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.

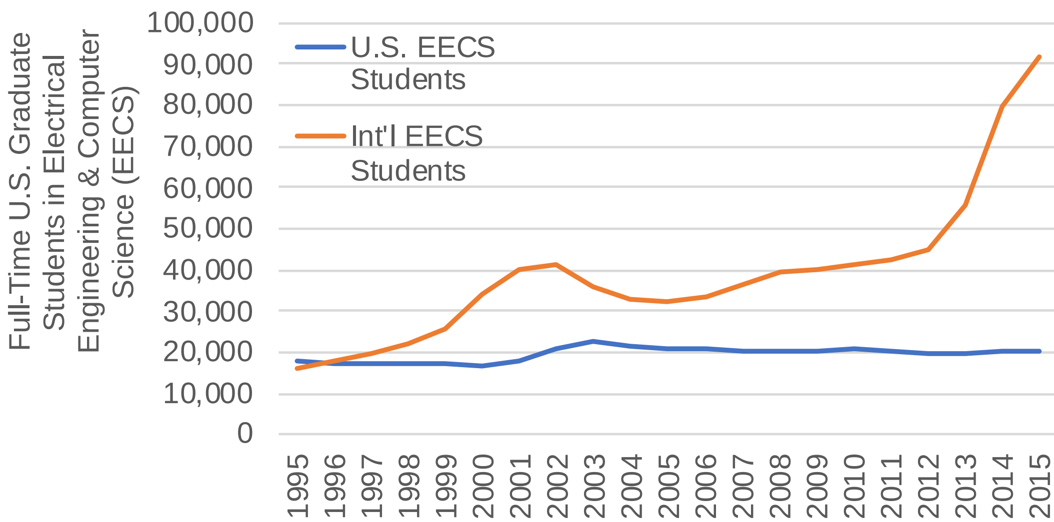

Figure 2. Full-time U.S. and international graduate students in Electrical Engineering (blue) and Computer Science (orange) at U.S. Institutions, based on National Science Foundation Survey of Graduate Students and Postoctorates and National Foundation for American Policy calculations.

2. **The U.S. semiconductor workforce is greying and the pipeline of younger talent is thin.** 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.

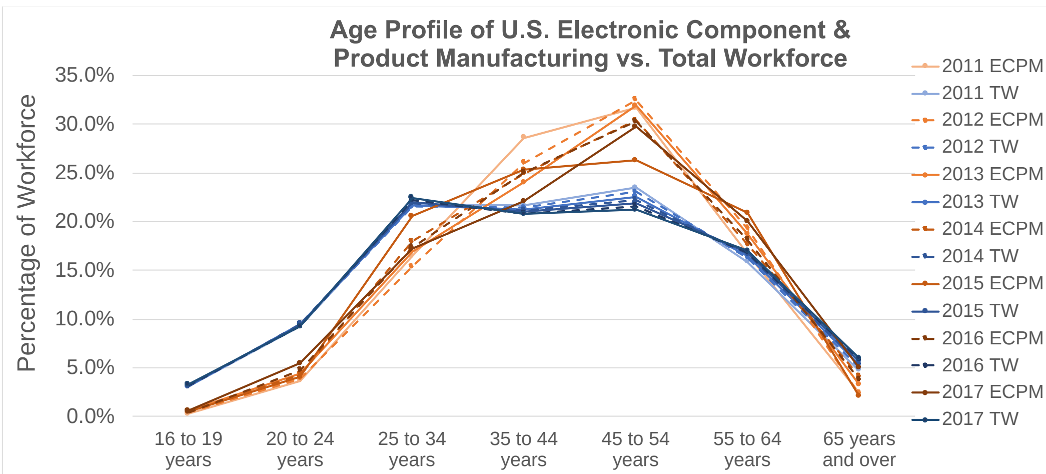

Figure 3. Age profile of workforce based on U.S. Bureau of Labor Statistics Survey information.

2.1 **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, including Google and Facebook, over the past two decades, many STEM students today have a much lower awareness of the role of semiconductors in the economy. Many of these students thus end up specializing in areas that are not relevant to a career in the semiconductor industry. Firms work to varying degrees to address these shortcomings through targeted engagement with college and university campuses on curriculum development and awareness building efforts. The degree of engagement is often a function of 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. Another contributing factor to this challenge for some firms is recruits' willingness to relocate outside major metropolitan areas where Google, Facebook, and other tech firms are predominantly located.

2.2 **New recruits often lack the skills to "hit the ground running."** Industry leaders highlighted that 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.

2.3 **There is a lack of diversity in the U.S. semiconductor workforce and broader STEM pipeline.** 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.[iii,iv] 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. One SIA member highlighted that 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.

2.4 **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.

3. **Industry consolidation and specialization has concentrated talent at a decreasing number of large firms.** One SIA member highlighted that many companies use mergers and acquisitions (M&A) as a way of acquiring talented teams of engineers that will increase competitiveness in existing or emerging technology areas of focus. As the U.S. semiconductor industry has gone through a period of consolidation and specialization, with a dwindling number of firms each focused on their own narrower ranges of technologies, there are fewer and fewer opportunities to acquire talent in this mode. Increasingly, the few firms in each market and technology thrust compete amongst each other for top talent with too few younger technical recruits moving up through the ranks.

3.2 **Firms, especially those in predominantly lower margin markets, must keep their operations lean to stay competitive.** The international playing field is not level, with other countries providing significant tax incentives and workforce development support targeted to the needs of national champion firms. In this globally competitive marketplace, firms compete on both technology performance and cost metrics, requiring lean operations that reduce available capital for on-the-job training and retraining, human resources, and other overhead costs.

Key Opportunities

Throughout the discussion, participants continually returned to the need for *large-scale public-private partnerships* to address workforce challenges facing high-tech industries, incluing semiconductors, that will be key to American prosperity and security now and in the future. U.S. semiconductor firms are actively working to hire more U.S. trained talent for high-paying jobs in the industry. This U.S. hiring focus is driven by many factors and varies by firm, but one SIA member identified the strong IP and trade secrets protections in the U.S. as key factors driving increased focus on U.S. hiring. Below is a summary of the key opportunities identified by participants.

1. **The U.S. federal government should act swiftly to reform our high-skilled immigration system to welcome highly skilled graduates of U.S. institutions.** Participants at the roundtable identified action on high-skilled immigration reform as the #1 change that would help the industry in the near term. 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.

2. **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.** At the roundtable, it was noted that 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. Increasing available funding for research in these areas would provide an important demand signal to the science and engineering community that this 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. The new DARPA Electronics Resurgence Initiative, 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 match the workforce and technology development challenges faced by the industry.

3. **Over the long-term, the federal government must do more to promote high quality STEM education at the K-12 level and up through the higher education system.** 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.[v] Federal agencies and fees collected through the U.S. high skilled immigration system provide some of the funds for federal K-12 STEM programs; however, the majority of the funding for K-12 education comes from the state and local levels. The largest fraction of federal funding for K-12 education comes in the form of Title I non-discretionary grants from the Department of Education, which should be better targeted toward developing STEM capable students.

   3.1 Government and industry should work to bring more hands-on experiences with semiconductors into more classrooms. There is a large body of evidence that shows 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" – as an analogue to biology curricula that include dissections of frogs, for example – should have a role in the curricula. SIA members and other industry stakeholders are actively working on programs that bring such hands-on experiences to students. 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 exploration known as High Tech U that 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.

   3.3 STEM education programs should be rigorously evaluated, and funding should be allocated to scale up successful models for broader implementation. Participants at the roundtable identified several programs, both 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, that 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.

4. **The U.S. semiconductor industry should strengthen engagements with existing federal, state, and local workforce development programs.** Governments at all levels have economic and workforce development investments that can be better leveraged when industry is in the lead. U.S. semiconductor firms should expand engagements with state and local entities, such as workforce development boards, to better focus workforce investments on areas of need. Participants at the roundtable discussed the development or expansion of competency models, stackable credentials, internships, and apprenticeships as potential avenues for action.

   4.1 **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. Unfortunately, U.S. semiconductor firms find that the existing apprenticeship model is too inflexible for this rapidly changing advanced manufacturing sector. 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.

   4.2 **State and local governments should actively engage with U.S. semiconductor firms to incentivize siting of new facilities and 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. These types of engagements at the state and local level are important avenues for maintaining and growing U.S. semiconductor employment. Firms should also engage workforce development boards and other avenues to build partnerships for workforce development efforts around the country.

Conclusion

The U.S. semiconductor industry has been one of the strongest drivers of the U.S. economy since the invention of the transistor in 1947 and its commercialization in the 1950s and 60s. Semiconductors are the brains that power our modern world, and the U.S. industry maintains a pole position in this critical market and at the leading edge of innovation. Brilliant teams of engineers and scientists working for U.S. firms drive this leadership position and public-private partnerships that have always been important to maintaining and growing this highly talented workforce and developing new technologies. Other nations are increasingly taking pages from that American playbook. The U.S. federal government and the U.S. semiconductor industry must act swiftly to address the workforce challenges discussed here if the U.S. is to continue to lead.

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[i] 2017 SIA Factbook. (2017, May). Retrieved from http://go.semiconductors.org/2017-sia-factbook-0-0-0.
[ii] Ibid.
[iii] 2017 Intel Diversity & Inclusion Report (2018, March 27). Retrieved from https://newsroom.intel.com/editorials/2017-diversity-inclusion-annual-report-approaching-first-leg-intels-journey/.
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[v] R. Tai, C. Q. Liu, A. V. Maltese, and X. T. Fan. (2006). Planning for Early Careers in Science. Science 312(5777):1143-1144.