Fab talent crunch: Taiwan's secret sauce for producing excellent semiconductor engineers

Judy Lin, DIGITIMES Asia, TaipeiThursday 1 December 2022

Credit: DIGITIMES Asia

As semiconductor companies worldwide expand to build chip capacity, talent shortage has become the greatest challenge to growth and thus attracted more attention to talent education. However, education takes time, and speed to bridge the talent gap is critical because dozens of new fabs will be up and running in the next few years. Taiwan's experience may serve as valuable lessons for other countries.

Semiconductor talents are in hot demand worldwide. The US aims to boost its share in global semiconductor manufacturing threefold from the current 10% to 30% by 2030, while the EU aspires to double its share to 20% by 2030, and **41 new fabs** are currently being built in 2022-2025 across the globe. Take TSMC's Arizona facility, for example, it is estimated to create 1,600 jobs there and has recruited 250 American engineers. Though the size of fabs may vary, simple math tells us that it would require at least 65,600

workers to run the 41 fabs. The question is: where to find all those people in the next few years?

Taiwan's talent gap is already well over 35,000 every month as of 1Q22, despite the fact that its semiconductor talent supply is the most abundant among peers. Old engineers and managers are retiring at normal speed, while some middle-aged people may choose to leave the industry to pursue personal ambitions. There are just not enough young engineers to fill the vacancies in Taiwan due to the low birthrates over the past 20 years.

"Countries should invest to cultivate science, technology, engineering, and mathematics (STEM) talents" is already sounding like a cliché. Everybody is doing it, but the supplies of STEM students worldwide are simply not enough for the semiconductor industry. Many STEM graduates would rather work in other technology, media, and telecom (TMT) sectors, which appear more interesting than semiconductors to them. To attract students early on, semiconductor companies in Taiwan are giving out generous scholarships, internships, and mentorship at undergraduate levels, or even starting from vocational high schools.

Burn Lin, the TSMC veteran who invented the immersion lithography technology and now the dean of the College of Semiconductor Research at National Tsing Hua University (NTHU) in Taiwan, told the audience at an Academia Sinica forum on November 28 that the ideal ratio for talents in the semiconductor manufacturing process is 50%: 25%: 25% for bachelor's degree, master's degree, and Ph.D. degree, respectively.

However, that is a tough target to reach. Even for TSMC, the world's leader in semiconductor manufacturing, employees with Ph.D. degrees only account for 4.1% of the total. **TSMC has said that they have started taking in non-science and engineering majors** and giving them comprehensive training, in order to get enough people to operate the production lines.

On average, TSMC employees work 8.6 years for the company, according to TSMC's 2021 annual report. The average turnover rate for the company in 2021 was 6.8%, higher than the 2.4% reported by Samsung. Even though semiconductor engineers are well-paid and flush with bonuses, many of them still chose to leave. "It's heavy-duty life working as a research engineer in any semiconductor company in Taiwan. Not everyone can endure that kind of pressure," said Simon Lu, an Academia Sinica physics researcher who had worked at a major semiconductor firm in Hsinchu but decided to return to academic life.

Education level of TSMC employees (% in total)		
Education level	**2020**	**2021**
Ph.D. degree	4.1%	4.1%
Masters degree	47.3%	47.2%
University	27.6%	27.8%
Other higher education	8.9%	8.9%
High School	12.0%	12.0%

Source: TSMC 2021 annual report

In the NTHU College of Semiconductor Research, post-grad students are required to have at least 160 hours of "internship" at selected semiconductor corporation partners before they graduate. Otherwise, the students will have to take a three-credit course as a waiver. NTHU sets English proficiency as a priority in their screening processes, through which they take in 80 MSc students each year.

"Semiconductor talents education has to cultivate experts, versatile generalists, and agile application-oriented talents to collaborate in innovation," said Lin, who also stressed that the four semiconductor research institutes affiliated with National Taiwan University, NTHU, National Yangming-Chiaotung University, and National Cheng-Kung University have to cooperate and complement each other to create synergy.

However, education does not guarantee training can produce the right people for semiconductor manufacturing. Chee Wee Liu, the distinguished professor who leads the Advanced Silicon Device and Process Laboratory of National Taiwan University, told DIGITIMES in an email that IC technology talents need more education and training than those who do IC design.

"IC technology requires a lot of teamwork, communication, and a selfless personality willing to make a little sacrifice for the whole team. That is important in talent development education. Some things cannot be learned by oneself without being taught, so professors are key," Liu said, "IC technology students need to be humble to ask questions and to learn knowledge in many fields such as mechanics, chemistry, materials, and physics."

Liu emphasized that cycle time is always important to IC production, and so is talent education. "The idea of the student pipeline is to have a seamless transition from school to industry. We have to teach fresh Ph.D. students what the industry will need in the next

5 years. The Ph.D. students can have a comfortable start in the industry and enjoy their work," said Liu.

In reply to semiconductor companies' difficulty in retaining talents due to a lack of work-life balance, Liu said that as an engineer passionate about semiconductors, work-life balance really means enjoying work and life every minute to him. "We do not distinguish life and work. Self-learning ability is required for full career development. Very often, we solve problems in our dreams," said Liu.

Intrinsic problems hard to resolve

US semiconductor companies are also collaborating with American universities and even those in Mexico to attract talent to their fabs. However, all of those efforts focus on the semiconductor design and manufacturing level and have not taken into account the workforce needed for backend assembly, testing, and packaging (ATP), said Deloitte Consulting LLP.

"Receiving less press coverage than the fabs that actually manufacture the chips, these back-end capabilities are still a critical and necessary part of the process and take up about 15% of the global semiconductor workforce," according to the Deloitte report.

Of the nearly 500 ATP facilities in the world, only 65 are in America and 24 are in Europe. "If the two regions wish to become more fully self-sufficient, they will need to grow the ATP workforce at an even faster rate than the manufacturing workforce."

Deloitte's report "the Global Semiconductor Talent Shortage" estimated that to reach the demand for future capacity growth, the US faces a 70,000-90,000 worker shortage over the next few years, while Japan and South Korea are at a shortage of 35,000 and 30,000, respectively. China is already lacking 300,000 people before the supply chain problems emerged during the pandemic time, while the EU has not been quantified.

There is optimism abounds in celebrating the passage of the CHIPS Act and the capital promised for the industry and research, with reports clamoring for more than 1 **million new jobs** will be created for the direct semiconductor supply chain and the supporting ecosystem. But without sufficient talent, there can be a massive waste of investment and redundant equipment.

Chips will be more expensive

Geopolitics and regionalization trends will break up the old way of doing chips. The world's global supply chain has been extremely efficient, thanks to a highly complementary division of labor among countries and free trade, but now with multiple

countries building up dozens of new fabs around the world, the talent gap can jeopardize the effectiveness of the investment.

The complexity of the semiconductor manufacturing processes involves design, devices, materials, and equipment, and each requires advanced technical knowledge and experience. The US and Europe are leaders in IC design/EDA software and fundamental research, while Europe and Japan lead the equipment and materials. Around 80% of chips are made in Taiwan, South Korea, China, and Japan, while 90% of the ATP work is done in Asia, mostly concentrated in China, Taiwan, Malaysia, and some other Southeast Asian countries. People talk about over-dependence on Taiwan foundry, but the labor-intensive ATP supply chain in Asia is also difficult to diversify, according to Deloitte.

Semiconductor engineer salaries are on the rise because some companies are more desperate than others in the competition for talent. Higher chip engineer income will be part of the extra costs of making chips. The Boston Consulting Group (BCG) estimates that a hypothetical alternative with parallel, fully "self-sufficient" local supply chains in each region to meet its current levels of semiconductor consumption would have required at least about US$1 trillion in incremental upfront investment, resulting in a 35% to 65% overall increase in semiconductor prices, and that will also be reflected in higher costs of electronic devices for end users.

The industry needs to prepare for the workforce in three years when eventually all the 41 fabs will finish construction and existing fabs still need people to operate the equipment and tools to produce. Deloitte advised that organizations should redesign the way humans and technology interact in work processes, and unleash the workforce by identifying and accessing future skills across the engineering and manufacturing workforce to drive superior performance and value. Although automation and artificial intelligence can help streamline processes and maybe save some manpower, they can only do it to an extent.