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An 'inviting place': How Arizona emerged as a leader in the US semiconductor revival

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Arizona's arrival as the nation's hot spot for the semiconductor industry can be measured in corporate expansions, investment dollars and cutting-edge technology.

That was never assured. Before the Great Recession, the region's economy depended on land speculation, real estate development, housing and related industries.

Economic development experts warned that Arizona needed to diversify its economy and improve its education system to thrive. One key strategy they suggested: develop a cluster of businesses in a niche industry to attract venture capital investment, open cutting-edge research labs, lure industry leaders and generate jobs. Think of the aerospace industry in Houston, medical research in San Diego or computing in Silicon Valley.

Progress toward that goal in Arizona stalled with the Great Recession and the COVID-19 pandemic economy. But over time, it worked. Experts and others, and not just in metro Phoenix, now talk about the "Silicon Desert," a phrase repeated by everyone from chipmaker Intel Corp. to the French newspaper Le Monde.

The $65 billion that Taiwan Semiconductor Manufacturing Co. plans to spend on Arizona's showcase tech investment, a three-factory, or "fab," complex in far northwest Phoenix, puts the region on the international map as well.

That amount of money could pay for five new aircraft carriers like the Gerald R. Ford, which deployed in late 2022. Or 90 Chase Fields in today's dollars.

TSMC's investment here has eclipsed Intel's two-factory expansion of its Chandler campus, an ongoing $34.5 billion project that once ranked as the largest private-sector investment in Arizona's history.

Much of Intel's expansion and TMSC's efforts were jump-started by the federal CHIPS and Science Act.

Of the 10 largest recipients of funds announced so far under the act, three will be located at least partly in Arizona.

The biggest deals include Intel's tentative receipt of $8.5 billion in grants for projects in Chandler and two other states, and $6.6 billion for the TSMC campus in north Phoenix. TSMC's complex will feature the industry's most advanced chipmaking technology on American soil.

That's in addition to $400 million to help construct a $2 billion plant for Amkor Technology to test, assemble and package semiconductors. That facility will be located about 10 miles west of the TSMC plant. Add to that the $162 million for Chandler-based Microchip Technology, though the company will also spread that money to projects in two other states.

The TSMC complex stands as one of the two largest direct investments ever by foreign companies on U.S. soil, according to a TSMC-funded report by the Massachusetts Institute of Technology. The other, MIT noted, is a Samsung semiconductor factory in Texas.

Each TSMC job could generate another four to six at other businesses throughout the metro area, said Christine Mackay, community and economic development officer for Phoenix. Many of those will be based at the planned science and technology park surrounding the TSMC campus.

"This is the single greatest project we've ever received in Arizona that shows what regional economic development is all about," Mackay said.

Why Arizona's competitive advantage yielded outsized gains

Arizona benefited from the surge of industrywide investment from the federal CHIPS and Science Act, but not just from good luck. Arizona pursued a strategy and played on its strengths.

Arizona landed 19 of 83 semiconductor-related projects announced in the U.S. after the CHIPS Act was passed, according to a report updated by the Semiconductor Industry Association in April. Arizona's share of these nongovernmental investments more than doubled that of any other state.

A persistent push by economic development officials and coordinated action by city, state, educational and business representatives were behind some of the success.

They sold Arizona as an "inviting place ... an easy place to do business," Mackay said.

Sandra Watson, president and CEO of the Arizona Commerce Authority, credited the semiconductor industry's "explosive growth" in the region to that collaboration.

"It's critical that everyone is working together toward a common goal," Watson said.

Taiwan Semiconductor Manufacturing: The company we barely know is an industry icon

The effort to woo TSMC began years before the CHIPS Act, tied up in the state's strategy to broaden Arizona's economic clout. At a recent industry event in Tempe, Sean Fogarty, vice president of international business development at the Greater Phoenix Economic Council, cited several factors that help the Phoenix area attract investments like TSMC's.

He and Mackay agreed they include: a growing and relatively young population, a pro-business climate, a flat state income tax, ASU hosting the nation's largest engineering school with 33,000 enrolled, workforce-development programs in the Maricopa County Community Colleges District, and a steady pipeline of companies that might relocate or expand here.

"Every fab I've done due-diligence work for asks, 'Is there a university nearby, and is the engineering school up to snuff?'" said G. Dan Hutcheson, vice chair at semiconductor-analytics firm TechInsights. "That's one reason TSMC was attracted to Arizona."

Plus, he added, Arizona ranks as the lowest-cost state to build a fab among states where industry infrastructure already exists. Those costs include labor and taxes. Quality-of-life issues also tend to favor Sunbelt locations, he said.

It helps that Arizona doesn't face natural disaster risks like earthquake-prone California or Taiwan. In April, a 7.4-magnitude temblor rattled the island nation. It briefly halted some operations and caused $92 million in damage at TSMC's facilities.

Nor does Arizona face widespread power-distribution problems like those that plagued Texas three years ago. Mackay described the metro Phoenix power grid overseen by Arizona Public Service Co. and Salt River Project as exceptionally good, with few outages. "Power reliability is critical in advanced manufacturing," she said.

Wendell Huang, TSMC's chief financial officer, agreed.

He cited strong university and community college systems in Arizona and a sound and growing ecosystem of other semiconductor manufacturers and suppliers in the vicinity.

"To tap global talent is one of the purposes for going overseas," he said. "We're so big in Taiwan that we have been recruiting all of the best engineers from the best colleges. At some point, we needed to go overseas."

Kyle Squires, dean of the Ira A. Fulton Schools of Engineering at ASU, estimates that most of the 33,000 students enrolled there would qualify for careers in the semiconductor industry.

"The graduates of most of our programs are either directly connected to the industry, like those in electrical engineering or materials sciences, or in adjacent fields like mechanical engineering," he said.

An important long-term legacy of CHIPS Act funding, he added, will be in developing more engineering careers.

Huang also noted how Arizona officials rolled out the welcome mat to big effect.

"We have received very strong support from the state government and municipal government, which is really appreciated," he said during a July interview at company headquarters in Hsinchu City, Taiwan.

It helped that Arizona already was home to semiconductor operations, he added. Those include Intel, Chandler-based Microchip Technology and On Semiconductor, now headquartered in Scottsdale.

"Chip firms want to operate near other chip firms because they can tap into an existing labor pool and share suppliers," said Chris Miller, an associate professor at Tufts University and author of "Chip War: The Fight for the World's Most Critical Technology."

The 'hub' spreads out: Making room for suppliers

The outreach continues as Arizona tries to build on its success, expand its global footprint in the microchip industry and bring in more high-tech companies.

Gov. Katie Hobbs led a delegation to Taiwan last year. Another group of business, community and academic leaders headed by the Arizona Commerce Authority visited in early September. They went on to expand partnerships in semiconductors and other advanced industries, including suppliers in these and other fields.

Many are smaller businesses that need help dealing with permits and other obstacles, Huang said.

"We advocate for them, help them, support them when talking to the U.S. government," he said. "Because the U.S. government wants to build up a whole supply chain, an ecosystem, they will need to support these smaller and medium-sized companies."

TSMC oversees 13 science and technology parks in Taiwan, where suppliers and equipment makers cluster near the fabs to improve collaboration and shorten delivery times.

Knowing that, Phoenix officials initially suggested two sites for similar campuses here, Mackay said. A large tract in Laveen between Baseline and Elliot roads was in the running, but the city preferred the north Phoenix location to present to TSMC.

"We spent three years building this tech park on paper to show them we were serious," Mackay said. When an Arizona delegation visiting Taiwan presented its plans during a 2019 trip, TSMC officials decided they needed to return for further visits, she said.

The company's north Phoenix complex west of Interstate 17 and north of Loop 303 will feature a similar connection, acting as a catalyst to luring dozens of local suppliers. Some want to relocate to a planned 2,400-acre technology and science park surrounding the TSMC complex near Dove Valley Road.

In May, developer Mack Real Estate Group successfully bid $56 million to buy a 2,400-acre parcel adjacent to the TSMC plant to build 28 million square feet of industrial, office and retail space, along with apartments. The parcel envelops the TSMC complex to the east, north and west and could bring 50,000 jobs.

In August, Tempe-based Amkor Technology announced plans to build a $2 billion factory in Peoria, about 10 miles west of the TSMC site. Amkor will test and package semiconductors. Packaging involves protecting the devices and connecting their electronic terminals to the final products.

Amkor chose the location to be close to TSMC, one of its customers. Amkor stands to secure $400 million in grants and $200 million in loans under the CHIPS Act. Its new Peoria facility will employ 1,000 people and begin production in 2027.

All of Amkor's manufacturing growth had been outside of the U.S., said Susan Kim, executive vice chairman and daughter of James Kim, founder and chairman of the company. "This brings a critical element of the semiconductor supply chain to Arizona."

Huang said he's happy with the pace of building and preparations for TSMC's Phoenix fabs. Applications for TSMC's products continue to expand, with innovation showing no signs of slowing.

"Almost everybody, every (artificial intelligence) player, is working with us," he said, to cite one major revenue driver.

The company's heavy R&D spending and relatively few manufacturing defects give it an edge. AI applications require more advanced chips, due to the computing power needed. Recent industry reports suggest that production quality at the Phoenix plant, in test runs, has been roughly as good as at TSMC's fabs in Taiwan.

Asked what keeps him up at night, Huang cited potential labor shortages involving engineers, technicians and other job categories, including apprentices. TSMC currently employs around 2,200 people in Phoenix, but the company projects that will need to nearly triple, to 6,000 employees, over the next five or six years, and other companies such as suppliers will also be hiring.

Arizona's semiconductor industry: What to know about the booming field

Questions about environmental impact

Other challenges loom for the semiconductor industry, in Arizona and elsewhere. Concerns about water use, emissions and other environmental challenges remain. The advocacy group CHIPS Communities United asked the federal government to conduct more thorough reviews before doling out CHIPS Act money.

The group has criticized the Commerce Department for failing to conduct full environmental impact assessments and for finding “no significant impact” at the TSMC Phoenix site, Intel’s Chandler expansion and a Micron plant in Boise, Idaho.

CHIPS Communities United, citing Commerce Department documents, said the TSMC fab will use more than 17 million gallons of water each day and generate more greenhouse gases than 32,000 homes. It will consume enough electricity to power 300,000 Arizona households and dispose of PFAS, which it calls toxic "forever chemicals," by shipping them to a treatment facility elsewhere without specifying how they will be disposed of.

"We feel there are significant environmental impacts," said Judith Barish, coalition director for CHIPS Communities United.

But TSMC says it will use much less water, about 4.75 million gallons daily, and recycle two-thirds of that. The higher figure of 17 million gallons, a company spokesperson said, was a preliminary estimate that didn't consider recycling efforts and the construction of a reclamation facility on the site.

Miller, the "Chip War" researcher and author, acknowledges that these are problems, but he agrees they can be managed.

"There's no way around the fact that chipmaking is resource-intensive, but we need large volumes of chips," he said. "I think chip firms generally do a reasonable job of managing these tradeoffs."

Hutcheson agrees. While he acknowledges the hazards, including the need for dangerous chemicals, the industry and TSMC have gotten better at dealing with them, he said. For instance, engineers doubled the walls of pipes that transport various gases.

"The companies know about these risks. They're all engineers and they live near the plants," Hutcheson said. "It would be their kids who would get killed."

TSMC and Intel report they are following many sustainability practices, with TSMC pointing to what it said would be an advanced water-recycling effort in Phoenix. TSMC appears in the Dow Jones Sustainability Indices — a favorable reflection of its environmental practices.

Water availability remains a key issue, as does electric power consumption, which explains why major utilities, including Arizona Public Service and Salt River Project, have incorporated their long-term planning with chip plants in mind.

Huang cited several of TSMC's sustainability and conservation efforts, from the Phoenix water-reclamation facility to a biodiversity program that it sponsors in Taiwan. Also, he noted that many of TSMC's chips "help the world save power," by reducing electricity consumption in smartphones and operating solar panels and windmills more efficiently.

What's next for the industry in Arizona?

As of Sept. 1, the Arizona Commerce Authority counted 45 "mega" projects being pursued by the state. State officials expect these projects to generate at least 1,000 jobs and $500 million each in capital investments in the semiconductor and other industries.

Combined, they could bring more than 76,000 potential new jobs and nearly $150 billion worth of investments.

The most recent big tech announcement involved ASM, which produces materials used to manufacture semiconductor chips. In late September, ASM and Scottsdale announced a deal to build a new corporate headquarters, a $400 million investment bringing 1,200 high-paying jobs.

“What separates Arizona’s semiconductor ecosystem from other clusters is not just the scale of our industry growth, but its diversity," Watson said.

"Arizona is seeing expansions across the entire value chain including in leading-edge manufacturing, (research and development), suppliers, equipment, advanced packaging and workforce.”

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This is one of a series of articles about Taiwan Semiconductor Manufacturing Co. and the growth of the semiconductor industry in Arizona. Read more on azcentral.com.