Semiconductor Resurgence Creates Opportunity at Community Colleges

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Abstract: Newly announced semiconductor fabrication facilities in Ohio, Arizona, Indiana, New York, and Kansas have led to a need to increase the number of semiconductor workers, including technicians and engineers. The recently signed CHIPS and Science Act provides $52 billion of funding to support the semiconductor industry, with over $5 billion allocated for workforce development. This paper focuses on how community colleges can support technician education and prepare a diverse student population for transfer into semiconductor disciplines at four-year universities.

Keywords: semiconductor, technical education, community college, CHIPS, and Science Act

Introduction

The resurgence of US semiconductor manufacturing is a national call to action that will require recruiting, educating, and supporting a workforce anticipating adding tens of thousands of new jobs within the next few years [1]. The Micro Nano Technology Education Center (MNT-EC), a nationwide consortium of thirty-eight community colleges, believes authentic partnerships with industry and four-year universities are key to addressing semiconductor workforce needs in both technician training and educating graduate-level engineers. Though the current need is in semiconductor workforce education, MNT-EC supports community college technical education in all MNT-based emerging technologies, all exhibiting need cycles. A strategy must be developed that allows community college technical education programs to quickly and effectively pivot to specific needs when they arise. The current and near-future semiconductor workforce need is great; however, this need can ebb and flow based on past market conditions and cycles. In some years, the need is substantial, yet in others, the need is sparse [2]. Creating broad technical programs that can educate students to meet the requirements in various aspects of electronics, such as semiconductor fabrication, quantum, cybersecurity, and more, will provide long-term stability to community college technical education programs. These workforce programs can thus respond to industry-specific needs when high and not a niche workforce demand when down.

The global semiconductor market grew by 4% in 2022 to $618 billion [3]. Though 2023 market growth is expected to retract by 3.6%, it is anticipated that long-term workforce needs will remain high with

the building of new fabrication plants [1]. Semiconductors are essential components in thousands of electronic devices, particularly electric and self-driving vehicles. They are used to manage functions such as navigation and parking and to monitor engine performance. Supporting technologies in semiconductor fabrication, such as vacuum deposition technologies and lithography, also need the support of community college workforce education. Community colleges need to focus on creating broad technical education programs in combination with short "Boot Camps" or training programs that are designed to provide educational experiences tailored to specific industries, such as semiconductor manufacturing, providing access to resources community colleges lack, like working in a cleanroom or using complex and expensive instruments. Industry training programs should commence near the conclusion of students earning a technical education degree focusing on skills community colleges were unable to teach that best prepared them to work for a specific company. These training programs should be industry designed and ideally performed at industry partner sites or with industry-leading experts who can best train workers to enter their fabrication facilities. Ideally, for the semiconductor industry, education centers can be built and resourced across the country with industry support. These education centers should be available for any community college student to utilize and provide the just-in-time education to best prepare students for entering industry-specific semiconductor fabrication plants.

In January 2021, the US Congress passed the Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Act [4], substantially strengthening domestic semiconductor production and innovation in the years ahead. The CHIPS and Science Act includes $52 billion in chip manufacturing incentives, research investments, and an investment tax credit for semiconductor manufacturing and semiconductor equipment manufacturing. In addition, the CHIPS and Science Act provides funding for semiconductor workforce development education programs at all levels, from Doctorate to Associate of Applied Science technician degrees. These investments will reinvigorate US leadership in chip technology and reinforce America's economy, national security, and supply chains. This significant investment in semiconductor manufacturing means educational institutions must ramp up enrollment and completion at all degree levels. For instance, community colleges must respond to the growing semiconductor technician workforce need, especially in localities where new fabrication facilities are being built, such as Phoenix, Arizona; Columbus, Ohio; West Lafayette, Indiana; Kansas City, Kansas, Clay, New York, and Boise, Idaho, among others [5]. In many instances, these localities do not have enough space in technical education programs to fill the workforce need [6]. As a result, community college students tend to stay where they are educated [7]. A national strategy that incentivizes movement to high industry-need regions must be developed to fill workforce needs. Industry must play an essential role in applying apprenticeships, internships, or providing scholarships to students if they agree to move for work in fabrication plants outside their community college area. Without strong industry support, community colleges cannot fill industry needs. Thus, industry and community colleges must collaborate to develop a strategy that provides them with the essential technicians needed in the semiconductor industry [8].

Fig. 1. A. Semiconductor Industry locations (Data collected from MNT-EC Industry Analysis performed by EMSI) B. Semiconductor Community College Consortium Participants (Green Pins Community Colleges supporting proposed new Semiconductor Fabs)

The CHIPS and Science Act requires the US to have a strong semiconductor workforce pipeline and includes workforce development measures as part of manufacturing incentives and R&D programs [9]. These measures incentivize community colleges to educate a skilled workforce to meet the needs of current and future technician demands. Industry analysis was performed at MNT-EC, which shows semiconductor fabrication facility locations (Figure 1A) and supporting community college technical education programs (Figure 1B) concentrated in these areas. Most importantly, community college partnerships have been formed in regions where the new semiconductor fabrication facilities have been proposed as shown by the green pins in Figure 1B. However, with the expected growth from new semiconductor fabrication facilities and the need to continue supporting small and medium-sized semiconductor companies, a national initiative that educates thousands of semiconductor technicians annually is necessary.

Ohio's economic developments exemplify the semiconductor resurgence. Intel has announced plans for an initial investment of more than $20 billion through constructing two new leading-edge microchip factories in Central Ohio [10]. Manufacturing in Ohio is growing, and along with the jobs created directly as a result of high-profile expansions and new establishments such as Intel, growth in the manufacturing sector will have a ripple effect on suppliers and manufacturing-adjacent companies building on their success in the state, increasing the demand for a skilled workforce.

Intel plans to hire 3,000 individuals in the next three years in semiconductor manufacturing, create work for 7,000 construction employees, and attract a supplier network, with some companies already negotiating on-site locations in Ohio [11]. Semiconductor manufacturing also creates a greater demand for skilled trades and water treatment technicians. In addition, Amgen has broken ground on a new biomanufacturing facility to be operational by 2024 that will employ over 400 Ohioans [12]. Honda also recently announced an increased investment in the state [13], both at their existing plant and a new facility dedicated to electric vehicle battery production. These developments will have a ripple effect on suppliers and manufacturing-adjacent companies, increasing the demand for a skilled technical workforce in a labor market already struggling to meet the demands for skilled technicians. This industry growth will create an exponential impact on Ohio. According to Lightcast LMI Modeling [14], the three announcements at Intel, Amgen, and Honda alone will account for an enormous influx of jobs and increased earnings in the state.

- The estimates for new jobs above will create an additional $1.96 billion in earnings and result in 26,144 new jobs for the region.
- The ripple effect will stretch beyond construction (7,620) and manufacturing (5,560), increasing opportunities in retail (1,554 jobs), healthcare (2,288 jobs), and hospitality and food services (1,196 jobs).
- Management jobs are projected to have a significant increase (2,593 jobs) along with Business and Financial Operations (2,088 jobs), Architecture and Engineering Occupations (958 jobs), and Computer Occupations (595 jobs).

Methods

MNT-EC has partnered with SEMI Foundation and the National Institute of Innovation and Technology to assess the semiconductor workforce needs of the US (Surveys collected from January 15 to March 6, 2023). The survey was designed to be completed in five minutes to increase industry participation. Currently, there is no reliable data on the number of semiconductor workers needed, and no reliable data differentiates between different academic levels. Hence, the MNT-EC survey was created to hear directly from industry what their actual workforce needs are. It is not possible for industry to provide an exact count of the number of workers needed yearly. Consequently, the survey focused on industry needs and level of concern for hiring and provided a rough estimate on the number of yearly hires over the next five years. The survey aims to determine the workforce needs for the semiconductor industry at a regional and national level, focusing on educational needs from Doctorate engineers to technicians earning degrees at community colleges.

Surveys were sent to semiconductor industry representatives through e-mail lists shared by the SEMI Foundation, the National Institute for Innovation and Technology (NIIT), MNT-EC, the Society of Manufacturing Engineers (SME), and the National Society of Advanced Technology Centers.

Survey questions included:

1) Industry location (state and city)
2) Industry role
3) Industry headcount
4) Workforce needs by education level
5) Approximate workforce needs per year for each education level
6) Yearly percent attrition
7) Level of concern hiring for each education level
8) Which education levels industry would consider for apprenticeships.

Results and Discussion

Figure 2 below shows the responses from 39 unique semiconductor industry leaders and companies toward Ph.D. engineers and community college-educated technicians. It is evident that there is a need for both technician-level talent and highly educated engineers. There is a slightly higher level of concern for hiring technicians (40% highly concerned technician versus 22% highly concerned Ph.D.). Educating a technician is expected to be less expensive than educating a Ph.D. engineer because a technician can be educated in one or two years versus eight to ten years for a Ph.D. engineer.

Community colleges are also more affordable than four-year universities. In addition, job expectations for a Ph.D. level worker are to oversee the entirety of a project versus a technician who will be responsible for specific project processes. Thus, a focus needs to be on providing support for both the PhD. and technician-seeking students and programs. Community college recruitment strategies must fulfill two purposes. One is to encourage high-achieving STEM students to pursue transfer opportunities at four-year universities in semiconductor-specific programs and increase the number of students in semiconductor-supporting technical education programs that will lead to direct employment in the semiconductor industry. For this to be successful, community colleges must develop strong partnerships with industry, and industry must provide guidance and feedback on community college technical education programs.

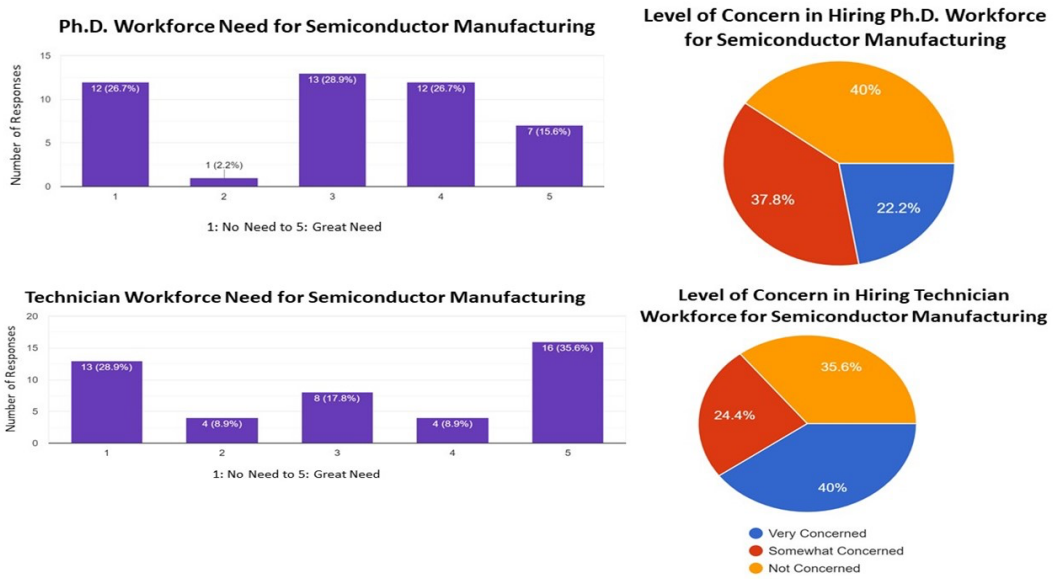

Fig. 2. Semiconductor Industry Workforce Needs and Concern Levels (45 unique Industry Responses)

One effective model to achieve impactful partnerships with industry is through the formation of Business Industry Leadership Teams (BILT) that are organized where industry supports the formulation of Knowledge, Skills, and Abilities (KSAs), needed competencies, and discusses trends with community college educators [15]. MNT-EC has a well-established microsystems BILT, which has developed a comprehensive KSA list that will be shared on the MNT-EC website by Summer 2023. Developing authentic community college-to-industry partnerships is the key to providing a well-prepared semiconductor technician workforce.

Conclusion

Designing and manufacturing the semiconductor devices needed for the future relies on a robust skilled technical workforce. A major concern in training a skilled semiconductor technical workforce is the capacity to educate technicians to work in fabrication facilities and train workers for all the ancillary technical jobs needed to support semiconductor manufacturing. Technical education has always been a strength of community colleges, but current circumstances have led to challenges in educating enough technicians to meet industry needs. Therefore, a nationwide approach is required to support

program development to increase academic pathways leading to student outcomes and certifications within the semiconductor manufacturing sphere.

Among community colleges, Pasadena City College (PCC) presently offers a certification and associate degree program in Advanced Materials - Nanotechnology, which is recognized by the Los Angeles Regional Consortium (LARC). An important recent development has been the establishment of the Micro Nano Technology Education Center (MNT-EC) at PCC and the Central Coast Partnership for Regional Industry-focused Micro/nanotechnology Education (CC-PRIME) project at Santa Barbara Community College (SBCC). In addition, the University of New Mexico, University of North Texas, Caltech, and over ten more research universities have partnered with the Micro Nano Technology Collaborative Undergraduate Research Network (MNT-CURN) to provide over 60 community college students year-long internship opportunities to better prepare them for entrance into the skilled technical workforce. All these programs are supported by the National Science Foundation Advanced Technological Education program and are organized whereas community colleges as a collective work in concert to grow a national technician workforce supporting the micro and nano technical education programs. The aim is to increase the number of community college faculty providing certificates and associate's degrees that lead directly to semiconductor industry jobs.

In Ohio, Intel Foundation awarded Columbus State Community College to lead the Ohio Semiconductor Collaboration Network in partnership with the Ohio Association of Community Colleges and the 23 community colleges [16]. The project will yield a robust and diverse workforce pipeline serving Intel, its suppliers, and the broader semiconductor industry through key deliverables: 1) enhanced curriculum, 2) faculty development, 3) experiential and project-based learning, 4) the establishment of the Ohio Semiconductor Collaboration Network, under the auspices of an OACC-led steering committee, and 5) wide dissemination of results and best practices.

Despite these developments, serious structural challenges persist. In particular, there is a low number and lack of diversity among students earning degrees or certificates and employment within semiconductor manufacturing [17]. Although semiconductor education requires access to specialized facilities at research universities, there is inconsistent coordination and a lack of formal programs between research universities and community colleges, impeding the facility access, training, and development of educational materials based on industry needs. The existing partnerships are often isolated, decreasing the impact that a nationwide effort could realize. In addition, industry focus frequently neglects community colleges in favor of the highly regarded and established four-year universities, which are perceived by industry as more essential to workforce development. A national partnership between community colleges aims to address these challenges by initiating a unified, coordinated approach through a partnership of all stakeholders, including community colleges, research universities, and industrial partners. In particular, efforts are needed to *attract* K-14 students from all backgrounds into semiconductor careers; *prepare* them with the skills needed by industry to pursue an industry career; and *connect* them with industry professional development opportunities, internships, and ultimately rewarding careers.

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