TAIWAN AND THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN

- Singapore's Semiconductor Industry

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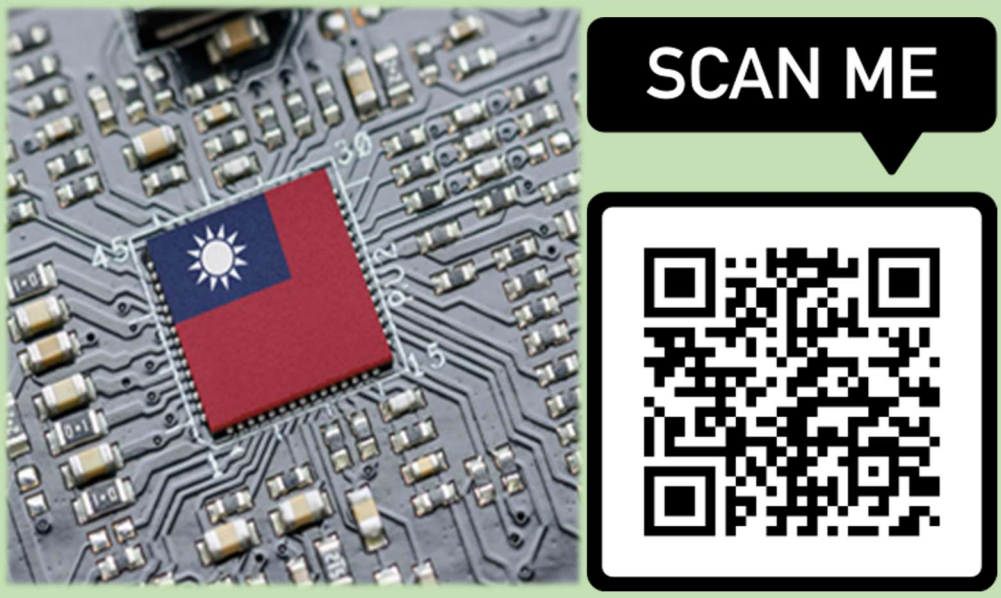

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Singapore's Semiconductor Industry

- **Singapore's semiconductor industry is made up of an ecosystem of global foreign giants and local small and medium-sized enterprises.**
- **Singapore has built significant infrastructure around legacy chip production.**
- **Singapore reports that it currently accounts for 10% of all chips produced worldwide and approximately 20% of global semiconductor manufacturing equipment production.**
- **Amidst geopolitical tension and semiconductor supply chain shifts, Singapore has emerged as an attractive destination for semiconductor players seeking to establish manufacturing operations in Southeast Asia.**
- **Semiconductor ties between Taiwan and Singapore are deepening, with investments from major Taiwanese players focusing on legacy chips present in various segments of Singapore's semiconductor industry.**

Source: Created by Microsoft Copilot

OVERVIEW

Singapore has a long history in semiconductor manufacturing. Shortly after American microelectronics company National Semiconductor set up Singapore's first semiconductor facility in 1968, two more big names, Fairchild and Texas Instruments, followed soon after. More than 7,000 jobs were created in just three years by those three semiconductor companies.[1] Additionally, in 1986, Singapore ventured into the foundry industry by establishing Chartered Semiconductor Manufacturing.[2] This early start was instrumental in establishing Singapore as a semiconductor hub, generating over a dozen semiconductor fabricators each with US$ 1 billion or more in investment, and firmly placing Singapore on the global tech map.

In recent decades, the global semiconductor landscape has witnessed tremendous changes, driven by various factors such as geopolitical tensions, technological advancements, and government-backed initiatives to support domestic semiconductor production and innovation. Singapore, despite its foundation in the semiconductor sector, is facing stiff global competition from both established and emerging players.

Global Shifts in Semiconductor Manufacturing

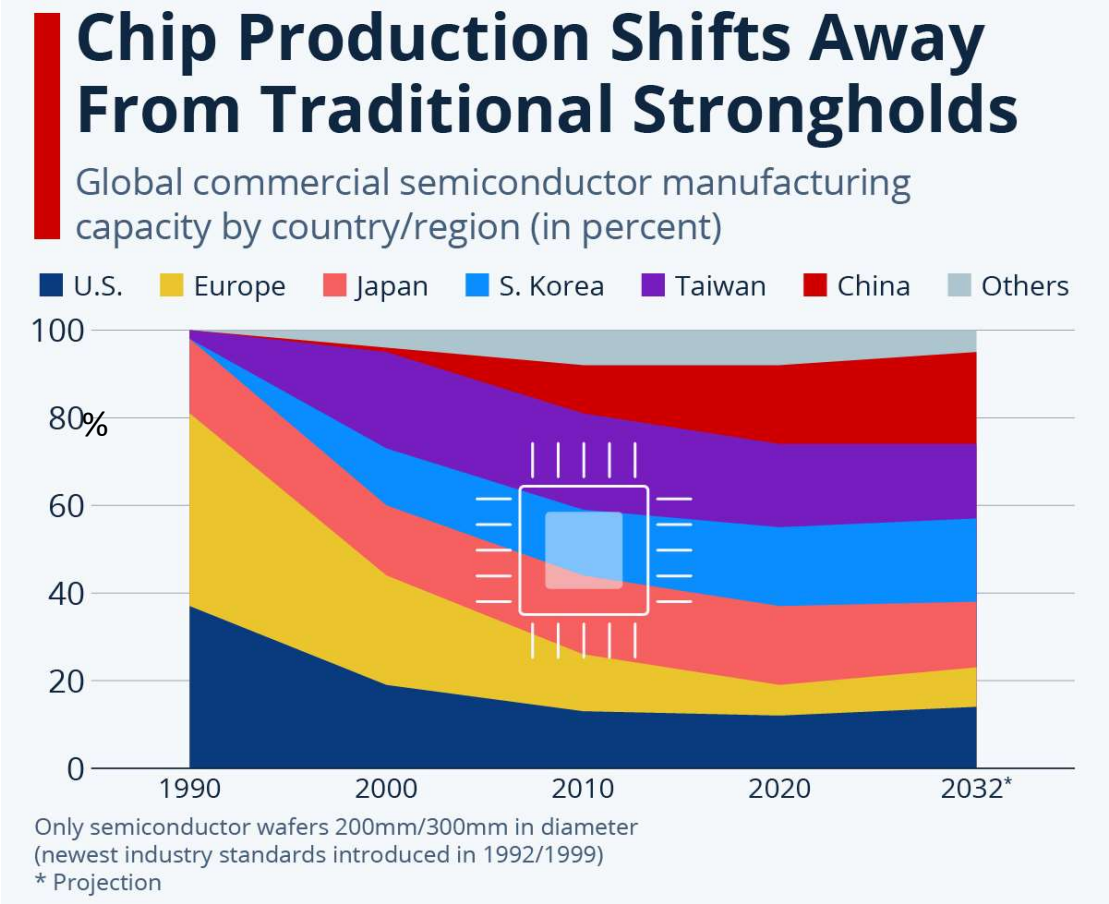
The United States, Japan and Europe used to dominate semiconductor production in 1990. Europe led with 44%, the U.S.A. followed with 37%, and Japan had 19% of the fabrication capacity.[3] However, their combined production share fell to 37% in 2020 as semiconductor production shifted to South Korea, Taiwan and China (see Figure 1).

As semiconductors are increasingly viewed as a strategic resource, the global competition to attract and anchor semiconductor investments has intensified.[4] In recent years, the United States, Japan and Europe have launched initiatives to attract semiconductor investments and production back

[1] "Is Singapore's semicon sector on the skids?" The Business Times, November 8, 2019.
[2] Economic Development Board, Singapore, Press Release: "National Semiconductor Pte. Ltd," December 17, 1968. https://www.nas.gov.sg/archivesonline/data/pdfdoc/PressR19681217c.pdf. Accessed on August 19, 2024; "Returning Singapore to the global stage of semiconductor production," The Business Times, May 7, 2019.
[3] Florian Zandt, "Where Can the Most Chips Be Manufactured?" Statista, December 5, 2023.
[4] U.S. Department of Commerce, Press Release: "Analysis for CHIPS Act and BIA Briefing," April 6, 2022.

on their shores.[5] The U.S.A.'s CHIPS and Science Act of 2022 provides US$ 39 billion in grants to boost semiconductor manufacturing.[6] The European Union has approved a € 43 billion (US$ 47 billion) plan to develop more fabs and increase semiconductor production in the region. Likewise, Japan has set aside ¥ 4 trillion (US$ 27 billion) to attract investments and enhance its semiconductor capabilities.[7] Other countries are also eyeing a slice of the semiconductor pie. Singapore, for example, seeks to leverage its strategic location, supportive government policies and political neutrality to attract new investments and grow its semiconductor industry.[8]

Figure 1: Global semiconductor manufacturing by country/region: 1990-2030



[5] Raj Varadarajan, Iacob Koch-Weser, Christopher Richard, Joseph Fitzgerald, Jaskaran Singh, Mary Thornton, and Robert Casanova, "Emerging Resilience in the Semiconductor Supply Chain," Semiconductor Industry Association and Boston Consulting Group, May 4, 2024

[6] National Institute of Standards and Technology, Department of Commerce, United States, "CHIPS for America Fact Sheet: Federal Programs Supporting the U.S. Semiconductor Supply Chain and Workforce," March 18, 2024.

[7] Council of the EU, Press Release: "Chips Act: Council gives its final approval," July 25, 2023; Commerce and Information Policy Bureau, Ministry of Economy, Trade and Industry, Japan, "Outline of Semiconductor Revitalization Strategy in Japan," July 2024.

[8] Ernst & Young, "When the Chips Are Down: ASEAN Could Be the Answer to the Semiconductor Crunch," 2022.

Note: Only semiconductor wafers 200mm/300mm in diameter
Source: Katharina Buchholz, "Chip Production Shifts Away from Traditional Strongholds," Statista, July 19, 2024.

Singapore's Role in the Global Semiconductor Supply Chain

The global semiconductor supply chain involves a wide range of highly specialized companies and institutions that are geographically dispersed but interconnected through a supply chain encompassing the seven sectors, each with its own specialized role (see Table 1).[9] Each sector plays a crucial role in the semiconductor ecosystem, contributing to the advancement of technology and innovation.

Table 1: Sectors in Semiconductor Supply Chain

	SECTOR	DESCRIPTION
1)	**Research & Development (R&D)**	The R&D sector determines the future capabilities and performance of semiconductor devices.
2)	**Design**	The blueprints for semiconductor devices, including the architecture and circuit design are created by engineers during this phase.
3)	**Front-End Manufacturing: Wafer Fabrication**	After the design stage, semiconductor chips are fabricated in facilities often referred to as fabs or foundries.
4)	**Back-End Manufacturing: Assembly, Testing and Packaging (ATP)**	After the wafers are fabricated, they are cut into individual chips, assembled into packages, tested for quality and functionality, and then prepared for shipment.
5)	**Electronic Design Automation (EDA) and Core Intellectual Property (IP)***	EDA refers to the software tools used for designing semiconductor devices. Core IP involves the essential designs and patents that are part of the semiconductor devices.
6)	**Equipment and Tools***	This sector provides the specialized machinery and tools required for semiconductor manufacturing, such as lithography equipment, etchers, and testers.
7)	**Materials***	Semiconductors require high-purity materials, including silicon, various gases, and chemicals used throughout the manufacturing process.

* These components are considered a specialized support ecosystem of chip manufacturing.
Source: SIA/BCG, April 1, 2021

Semiconductor supply chains include research and development (R&D), production, production inputs, and distribution for end-use. R&D underpins all

[9] Antonio Varas, Raj Varadarajan, Ramiro Palma, Jimmy Goodrich, and Falan Yinug, "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era," Semiconductor Industry Association (SIA) & Boston Consulting Group (BCG), April 1, 2021.

production and its inputs. Semiconductor production includes three segments, namely, design, manufacturing, and assembly, testing, and packaging (ATP). The packaged chips are then distributed to various end-users, including electronics manufacturers, automotive companies, and consumer electronics firms. These end-users incorporate the chips into their products, such as smartphones, cars, and various appliances.

The production of semiconductors relies on associated elements of the supply chain: semiconductor manufacturing equipment (SME), electronic design automation (EDA) software, and intellectual property related to chip designs (called core IP). The highest value and most technologically complex parts of this process are the design and fabrication segments of production, and the SME element of the supply chain.

In addition, the semiconductor manufacturing ecosystem is a global network characterized by its complexity and specialization (see Figure 2). The semiconductor industry is highly concentrated, with companies headquartered in the United States, Taiwan, South Korea, Japan, China and the European Union (EU) accounting for nearly all semiconductor revenue.[10] Within each process role, the industry is further concentrated, with companies from specific locales dominating the market.

Specific regions excel and specialize in different aspects of the global semiconductor supply chain. For example, U.S.-headquartered companies lead in design, core IP, and EDA; the United States, EU, and Japan jointly lead in equipment; companies headquartered in China, Japan, Taiwan, and South Korea lead in materials; South Korea- and Taiwan-headquartered companies lead the world in advanced node fabrication (technology nodes with feature sizes of 7 nm or smaller); while Taiwan and China are major players in assembly, test, packaging (ATP).

The semiconductor industry operates as a global effort, with no single country or region dominating every segment of the value chain. While Asia, particularly Taiwan and South Korea, stands out with their strong manufacturing hubs, other regions also play crucial roles. This means the end-to-end process for creating a semiconductor generally involves multiple actors across the globe. A plant in Japan might cut silicon ingots into wafers, which are then shipped to the United States for fabrication into semiconductors. The

[10] Office of Technology Evaluation, Bureau of Industry and Security, U.S. Department of Commerce, "Assessment of the Status of the Microelectronics Industrial Base in the United States," December 2023.

next leg of the process could take them to Malaysia for sorting, cutting into dies, assembly, packaging, and testing. Finally, they might be sent to Singapore for incorporation into a finished product as a chip.[11]

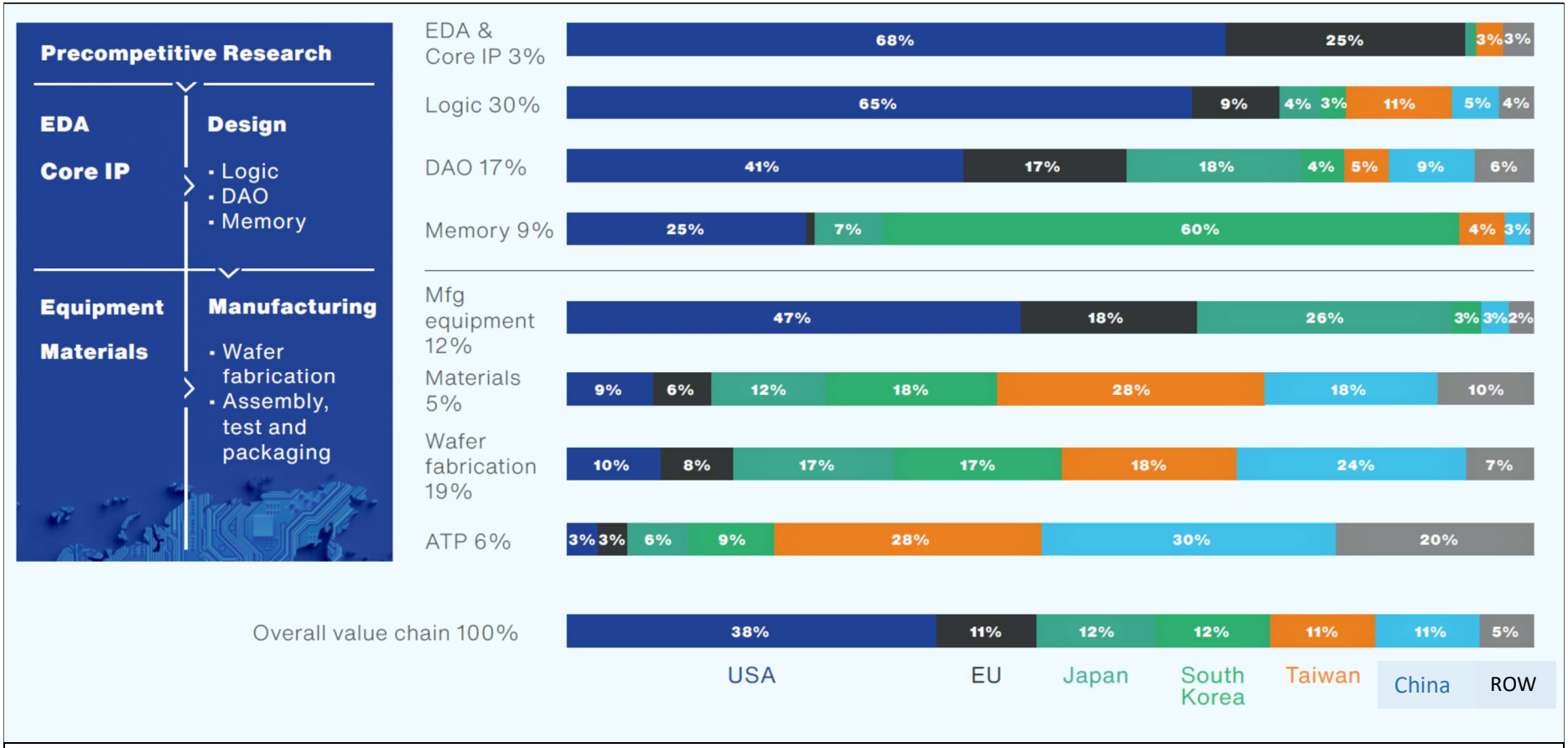
In 2022, in terms of value-added to the overall semiconductor value chain by region, the U.S.A. led with 38%, followed by Japan and South Korea at 12% each. Taiwan, the European Union, and China each contributed 11%, while the rest of the world, categorized as "Rest of the World" (ROW)" accounted for 5% of value-add to the overall semiconductor value chain. Countries in the "ROW" category, which includes countries like Singapore, India, Israel, and Malaysia, play crucial roles in specific segments of the value chain despite their smaller overall percentage (see Figure 2).

In terms of value-added to the overall semiconductor value chain by activity, design of logic chips (30%) is the highest value-added activity in the global semiconductor value chain in 2022. Wafer fabrication (19%) is the second highest value-added activity in the overall semiconductor value chain; followed by design of discrete, analog, and other (DAO) chips (17%); semiconductor manufacturing equipment production (12%); design of memory chips (9%); assembly, testing and packaging (ATP) (6%); semiconductor materials (5%); and electronic design automation (EDA) and core intellectual property (IP) (3%). The value-added distribution in the global semiconductor value chain for 2022 underscores the contributions of chip design, wafer fabrication and semiconductor manufacturing equipment production. These high value-added activities are again dominated by the major players, highlighting their advanced technological capabilities, substantial investments in R&D, and robust industrial ecosystems (see Figure 2).

Unsurprisingly, the global semiconductor value chain is dominated by the major players – the United States, Taiwan, South Korea, Europe, Japan and China – which have significant investments in semiconductor manufacturing, research and development (R&D), and technology development (Figure 2).

[11] Ondrej Burkacky, Matteo Mancini, Mark Patel and Giulietta Poltronieri, "Exploring new regions: The greenfield opportunity in semiconductors," McKinsey & Company, January 29, 2024.

Figure 2: Semiconductor industry value-added by activity and region: 2022 (%)



Notes on regional breakdown:

- EDA, design, manufacturing equipment, and raw materials based on company revenues and company headquarters location.
- Wafer fabrication and assembly & testing based on installed capacity and geographic location of the facilities.
- RoW includes Singapore, Israel, India and the rest of the world.

Source: Raj Varadarajan, Iacob Koch-Weser, Chris Richard, Joseph Fitzgerald, Jaskaran Singh, Mary Thornton, Robert Casanova and David Isaacs, "Emerging Resilience in The Semiconductor Supply Chain," Boston Consulting Group, May 2024, p. 10.

Singapore's semiconductor industry is comprehensive, covering all key areas of the supply chain. While smaller in scale, it contributes significantly to the global value chain, particularly in wafer fabrication and semiconductor manufacturing equipment production.[12]

IC Research & Development

The Institute of Microelectronics (IME) is a research institute under Singapore's Agency for Science, Technology and Research (A*STAR).[13] Positioned to bridge the R&D between academia and industry, IME's mission is to add value to Singapore's semiconductor industry by developing strategic competencies, innovative technologies and intellectual property; enabling enterprises to be technologically competitive; and cultivating a technology talent pool to inject new knowledge to the industry.

IC Design, Electronic Design Automation and Core Intellectual Property

The Centre for Integrated Circuits and Systems (CICS) at Nanyang Technological University (NTU), which is jointly funded by NTU and the Singapore EDB, focuses on developing advanced IC design technologies for applications in medical technology, clean technology, and consumer electronics. Its research areas include analog, mixed-signal, power management, RF and mm-wave ICs, and energy harvesting.

In 2012, U.S. Qualcomm established an IC Design and Engineering R&D Center in Singapore to leverage local and regional talent. This center focuses on developing hardware and software design solutions and supports Qualcomm's existing product test center in Singapore. Its test center of excellence in Singapore carries out design verification and failure analysis for the smartphone chipmaker's new products and technologies.[14]

Taiwan's MediaTek Incorporated, the world's fifth largest global fabless semiconductor company, has been in Singapore since 2004. It develops highly-integrated, ultra-low-power system-on-chip devices spanning various

[12] "What makes Singapore a prime location for semiconductor companies driving innovation?" Economic Development Board, August 20, 2024.
[13] "Welcome to the Institute of Microelectronics," A*STAR, https://www.a-star.edu.sg/ime/home, Accessed on September 13, 2024.
[14] Qualcomm, Press Release: "Qualcomm Establishes Integrated Circuit Design and Engineering R&D Center in Singapore," March 29, 2012.

platforms, including smart home, connectivity, Internet of Things (IoT), Application-Specific Integrated Circuits (ASICs) and smart mobile devices.[15]

Frontend Manufacturing: Wafer Fabrication

Singapore's sole attempt to establish its own foundry, Chartered Semiconductor Manufacturing, modeled after Taiwan's TSMC, ultimately resulted in its acquisition by the US-headquartered firm GlobalFoundries in 2010.[16] Thereafter, rather than devoting significant efforts to create a national champion by grooming home-grown fabs, Singapore's strategy has shifted to strategically attract established foreign players including GlobalFoundries, STMicroelectronics and United Microelectronics Corporation, Vanguard International Semiconductor (VIS), and Next eXPerience (NXP) Semiconductors to invest in the country.

Backend Manufacturing: Assembly, Testing and Packaging

Taiwan-headquartered Advanced Semiconductor Engineering (ASE), China-based Jiangsu Changjiang Electronics Technology (JCET) and Singapore-headquartered but Chinese-owned UTAC Holdings Ltd are prominent companies in Singapore's semiconductor assembly, testing, and packaging industry.[17] Local companies play a crucial role in supporting major players in the semiconductor industry in Singapore. For example, mainboard-listed AEM Holdings, which provides advanced chip testing solutions, is a crucial partner of United States chipmaker Intel.[18]

Semiconductor Manufacturing Equipment

Kulicke and Soffa Industries, a leading chip packaging and testing equipment maker, moved its corporate headquarters from the U.S.A. to Singapore in 2014. Its largest manufacturing facility, located in Singapore, is known for its advanced manufacturing capabilities, producing a wide range of semiconductor assembly equipment. This includes wire bonders, wedge bonders, and advanced packaging solutions. Its Singapore facility is a key hub for their global operations.[19]

[15] "About MediaTek," MediaTek, https://www.mediatek.com/who-we-are, Accessed on September 16, 2024.
[16] "GlobalFoundries ramping up S'pore chip operations," The Business Times, April 20, 2014.
[17] UTAC Holdings Ltd is owned by Wise Road Capital, a private equity firm based in Beijing, China.
[18] "Diverse capabilities, infrastructure help drive chips industry in Singapore," Economic Development Board, Singapore, September 3, 2022.
[19] "Overview," Kulicke and Soffa Industries, https://www.kns.com/Company/About-K-S/Overview, Accessed on September 13, 2024.

Dutch SME giant ASML maintains an office in Singapore which supports its field service engineers and other operations in the region.[20] Dutch SME parts supplier BE Semiconductor Industries N.V. (Besi) maintains an office for support and sales in Singapore, while its regional manufacturing takes place in Malaysia. Besi Singapore is the Die Attach group's primary contact point in Asia, specializing in high-speed epoxy and flip chip die bonding.[21] NTS Group, a Dutch-based maker of complex, mechanic and mechatronic equipment used by semiconductor firms recently opened a major new assembly and manufacturing plant in Singapore for global clients in the Asian region.[22]

ASMPT (formerly known as ASM Pacific Technology Limited), a Singapore-headquartered company listed in Hong Kong, has 11 manufacturing facilities in China, Hong Kong, Germany, Singapore, the Netherlands, and the United Kingdom. It manufactures surface mount technology equipment and semiconductor back-end equipment, including assembly equipment and packaging equipment.[23]

Singapore Exchange-listed UMS Holdings is an integrated original equipment manufacturer (OEM) for front-end semiconductor gear.[24] It specializes in manufacturing high precision front-end semiconductor components and performs complex electromechanical assembly and final testing services, primarily to its key client Applied Materials.[25]

Semiconductor Materials

Most of the big players often have an established pool of suppliers. Local companies such as ELH Tech, has successfully raised its standards and now supplies 3D-printed parts and components to local foundries, including STMicroelectronics.[26]

[20] "Locations," ASML, https://www.asml.com/en/company/about-asml/locations#singapore, Accessed on October 7, 2024.
[21] "Company Overview," BESI, https://www.besi.com/company/company-overview/, Accessed on October 7, 2024.
[22] NTS, Press Release: "NTS strengthens position as one-stop supplier with the opening of their new facility in Singapore," September 20, 2024.
[23] "ASMPT Singapore Pte. Ltd.", ASM Pacific Technology Ltd, https://www.asmpt.com/, Accessed on September 13, 2024.
[24] "Our Business," UMS Group, https://www.umsgroup.com.sg/abt_business.html#:~:text=We%20are%20a%20precision%20engineering,assembly%20and%20final%20testing%20services, Accessed on September 19, 2024.
[25] "Equities Market Insights: UMS Holdings," DBS Treasures, https://www.dbs.com.sg/treasures/aics/templatedata/article/equity/data/en/DBSV/012014/UMSH_SP.xml, Accessed on September 19, 2024.
[26] "Singapore chipmakers see growth wave amid generative AI boom," Economic Development Board, Singapore, May 9, 2024.

Advanced Substrate Technologies (AST), a subsidiary of Japan's TOPPAN Holdings, is constructing a facility – the first in Singapore – to produce high-end flip-chip ball grid array (FCBGA) substrates used in chips vital to AI applications such as custom processors and networking chips. [27]

Wah Lee Tech (Singapore) Pte, Ltd., a subsidiary of Wah Lee Group based in Taiwan, was founded in Singapore in 2003. Its semiconductor segment provides silicon chips, as well as chemicals and special gases used for the manufacture of ICs.[28]

Singapore's Share of Global Production

- EDB reported in August 2024: Singapore accounted for 10% of all chips produced worldwide and 20% of global semiconductor manufacturing equipment production.
- Knometa Research: As of December 2023, the "Rest of the World" (ROW) category which includes smaller players like Singapore, Israel, Malaysia and India, accounted for 7.3% of the global monthly 8-inch equivalent IC production capacity.

Singapore's Economic Development Board (EDB) reported in August 2024 that the city state is "already an integral part of the global semiconductor supply chain," accounting for "10% of all chips produced worldwide and approximately 20% of global semiconductor manufacturing equipment production."[29]

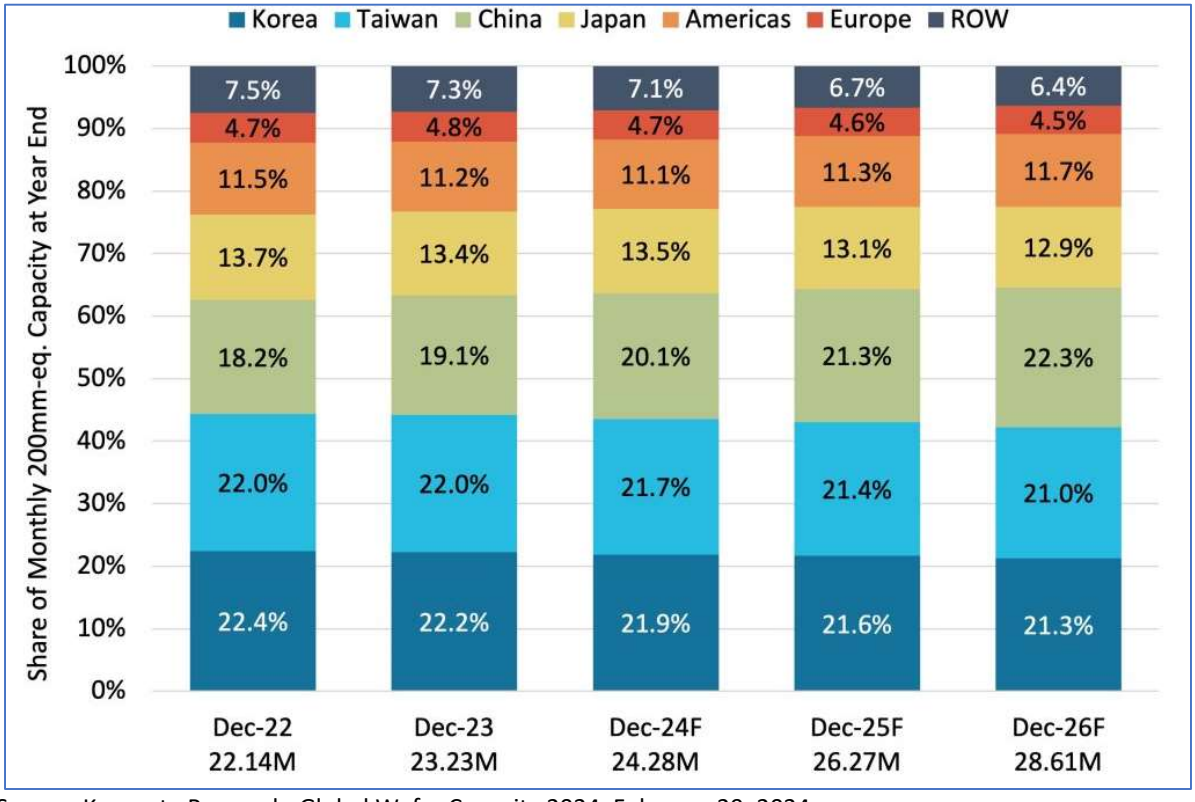
Figure 3 shows the market share of 200 mm wafer capacity by region from December 2021 to December 2026. Korea, Taiwan and China lead in global monthly wafer capacity. Each of these countries holds a significant share of the global monthly wafer capacity, contributing around 20% each from 2022

[27] "What makes Singapore a prime location for semiconductor companies driving innovation?" Economic Development Board, August 20, 2024. https://www.edb.gov.sg/en/business-insights/insights/what-makes-singapore-a-prime-location-for-semiconductor-companies-driving-innovation.html, Accessed on September 5, 2024.
[28] "Wah Lee Products: Semiconductor," Wah Lee Industrial Corporation, https://www.wahlee.com/EN/Products/List/?id=mlnraXWF1yBMoOm5L83Rww==&Top=mlnraXWF1yBMoOm5L83Rww==, Accessed on September 16, 2024.
[29] "What makes Singapore a prime location for semiconductor companies driving innovation?" Economic Development Board, August 20, 2024.

to 2026. The Americas and China are projected to see an increase in their share, while the "Rest of the World" (ROW) category, which includes countries like Singapore, Israel, Malaysia, and India, is expected to experience a gradual decline in its share of the global wafer capacity.

Although Singapore's semiconductor industry is significant, its share of global semiconductor production is relatively modest compared to major semiconductor-producing regions including Korea, Taiwan, China, Japan, the Americas and Europe. In December 2023, the "ROW" category accounted for only 7.3% of the global monthly 8-inch equivalent integrated circuit (IC) production capacity and this figure is expected to fall to 6.4% in December 2026 (see Figure 3). This trend accentuates the dominance of the major semiconductor-producing regions and the challenges smaller players like Singapore face in increasing its share of global production.

Figure 3: Share of Monthly IC Production Capacity for 8-Inch Equivalent by Geography: Dec 2022 to Dec 2026

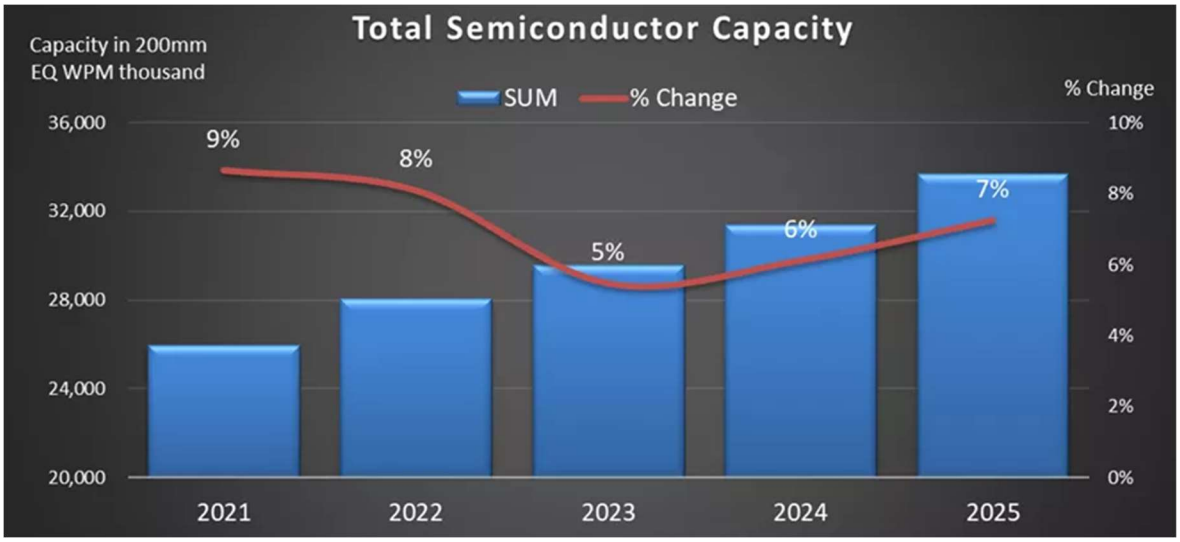


Source: Knometa Research, Global Wafer Capacity 2024, February 29, 2024.

According to McKinsey & Company, the global semiconductor industry is poised for a decade of growth and is projected to become a trillion-dollar

industry by 2030.[30] To meet the surge in global demand for chips, there is a substantial investment in new semiconductor capacity across the world. The Semiconductor Equipment and Materials International (SEMI)'s latest World Fab Forecast report says that the global chip manufacturing industry is projected to boost capacity by 6% in 2024 and 7% in 2025, reaching US$ 33.7 million 200 mm (8-inch) equivalent wafer per month (wpm) (see Figure 4).[31]

Figure 4: Total Semiconductor Capacity of 8-Inch Equivalent Wafers: 2021 to 2025



Note: SUM refers to semiconductor unit manufacturing. It represents the total capacity or production capability of semiconductor manufacturing facilities.
Source: SEMI, Press Release: "Global Semiconductor Fab Capacity Projected to Expand 6% In 2024 And 7% In 2025, Semi Reports," June 18, 2024.

All major chipmaking regions are expected to see capacity growth in 2025. The Chinese chipmakers are expected to maintain double-digit capacity growth, registering a 14% increase to 10.1 million wpm in 2025 – nearly a third of the industry's total – after logging a 15% rise to 8.85 million wpm in 2024. Taiwan is forecasted to rank second in capacity in 2025 at 5.8 million wpm, a 4% growth rate, while South Korea is projected to take the third spot next year, expanding capacity 7% to 5.4 million wpm. Japan, the Americas, and Europe & the Mideast region are expected to grow semiconductor

[30] Ondrej Burkacky, Julia Dragon, and Nikolaus Lehmann, "The semiconductor decade: A trillion-dollar industry," McKinsey & Company, April 1, 2022.
[31] SEMI, Press Release: "Global Semiconductor Fab Capacity Projected to Expand 6% In 2024 And 7% In 2025, Semi Reports," June 18, 2024. "Wafers per month" capacity measures the total number of wafers a facility can produce in a month. The 200 mm equivalent metric is a standard way to measure semiconductor production capacity across different wafer sizes by converting them into a common unit. This metric gives an overall picture of the production capacity of a fab, including all the processes from start to finish.

manufacturing capacity by 4.7 million wpm (3% YoY), 3.2 million wpm (5% YoY), and 2.7 million wpm (4% YoY), respectively (see Table 2).[32]

Table 2: Manufacturing Capacity of 8-Inch Equivalent Wafers by Region: 2024 and 2025

Region	Manufacturing Capacity in 2024 (million wpm)	Manufacturing Capacity in 2025 (million wpm)	Year-on-Year Growth in 2025 (%)
China	8.6	10.1	14
Taiwan	5.7	5.8	4
South Korea	5.1	5.4	7
Japan	4.7	4.7	3
Americas	3.1	3.2	5
Europe & Mideast	2.7	2.7	4
Southeast Asia	1.7	1.8	4
TOTAL	**31.6**	**33.7**	**7**

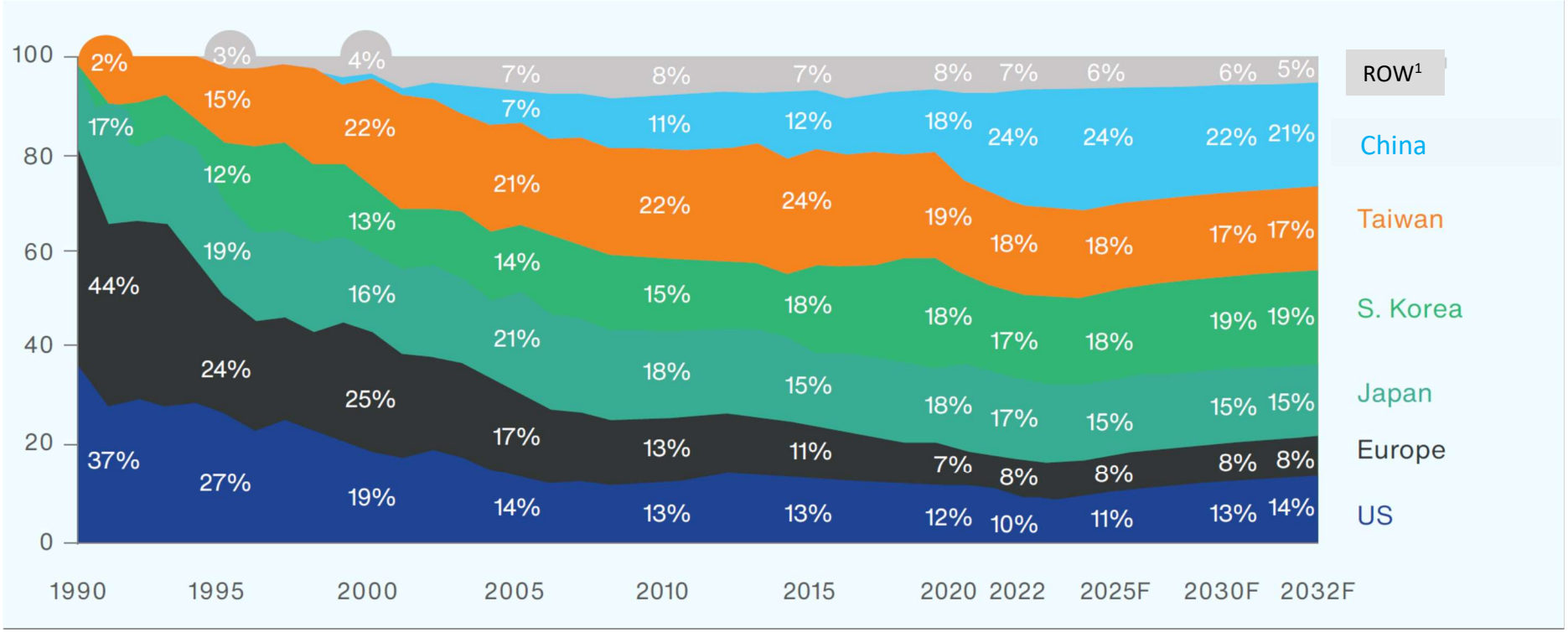
Source: SEMI, Press Release: "Global Semiconductor Fab Capacity Projected to Expand 6% In 2024 And 7% In 2025, Semi Reports," June 18, 2024.

Southeast Asia, which includes Singapore, is expected to grow semiconductor manufacturing capacity by 1.8 million wpm (4% YoY). With significant capacity expansions forecasted in China, Taiwan, South Korea, and other countries in Southeast Asia in 2025, Singapore will face intense competition not only from established major players but also from emerging players (see Table 2).

Concurrent with the anticipated capacity growth in all major chipmaking regions in the near future, the semiconductor industry is witnessing the reshaping of global fab capacity shares. The United States, for instance, is projected to increase its share of global semiconductor manufacturing capacity from 10% in 2022 to 14% by 2032, largely due to the CHIPS and Science Act. South Korea is also expected to see a rise in its share from 17% to 19% over the same period (see Figure 5).

[32] Ibid.

Figure 5: Global 200mm (8-inch equivalent) Commercial Semiconductor Fab Capacity Share by Region: 1990-2032F



1. "ROW" includes Malaysia, Singapore, India, and the rest of the world.

Note: Rounding errors- may not total 100% due to rounding. All values shown in 300 mm (12") equivalents; excludes capacity below 5K wafer starts per month (wspm) or produced on wafer sizes less than 8 inches. WSPM is a measurement of the output of a semiconductor wafer plant. It refers to how many wafers that is put into the front of the line each month. This is determined by the capacity of the bottleneck step, as well as how much time the overall processes take.

Source: Raj Varadarajan, Iacob Koch-Weser, Christopher Richard, Joseph Fitzgerald, Jaskaran Singh, Mary Thornton, and Robert Casanova, "Emerging Resilience In The Semiconductor Supply Chain," Semiconductor Industry Association and Boston Consulting Group, May 8, 2024, p. 15.

On the other hand, regions like China, Taiwan, Japan, and the "Rest of the World" (ROW) category are anticipated to experience a decline in their share of global semiconductor capacity.

The "ROW" category, which includes smaller players like Singapore, India and Malaysia, accounted for 7% share of global monthly 8-inch equivalent semiconductor capacity in 2022. This combined share held by the "ROW' category is expected to fall to 5% in 2030. These shifts underscore the dynamic nature of the semiconductor industry and the strategic moves by countries to bolster their positions in this critical sector (see Figure 5).

Singapore's Share of the Global Semiconductor Market

- Statista: Singapore's semiconductor market is projected to reach approximately US$ 43.4 billion in 2024.
- McKinsey Global Institute: 6% of finished chips traded globally came from Singapore in 2022, making the country one of the top destinations for semiconductor trade.

Projections from the World Semiconductor Trade Statistics (WSTS) show global semiconductor sales are expected to expand 16% to US$ 611.2 billion in 2024.[33] According to Statista, Singapore's semiconductor market is projected to reach approximately US$ 43.4 billion in 2024 and is expected to grow at an annual rate of 10.3% from 2024 to 2029, reaching US$ 70.9 billion by 2029.[34]

Singapore maintains an open, heavily trade-dependent economy that plays a critical role in the global semiconductor supply chain, both as an importer and exporter.[35] It sits at the critical transportation choke point of the Strait of Malacca, where raw materials and finished goods pass through.[36] As the shortest shipping route between East Asia and the Middle East and Europe,

[33] World Semiconductor Trade Statistics, Press Release: "WSTS Semiconductor Market Forecast Spring 2024", June 4, 2024.
[34] "Semiconductors – Singapore," Statista, Aug 2024. https://www.statista.com/outlook/tmo/semiconductors/singapore, Accessed September 2, 2024;
[35] "2023 Investment Climate Statements: Singapore," US Department of State, https://www.state.gov/reports/2023-investment-climate-statements/singapore/, Accessed on September 13, 2024.
[36] Joris Teer and Mattia Bertolini, Threats to the Supply of Critical Raw Materials for Semiconductors (The Hague: The Hague Centre for Strategic Studies, 2022).

the Straits of Malacca accounts for 30% of global trade.[37] Both South Korea and Japan, for example, depend on the Strait of Malacca for sea freight to Europe.

Singapore's strategic location, robust infrastructure, and pro-business policies make it a prime location for semiconductor companies. According to the McKinsey Global Institute, 6% of finished chips traded globally came from Singapore in 2022, with a total value of approximately US$ 66 billion, putting it fifth in the world, behind Taiwan, South Korea, China and Malaysia (see Table 3).[38]

Table 3: Total Value and Share of World's Top 10 Sources of Finished Chips: 2022

Rank	Country/Territory	Share (%)	Value (US$ billion)
1.	Taiwan	31	364
2.	South Korea	15	183
3.	China	14	165
4.	Malaysia	9	102
5.	**Singapore**	**6**	**66**
6.	Japan	5	61
7.	United States	4	50
8.	Philippines	3	36
9.	Vietnam	3	32
10.	Thailand	2	28

Source: "Top trading partners in components – chips in 2022," McKinsey Global Institute, https://www.mckinsey.com/mgi/our-research/global-trade-explorer-what-are-the-main-traded-sectors-of-an-economy?eco=wld&sector=02m&toggle=c&year=2022&sub-sector=m12, Accessed September 12, 2024.

Additionally, among the top 10 export destinations for finished chips in 2022, Singapore ranked fourth with a 6% share valued at approximately US$ 64 billion. This places Singapore just behind China, Hong Kong, and Taiwan as an export destination for finished chips (see Table 4).

[37] "These Four Chokepoints Are Threatening Global Trade," Boston Consulting Group, February 12, 2024

[38] "Top trading partners in components – chips in 2022," McKinsey Global Institute, https://www.mckinsey.com/mgi/our-research/global-trade-explorer-what-are-the-main-traded-sectors-of-an-economy?eco=wld&sector=02m&toggle=c&year=2022&sub-sector=m12, Accessed September 12, 2024.

Table 4: Total Value and Share of World's Top 10 Export Destinations of Finished Chips: 2022

Rank	Country/Territory	Share (%)	Value (US$ billion)
1.	China	33	356
2.	Hong Kong SAR	18	197
3.	Taiwan	7	78
4.	**Singapore**	**6**	**64**
5.	South Korea	5	58
6.	Vietnam	5	50
7.	Malaysia	4	47
8.	United States	3	34
9.	Japan	3	32
10.	Germany	2	19

Source: "Top trading partners in components – chips in 2022," McKinsey Global Institute, https://www.mckinsey.com/mgi/our-research/global-trade-explorer-what-are-the-main-traded-sectors-of-an-economy?eco=wld&sector=02m&toggle=c&year=2022&sub-sector=m12, Accessed September 12, 2024.

The semiconductor industry is the second-most profitable industry in the world and is fiercely competitive.[39] On one end of the spectrum, Singapore faces formidable competition from world leading players that have made tremendous advancements in semiconductor technology. At the other, it faces competition for semiconductor investments from emerging players in Southeast Asia like Malaysia, Indonesia, and Vietnam, which are making concerted efforts to woo investments and climb up the value chain in the global chip industry (see Figure 6). Malaysia, for instance, has an established presence in chip assembly, packaging and testing as well as electronics manufacturing services and reported that its market share in the global chips testing and packaging market reached 13% in 2023.[40] Singapore, therefore, must continuously adapt and innovate to maintain its position in the global semiconductor market.

[39] Ondrej Burkacky, Matteo Mancini, Mark Patel, Giulietta Poltronieri, and Taylor Roundtree, "Exploring new regions: The greenfield opportunity in semiconductors," McKinsey & Company, January 29, 2024.
[40] Malaysian Investment Development Authority, Press Release: "MSIA: Local semiconductor sector to pick up in second half of 2024," February 18, 2024.

Figure 6: Major Semiconductor Manufacturers' Manufacturing Base in Southeast Asia

EXPERTISE	SEMICONDUCTOR COMPANY	MANUFACTURING BASE
Integrated Device Manufacturing	Infineon Technologies	**Singapore**, Malaysia, Indonesia
	Intel	Malaysia, Vietnam
	Micron Technology	**Singapore**, Malaysia
	Texas Instruments	Malaysia, Philippines
	STMicroelectronics	**Singapore**, Malaysia
Assembly, Testing and Packaging	Advanced Semiconductor Engineering (ASE)	Malaysia, **Singapore**
	Jiangsu Changjiang Electronics Technology (JCET)	**Singapore**
	Amkor Technology	Malaysia, Philippines
	UTAC Holdings	**Singapore**, Thailand, Indonesia
Foundry	GlobalFoundries	**Singapore**
	United Microelectronics Corporation	**Singapore**

Source: Yush Chau, "[Big read] Not a zero-sum game: Semiconductor pie big enough for Singapore and Malaysia," ThinkChina, May 20, 2024; "What makes Singapore a prime location for semiconductor companies driving innovation?" Economic Development Board, August 20, 2024; "Who We Are," UTAC Holdings, Accessed on September 13, 2024.

Major Players in Singapore's Semiconductor Industry

Today, Singapore's semiconductor industry is made up of a vibrant ecosystem of global giants and small and medium-sized enterprises.[41] It covers diverse players in IC design, manufacturing, research and development, testing and other related activities.[42]

Major international players in IC design including Taiwan-headquartered MediaTek and Realtek, and U.S.-headquartered Qualcomm, Broadcom and Maxlinear have established operations in Singapore.

Singapore has also attracted investments from major chip multinationals like U.S.-headquartered Micron, Marvell Technology and GlobalFoundries;

[41] Ovais Subhani, "Singapore wins more investments from major chipmakers as they seek to de-risk supply chains," The Straits Times, July 12, 2024.
[42] Choo Yun Ting, "Diverse capabilities, infrastructure help drive chips industry in Singapore," The Straits Times, September 3, 2022.

Taiwan-headquartered TSMC, United Microelectronics Corporation (UMC) and VIS; and Germany-based Siltronic AG.

Meanwhile, Singapore's semiconductor manufacturing equipment (SME) exports are largely attributable to U.S.-headquartered Applied Materials and KLA Corporation, and Netherlands-based ASM International.[43] Singapore is the South-east Asia headquarters of Applied Materials, one of the world's top suppliers of machines that make semiconductors.[44] In fact, Singapore has emerged as the largest production hub outside the United States for U.S.-based firms including Micron and Applied Materials. KLA has its regional headquarters in Singapore, which currently serves as a key manufacturing and engineering hub for the company.[45]

In the area of assembly, testing and packaging, Taiwan's Advanced Semiconductor Engineering, Inc. (ASE), China's Jiangsu Changjiang Electronics Technology Co., Ltd. (JCET) and Singapore-headquartered United Test and Assembly Center Ltd (UTAC) and Silicon Box are major names that have set up their operations in Singapore.

Investments in new manufacturing and research and development (R&D) facilities also came from other semiconductor value chain companies such as Taiwanese fabless chipmaker MediaTek, U.S. chip equipment-maker Applied Materials, German wafer-disc manufacturer Siltronic, and U.S. computer processor and graphics maker Advanced Micro Devices (AMD).[46] One example is the Applied Materials - A*STAR Joint Lab for Applied Process Equipment Accelerator (APEX), which focuses on developing semiconductor manufacturing processes that minimize material waste and maximize resource efficiency; developing components and methods to enhance the quality and functionality of semiconductor equipment targeted for ICAPS markets (IoT, Communications, Automotive, Power and Sensors); and creating computer

[43] Andre Barbe and Will Hunt, "Preserving the Chokepoints: Reducing the Risks of Offshoring among US Semiconductor Manufacturing Equipment Firms," Center for Security and Emerging Technology, May 2022.
[44] Ovais Subhani, "US chip gear giant Applied Materials to double S'pore manufacturing, R&D and headcount," The Straits Times, June 18, 2024.
[45] Ovais Subhani, "Semiconductor firm KLA opens new Singapore plant that will create 400 new jobs," The Straits Times, October 4, 2024.
[46] Ovais Subhani, "Big hopes as Singapore gears up to ride EV microchip boom," The Straits Times, January 20, 2024.

models to test, simulate and optimize new processes and designs. The joint lab will also enable small and medium-sized enterprises in Singapore to support development of these solutions.[47]

Playing a supporting role, Singapore's homegrown companies and various small and medium enterprises provide services, solutions, materials, and equipment to bigger chipmakers, or components and spare parts to large equipment manufacturers.[48] Homegrown mainboard-listed AEM Holdings, which provides advanced chip testing solutions, is a crucial partner of United States chipmaker Intel.[49] Additive manufacturing company ELH Tech is an example of a small and medium enterprise supplying 3D-printed parts and components to foundries in Singapore, including STMicroelectronics.[50]

Importance of Semiconductor Industry to Singapore

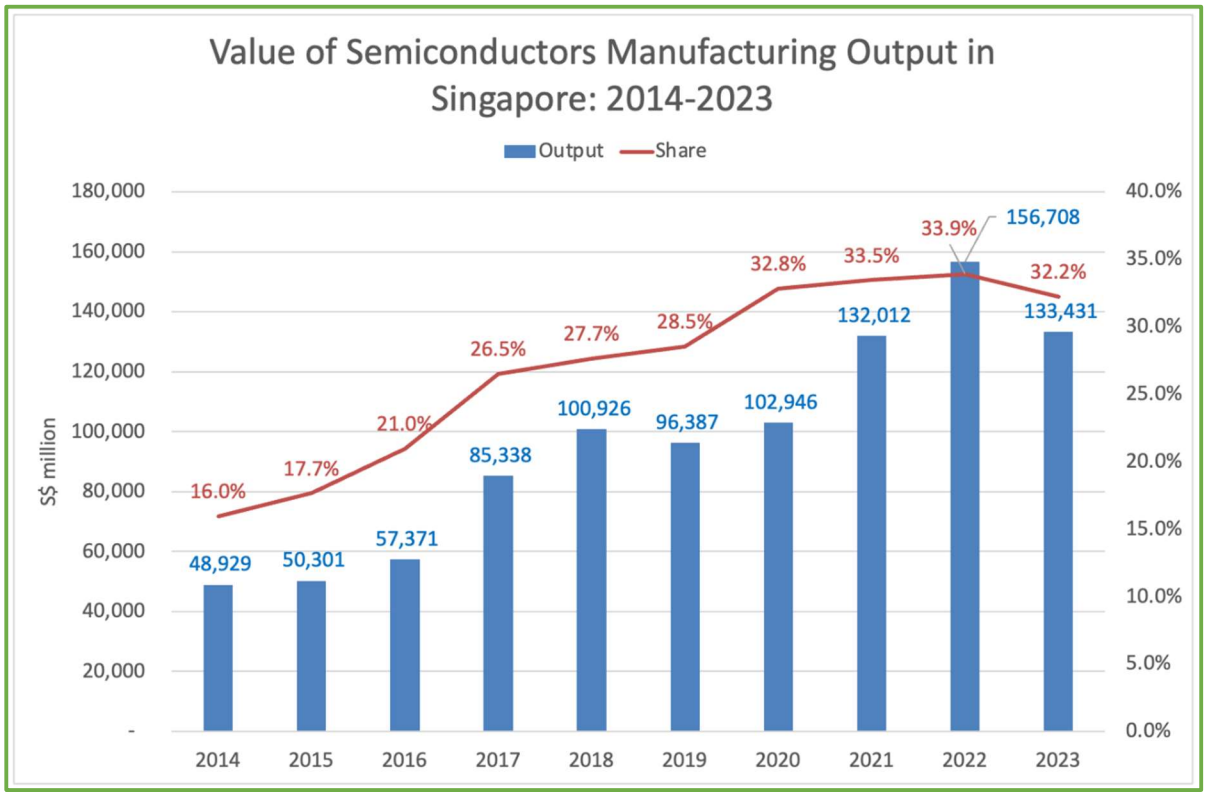
Singapore's semiconductor industry has experienced remarkable growth over the past decade. The increase in its contribution to GDP by 2-3 times from 2014 to 2023 underscores both the rising importance of the semiconductor sector and the effectiveness of Singapore's strategic efforts.

With strong government support, Singapore's semiconductor industry has been booming, attracting investments from many major multinational companies. The Singaporean government said last month (September) that Singapore produced 10% of the world's chips and about 20% of the world's semiconductor equipment. In the past ten years, Singapore's semiconductor output value has increased by 2.7 times, and its added value has increased by 3.3 times. The compound annual growth rate (CAGR) of both output and value-added has reached double digits. Its contribution to gross domestic product (GDP) has doubled from 2.8% to 5.6%. It is, therefore, a very important sector

[47] EDB Singapore, Press Release: "A*STAR and Applied Materials announce new joint lab for semiconductor equipment and local supply chain development," September 5, 2024.
[48] Tessa Oh, "Chip wars: Singapore SMEs get a boost from big players' efforts to nurture ecosystem," The Business Times, July 17, 2024.
[49] Enterprise Singapore, Success Stories: "From being in the red to $1b market cap: Singapore chip testing firm is now world-class," first published February 3, 2022, updated September 27, 2024.
[50] "Chip wars: Singapore SMEs get a boost from big players' efforts to nurture ecosystem," The Business Times, July 17, 2024.

for Singapore's economic development (see Figures 7 and 8).

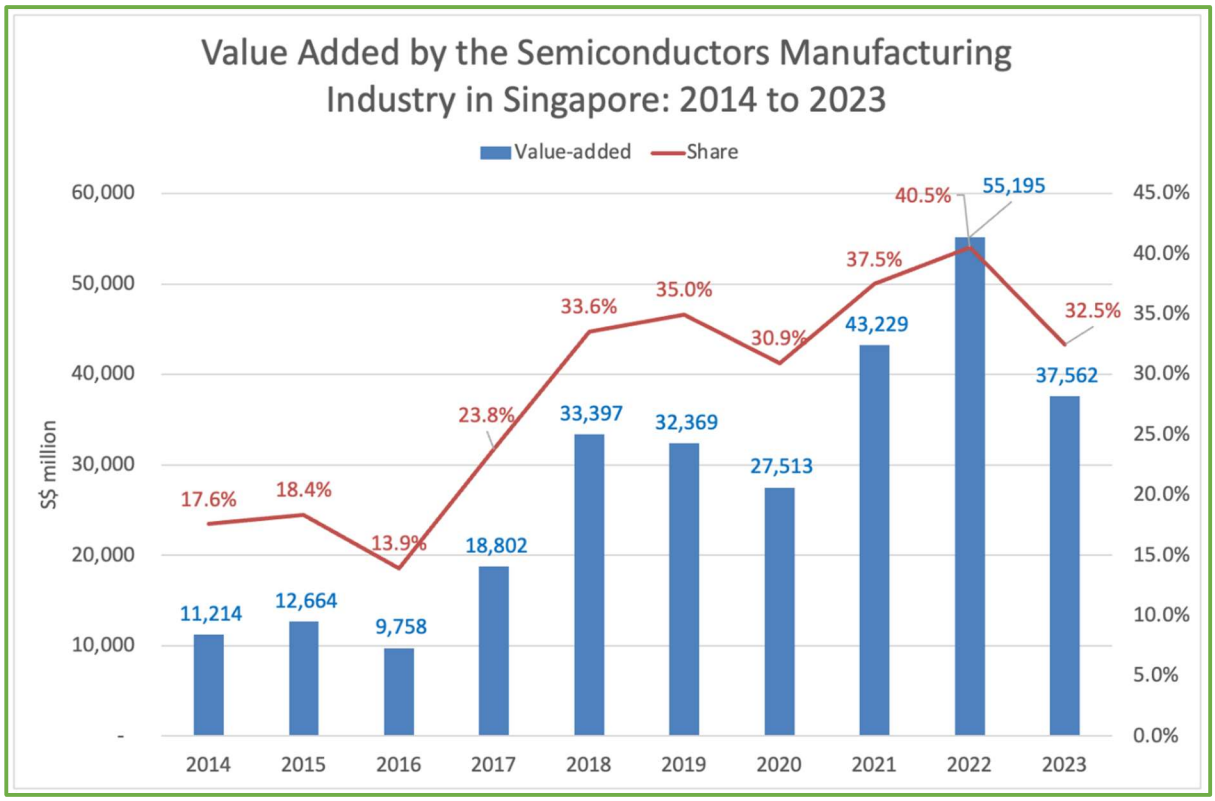
Figure 7: Value of Semiconductors Manufacturing Output in Singapore: 2014 to 2023



Source: Department of Statistics, Singapore, "Principal Statistics Of Manufacturing By Industry Cluster - Total Output," https://tablebuilder.singstat.gov.sg/table/TS/M355171, accessed September 4, 2024.
Exchange rate: S$ 1= US$ 0.73 as of April 2024.

In terms of output value, the compound annual growth rate of Singapore's semiconductor industry output value from 2014 to 2023 is 11.8%. In 2014, the output value of Singapore's semiconductor industry was S$ 48.9 billion (US$ 35.7 billion), accounting for 16.0% of the manufacturing output value. In 2017, it rapidly expanded to S$ 85.3 billion (US$ 62.3 billion), accounting for 26.5% of the manufacturing output value. In 2018, it grew to S$ 100.9 billion (US$ 73.7 billion), accounting for 27.7% of the manufacturing output value. Singapore's semiconductor industry reached a peak of S$ 156.7 billion (US$ 114.4 billion) in 2022, accounting for more than one-third (33.9%) of the manufacturing output value. In 2023, affected by the ebb of the global semiconductor industry, it slightly declined to S$ 133.4 billion (US$ 97.4 billion), with the proportion of output value decreasing to 32.2% (see Figure 7).

Figure 8: Value Added by the Semiconductors Manufacturing Industry in Singapore: 2014 to 2023

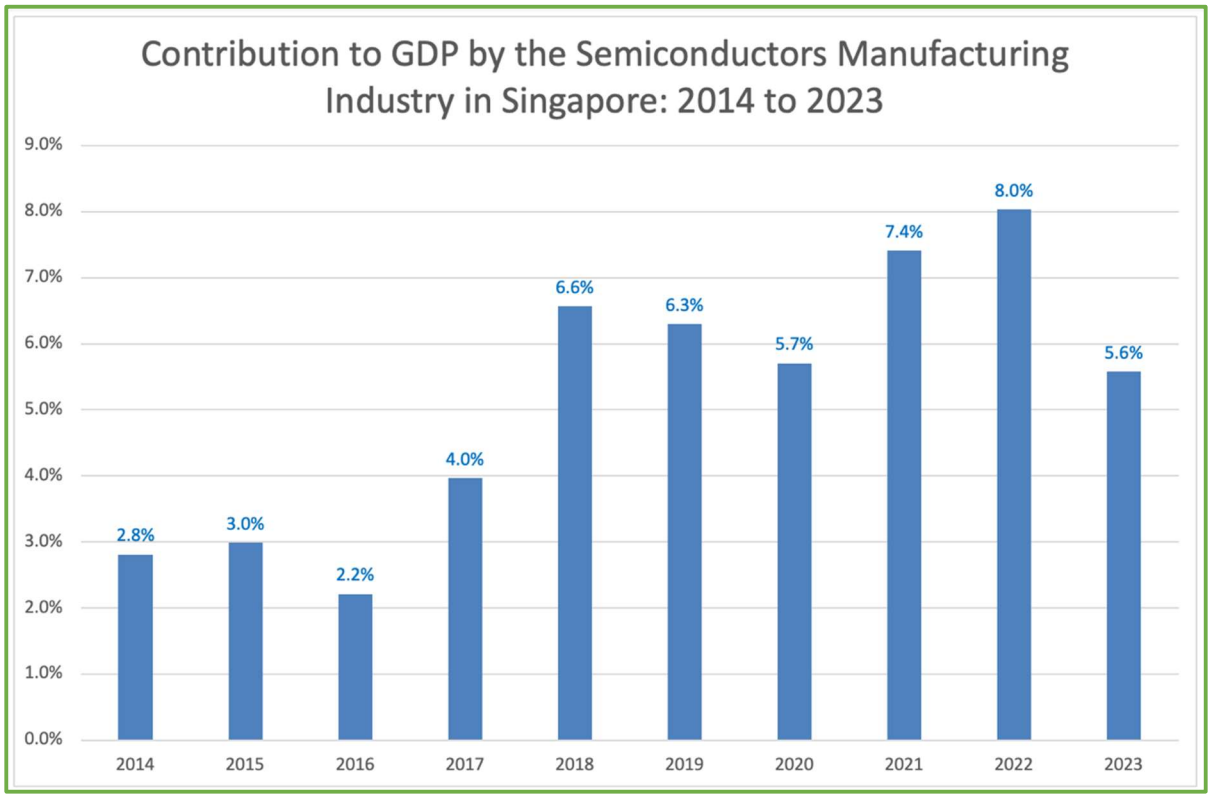


Source: Department of Statistics, Singapore, "Principal Statistics Of Manufacturing By Industry Cluster - Value Added," https://tablebuilder.singstat.gov.sg/table/TS/M355181 , accessed September 4, 2024.
Exchange rate: S$ 1= US$ 0.73 as of April 2024.

In terms of value-added, the compound annual growth rate of the value-added of Singapore's semiconductor industry from 2014 to 2023 is 14.4%. In 2014, the value-added of Singapore's semiconductor industry was S$ 11.2 billion, accounting for 17.6% of the value-added of the manufacturing industry. In 2017, it rapidly expanded to S$ 18.8 billion (US$ 13.8 billion), accounting for 23.8% of the added value of the manufacturing industry. In 2018, it grew to S$ 33.4 billion (US$ 24.4 billion), accounting for 33.6% of the value-added of the manufacturing industry. Singapore's semiconductor industry reached a peak of S$ 55.2 billion (US$ 40.3 billion) in 2022, accounting for more than 40% (40.5%) of the value-added of the manufacturing industry. Affected by the ebb of the global semiconductor industry, it declined sharply to S$ 37.6 billion (US$ 27.4 billion) in 2023, with the proportion of value-added in manufacturing output

value decreasing to 32.5% (see Figure 8).

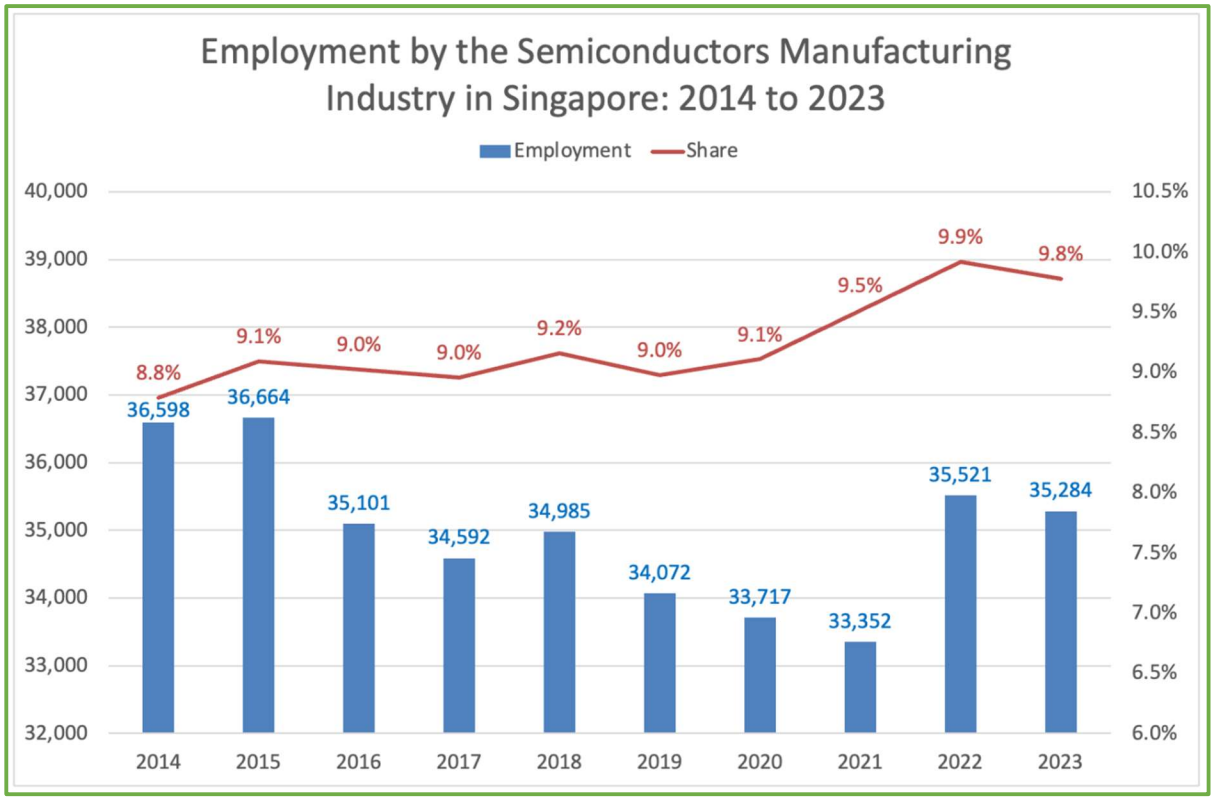
Figure 9: Contribution to GDP by the Semiconductors Manufacturing Industry in Singapore: 2014 to 2023



Source: Department of Statistics, Singapore, "Principal Statistics Of Manufacturing By Industry Cluster - Total Output," "Gross Domestic Product At Current Prices, By Industry (SSIC 2020)," https://tablebuilder.singstat.gov.sg/table/TS/M355171, https://tablebuilder.singstat.gov.sg/table/TS/M015731#! accessed September 10, 2024.

With respect to contribution to GDP, the contribution of Singapore's semiconductor industry was 2.8% in 2014, rapidly increased to 4.0% in 2017, 6.6% in 2018 and 7.4% in 2021, and reached a peak of 8.0% in 2022. In 2023, it declined to 5.6% due to a downturn in the global semiconductor market. In other words, in 2022, for every 100 Singapore dollars of gross domestic product in Singapore, the semiconductor industry contributed 8 Singapore dollars (see Figure 9). This shows the industry's critical role in Singapore's economy, especially during periods of high demand.

Figure 10: Employment by the Semiconductors Manufacturing Industry in Singapore: 2014 to 2023



Source: Department of Statistics, Singapore, "Principal Statistics Of Manufacturing By Industry Cluster - Employment," https://tablebuilder.singstat.gov.sg/table/TS/M355151 , accessed September 4, 2024.

The semiconductor workforce in Singapore has consistently hovered around 35,000 employees in the past ten years. Despite the relatively stable employment numbers, the industry has seen increased output value, value-added, and contribution to GDP over the years. In other words, Singapore's semiconductor industry productivity has seen significant improvement. The number of employees in Singapore's semiconductor industry was 36,598 in 2014. Even though its output value and value-added grew rapidly in 2018, its number of employees decreased slightly to 34,985. When the output value and value-added of Singapore's semiconductor industry reached their peak in 2022, the number of employees was 35,521, and it remained stable at 35,284 in 2023 (see Figure 10).

Despite facing some challenges, the semiconductor industry in Singapore is poised for significant growth in the coming years. The global semiconductor market is expected to see robust growth in 2024 and 2025, according to the

WSTS.[51] With its significant contribution to its GDP, the semiconductor industry remains a crucial pillar of Singapore's economy.

Hub for Manufacture of Legacy Chips

Singapore's early entry in the semiconductor industry has enabled it to foster an ecosystem of suppliers and manufacturers across the semiconductor value chain. Like many countries, Singapore offers financial incentives to develop and grow its semiconductor industry. Singapore, however, does not compete on the basis of financial incentives alone. Its strong fundamentals, including its stability, robust intellectual property protection regime, and skilled workforce, have enabled it to develop and grow the semiconductor sector over the decades.[52]

While Singapore has attracted a number of major players to set up their operations on its shores, it relies on global supply chains for advanced chip fabrication.[53] Intel, Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung, otherwise known as the "Big Three", are the global leaders in high-volume manufacturing of cutting-edge chips. All three do not currently have advanced fabrication facilities in Singapore.[54]

Global competition for high-end semiconductor investments is intense. The United States, Japan and the European Union, are offering large subsidies to the tune of billions to attract the big three semiconductor manufacturers to set up high end semiconductor production in their respective home countries. For example, Japan has offered a subsidy of ¥ 476 billion (US$ 3.3 billion) for TSMC's Kumamoto factory, a joint venture named Japan Advanced Semiconductor Manufacturing Inc. (JASM), and another subsidy of ¥ 732 billion

[51] World Semiconductor Trade Statistics, Press Release: "WSTS Semiconductor Market Forecast Spring 2024," - June 4, 2024.
[52] Ministry of Trade and Industry, Singapore, "Written reply to Parliamentary Question on Singapore's semiconductor manufacturing industry," September 12, 2022.
[53] Prime Minister's Office, Singapore, Press Release: "Transcript of Deputy Prime Minister and Minister for Finance Lawrence Wong's Fireside Chat at the Milken Institute Asia Summit on 13 September 2023," September 13, 2023.
[54] Ibid.

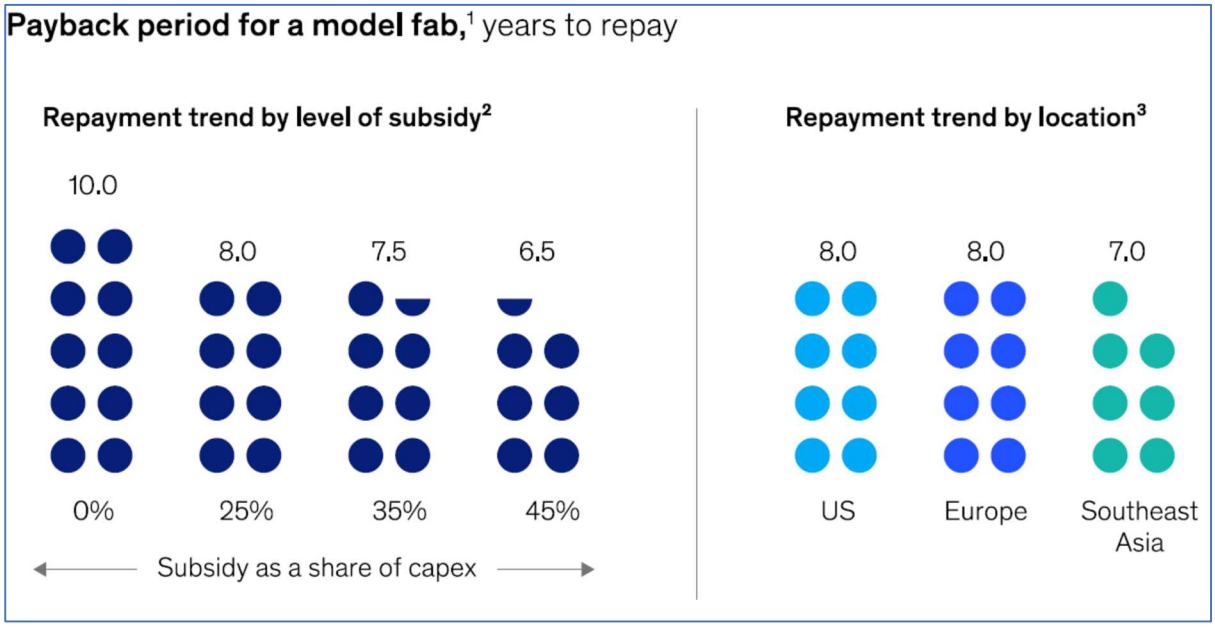
(US$ 4.9 billion) for TSMC's Kumamoto Fab 2.[55] In April 2024, the U.S. Department of Commerce and TSMC Arizona announced up to US$ 6.6 billion in direct funding under the CHIPS and Science Act, fulfilling a goal to bring the most advanced chip manufacturing in the world to the United States.[56] Meanwhile, the EU Commission approved € 5 billion ($5.5 billion) worth of state aid in August this year for TSMC's new semiconductor plant in Dresden, Germany.[57]

A recent McKinsey analysis reveals that subsidy levels have a greater impact than location on reducing the payback period for fab investments. The average cost of constructing and equipping a new fab is approaching US$ 10 billion and could exceed that in some cases. In terms of location, the payback period for a fab in the United States or Europe is 8 years but this is reduced to 7 years for a fab in Southeast Asia. With subsidies offered at much higher levels than before, the effect on the payback period for a fab is also greater. A cost subsidy equal to 45% of the required investment, for example, will reduce the payback period to 6.5 years, compared with 10.0 years for unsubsidized facilities (see Figure 11).

With major players like the U.S.A, Europe, and Japan offering substantial subsidies, the cost of entry for other regions that want to attract high-end semiconductor investments is raised significantly. It is difficult for Singapore, a small country, to outbid large players at the level of subsidies they are offering. Singapore, therefore, has expressed it may have to forgo new high-end chip manufacturing investments because it cannot afford to engage in an expensive "subsidies arms race".[58]

[55] "TSMC's first Japan plant to hit 60% local procurement by 2030," The Japan Times, April 7, 2024.
[56] TSMC, Press Release: "TSMC Arizona and U.S. Department of Commerce Announce up to US$6.6 Billion in Proposed CHIPS Act Direct Funding, the Company Plans Third Leading-Edge Fab in Phoenix," April 8, 2024.
[57] Hakan Ersen and Toby Sterling, "EU approves German state aid for $11 billion TSMC chip plant," Reuters, August 20, 2024.
[58] Prime Minister's Office, Singapore, Press Release: "Transcript of Deputy Prime Minister and Minister for Finance Lawrence Wong's Fireside Chat at the Milken Institute Asia Summit on 13 September 2023," September 13, 2023.

Figure 11: Impact of Subsidy Levels on Payback Period for Fab Investments



[1] Assuming a 28nm fab with a capacity of 500,000 wafers per annum; payback period calculated without discounting cash flows.
[2] Assuming a U.S. location; subsidy as share of capex.
[3] Assuming 25% capex subsidy. Locations differentiated through regional labor and utility costs, as well as regional differences in capex (ie, building costs).
Source: Ondrej Burkacky, Matteo Mancini, Mark Patel, Giulietta Poltronieri and Taylor Roundtree, "Exploring new regions: The greenfield opportunity in semiconductors," McKinsey & Company, January 29, 2024.

Instead of competing for control and production of high-end chips, which drive advanced technologies like artificial intelligence (AI) and machine learning, Singapore's semiconductor ecosystem is primarily built around legacy chips (see Figure 12). These mature nodes, typically larger than 7 nanometers (nm), are essential for many industries, including automotive, consumer electronics, and industrial applications, and have a stable demand.[59] By concentrating on legacy chips, which require older manufacturing processes, Singapore can leverage its existing strengths without engaging in the intense competition for cutting-edge chip production. This strategy allows Singapore to maintain a significant role in the global semiconductor supply chain, supporting industries that rely on these mature technologies.

In recent years, Singapore has seen a surge in new investments to produce mature node chips. For example, in February 2022, Taiwan's chipmaker UMC announced plans to invest S$ 6.8 billion (US$ 5 billion) in the

[59] Claire Huang, "Singapore factory output falls 9.2% in March as chip production shrinks," The Straits Times, April 26, 2024.

phase 3 expansion of its Fab12i, or Fab12i P3, to produce 22 nm and 28 nm chips in Singapore.[60]

In September 2023, US-headquartered Global Foundries officially opened its new S$ 5 billion (US$ 4 billion) wafer fab facility in Singapore.[61] The new fab, focused on end-markets such as automotive, 5G mobility, and secure devices, will produce an additional 450,000 wafers (300mm) annually, raising GlobalFoundries Singapore's overall capacity to approximately 1.5 million wafers (300mm) each year.[62]

Earlier this year (June 2024), NXP Semiconductors and TSMC's subsidiary, VIS, announced their plan to build a US$ 7.8 billion wafer chip plant in Singapore.[63]

Figure 12: Leading Semiconductor Companies in Singapore by Node

COMPANY	TYPE	NODE
Micron	IDM	It utilizes various process nodes, leveraging a range of mature node process technologies. The most advanced DRAM process technology used is the 1α (1-alpha) node, which falls within the 10 to 19 nm range.
Infineon	IDM	It utilizes various process nodes, leveraging a range of mature node process technologies. Additionally, Infineon collaborates with UMC for the production of automotive microcontrollers using a 40 nm process.
NXP Semiconductors	IDM	It focuses on mature 130 nm to 40 nm technologies.
STMicroelectronics	IDM	It utilizes various process nodes, leveraging a range of mature node process technologies, including those at 28 nm and 40 nm nodes.
GlobalFoundries	Foundry	It utilizes various process nodes, leveraging a range of mature node process technologies such as 14 nm and 28 nm.
United Microelectronics Corporation (UMC)	Foundry	It utilizes various process nodes. Its new fab, Fab 12i P3, will focus on 22 nm and 28 nm processes.
Vanguard International Semiconductor (VIS)	Foundry	It is centered on 28 nm and above mature processes.

[60] UMC, Press Release: "UMC announces new 22nm wafer fab in Singapore," February 24, 2022; TrendForce, Press Release: "Explore the Foundry Landscape in Singapore as UMC's Plant Nears Completion Mid-Year," January 11, 2024.

[61] GlobalFoundries, Press Release: "GlobalFoundries Officially Opens US$4 Billion Expansion Facility in Singapore, Creating 1,000 New Jobs," September 12, 2023.

[62] Ibid.

[63] VIS, Press Release: "VIS and NXP to Establish a Joint Venture to Build and Operate a 300mm Fab," June 5, 2024.

Source: TrendForce, Press Release: "Explore the Foundry Landscape in Singapore as UMC's Plant Nears Completion Mid-Year," January 11, 2024; Thy Tran, "Inside 1α — the world's most advanced DRAM process technology," Micron, January 2021; "Products," Infineon, https://www.infineon.com/cms/en/product/, Accessed on October 2, 2024; NXP, Press Release: "VIS and NXP to Establish a Joint Venture to Build and Operate a 300mm Fab," June 5, 2024; Steven Leibson, "GlobalFoundries Chases Down a Different Semiconductor Rabbit Hole," Electronic Engineering Journal, July 5, 2022; "Home," UMC, https://www.umc.com/en/Home/Index, Accessed on September 25, 2024; Ovais Subhani, "Big hopes as Singapore gears up to ride EV microchip boom," The Straits Times, January 20, 2024; TrendForce, Press Release: "Taiwanese Chipmakers Expand Overseas to Capitalize on Geopolitical Shifts and De-Sinicization Benefits, Says TrendForce," June 5, 2024.

Singapore has set its focus on attracting investments from major foreign players, fostering collaborations and creating a conducive environment for R&D to maintain its position in the semiconductor landscape.[64] Despite not having advanced fabs from the big three semiconductor companies, Singapore hosts regional headquarters for Intel and Samsung, focusing on sales and marketing.[65] Additionally, Applied Materials and Micron Technology have significant operations in Singapore, with Micron's global Centre of Excellence for NAND flash memory located there.[66]

SINGAPORE'S SEMICONDUCTOR STRATEGY AND POLICIES

Key Government Agencies

Singapore's Ministry of Trade and Industry (MTI) and its Economic Development Board (EDB) play major roles in assisting and steering the development of industry. As the lead government agency that plans and executes economic and industrial development strategies for Singapore, MTI's EDB supports the semiconductor industry by providing information, industry connections, and government incentives for investments and industry development in Singapore.[67] Other government agencies such as Enterprise Singapore, JTC Corporation, Agency for Science, Technology and Research

[64] "How Singapore has become a leading force in tech innovation," Economic Development Board, Singapore, November 3, 2023.
[65] "Contact Information," Samsung Semiconductor, https://semiconductor.samsung.com/support/contact-info/global-network/singapore/, accessed on August 30, 2024.
[66] Micron, Press Release: "Micron Unveils Expanded NAND Flash Memory Fabrication Facility in Singapore," August 14, 2019.
[67] Economic Development Board, Singapore, "Who We Are," EDB, https://www.edb.gov.sg/en/about-edb/who-we-are.html. Accessed on August 20, 2024.

(A*STAR) and the Ministry of Education (MOE) also play a part to support and develop the semiconductor industry.

While the EDB focuses on attracting global investments, MTI's Enterprise Singapore is dedicated to supporting local enterprises and enhancing their global competitiveness. Enterprise Singapore helps local semiconductor companies collaborate with global semiconductor firms as solution providers or co-development partners.[68]

The JTC Corporation, another statutory board under Singapore's MTI, serves as the government's industrial landlord and caters to the infrastructure needs of semiconductor players of varying sizes. JTC has four wafer fab parks, totaling 374 hectares.[69] These parks are home to 14 global semiconductor companies. At the same time, "plug-and-play" developments, such as the JTC semiconSpace, where two single-storey units can be combined, and JTC nanoSpace, a multi-tenant cleanroom development, cater to smaller players.[70] JTC announced in July this year that it was preparing 11% more land in Singapore's wafer fabrication parks, in a bid to attract more top semiconductor giants and ride the artificial intelligence wave.[71] This expansion is crucial as it helps meet the growing demand for legacy chips, which are vital for data centers, mobile phones, and automobiles.[72]

The National Research Foundation (NRF) and the Research, Innovation and Enterprise 2025 (RIE2025) plan play pivotal roles in advancing semiconductor R&D initiatives in Singapore. The NRF was formed in 2006 under the Prime Minister's Office, Singapore, to support the Research, Innovation and Enterprise Council (RIEC) in its work through the development and coordination of national policies to grow Singapore's research capability, support economic growth and meet Singapore's future national challenges.[73]

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[68] "About Us," Enterprise Singapore, Ministry of Trade and Industry, Singapore, https://www.enterprisesg.gov.sg/about-us/overview, Accessed on September 30, 2024.
[69] JTC Corporation, "Wafer Fab Parks," JTC, https://www.jtc.gov.sg/find-land/land-for-long-term-development/wafer-fab-parks#about. Accessed on August 20, 2024.
[70] Choo Yun Ting, "Cashing in on chips," The Straits Times, January 4, 2023.
[71] Rebecca Metteo and Louisa Tang, "Singapore prepares more land to woo semiconductor giants looking to ride AI wave," ChannelNewsAsia, July 12, 2024.
[72] Choo Yun Ting, "Cashing in on chips," The Straits Times, January 4, 2023.
[73] "About NRF," National Research Foundation, https://www.nrf.gov.sg/about/about-nrf-singapore/nrf-singapore/, Accessed on October 15, 2024.

Over the past decades, the Singapore government has committed to sustaining investments in research, innovation, and enterprise at about 1% of Singapore's GDP over the period 2021-2025 (S$ 25 billion or about US$ 18.3 billion).[74] In Budget 2024, Singapore announced a S$ 3 billion (US$ 2.2 billion) top-up to RIE 2025. In total, about S$ 28 billion (US$ 20.4 billion) over five years will go towards growing the overall R&D ecosystem in Singapore. The funds will support both the public and private sector, including collaborative R&D projects between the two sectors.[75] Semiconductor R&D, including the development of new chip designs, manufacturing processes and equipment, is a key focus area.[76]

Research in semiconductors is mostly organized under the Institute of Microelectronics, founded in 1991, which is part of the A*STAR. Over the years, A*STAR has collaborated with various companies in the field of semiconductors. A*STAR and Applied Materials, for example, have collaborated in the field of semiconductors for more than 10 years. Their latest initiative, the Applied Materials – A*STAR Joint Lab for Applied Process Equipment Accelerator (APEX), seeks to innovate and advance semiconductor equipment capabilities.[77] The joint lab will also equip Singapore's small and medium-sized enterprises with the expertise and knowledge necessary to produce high-quality and reliable semiconductor components.

Additionally, the Ministry of Education (MOE) in Singapore plays a significant role in supporting the semiconductor industry through various educational and training initiatives.

Policy

The EDB is instrumental in crafting strategic plans and policies that create a favorable environment for the semiconductor industry, a crucial part

[74] "The RIE2025 Plan," National Research Foundation, https://www.nrf.gov.sg/rie-ecosystem/ecosystem/, Accessed on October 16, 2024.
[75] "What makes Singapore a prime location for semiconductor companies driving innovation?" EDB, Singapore, August 20, 2024.
[76] Ibid.
[77] A*STAR, Press Release: "A*STAR and Applied Materials Announce New Joint Lab for Semiconductor Equipment and Local Supply Chain Development," September 9, 2024.

of Singapore's advanced manufacturing sector, particularly within the broader electronics segment.

The "Semiconductor Vision 2020" taskforce was a cooperation between the EDB and various companies from the industry to coordinate efforts for next generation manufacturing.[78] The EDB's "Manufacturing 2030" plan aims to grow Singapore's manufacturing sector by 50% of its 2021 value of S$ 106 billion (US$ 80 billion) by 2030, while remaining approximately 20% of gross domestic product (GDP).[79] To achieve the goals set out in the "Manufacturing 2030" plan, Singapore has launched its Electronics Industry Transformation Map (ITM) 2025 (see Figure 13).

Figure 13: Singapore's Semiconductor Policy

Guidance	**Target**	**Manufacturing 2030** • Grow Singapore's manufacturing sector by 50% of its value in 2021– valued at S$ 106 billion (US$ 80 billion) – while maintaining its share of about 20% of gross domestic product (GDP).
	Policy	**Electronics Industry Transformation Map (ITM) 2025** • Ambition for Singapore to be a critical global node for advanced Electronics manufacturing and innovation. ➢ Anchor R&D and manufacturing capabilities from globally leading companies to enhance Singapore's leadership in key areas ➢ Partner companies, Institutes of Higher Learning (IHLs) and the Singapore Semiconductor Industry Association to strengthen the local talent pipeline for growth areas. ➢ Transform Singapore's electronics manufacturing into a low-carbon footprint sector.

[78] Alvin Tan, 'Speech by MOS Alvin Tan at SSIA Semiconductor Business Connect 2021', *Ministry of Trade and Industry, Singapore*, https://www.mti.gov.sg/Newsroom/Speeches/2021/07/Speech-by-MOS-Alvin-Tan-at-SSIA-Semiconductor-Business-Connect-2021.

[79] Singapore Economic Development Board, 'Singapore Seeking Frontier Firms for 'Manufacturing 2030'', Economic Development Board, Singapore, 2 February 2021, https://www.edb.gov.sg/en/business-insights/insights/singapore-seeking-frontier-firms-for-manufacturing-2030.html.

Measures	**Key Initiatives**	**Tax Incentives** • Corporate Income Tax Exemptions ➢ 10-year exemption for advanced technology process nodes (28nm and below). ➢ 5-year exemption for 65nm and below nodes fabrication lines. ➢ 2-year exemption for 130nm and below fabrication lines. • Pioneer Certificate Incentive ➢ Tax exemptions on qualifying income for up to 15 years. • Development and Expansion Incentive ➢ Reduced corporate tax rate on qualifying income for up to 10 years. • International Headquarters (IHQ) Award ➢ Tax at concessionary rate of 5%, 10% or 15% on qualifying income in excess of base income. **Import Duty Exemptions:** • Exemptions for IC manufacturers to purchase imported semiconductor materials and equipment. **Investment in R&D:** • S$ 18 billion (US$ 13.7 billion) allocated between 2021 and 2025 to support innovation in the semiconductor sector. • S$ 112 million (US$ 85 million) investment to set up the National Gallium Nitride Technology Centre. This “boutique foundry” will serve as a shared resource and translation centre, focusing on the development and commercialization of gallium nitride (GaN) technologies. **Internship Opportunities:** • EnterpriseSG, EDB, Singapore Precision Engineering and Technology Association, Singapore Semiconductor Industry Association and various industry partners have created quality internship opportunities for students from Polytechnics and Institutes of Technical Education (ITEs).

Outcome	**Announcements on Key Investments**	Feb 2022: **UMC** announced plans to invest US$ 5 billion in the phase 3 expansion of its Fab12i, or Fab12i P3, in Singapore and also designated the new facility one of the most advanced semiconductor fabs in the country, set to roll out chips made on its 22 nanometer and 28nm processes. Jul 2023: **Silicon Box**, a semiconductor heterogenous integration startup unveiled its S$ 2 billion (US$ 1.5 billion) advanced semiconductor manufacturing foundry for chiplets. Sep 2023: **GlobalFoundries** officially opened its new S$ 5 billion (US$ 4 billion) wafer fab facility in Singapore focused on end-markets such as automotive, 5G mobility and secure devices. Mar 2024: **Advanced Substrate Technologies (AST)**, a Singapore-based subsidiary of TOPPAN Holdings Inc., broke ground on a Singapore facility to produce high end substrates and develop advanced technologies to meet global demand. Jun 2024: **VisionPower Semiconductor Manufacturing Company**, a joint-venture between VIS and NXP Semiconductor, announced that it will build a S$ 10.5 billion (US$ 7.8 billion) wafer manufacturing plant in Singapore for automotive, industrial, consumer and mobile device markets. Jun 2024: **Siltronic** opened its new S$ 2.9 billion (US$ 2.2 billion) production facility for 300mm wafers, making Singapore its largest production site globally. Jun 2024: **Pall Corporation**, opened a new S$ 202 million (US$ 150 million) state-of-the-art facility in Singapore to produce microelectronics filters for advanced node semiconductor manufacturing. Jun 2024: **MediaTek** has committed to investing S$ 500 million (US$ 380 million) in Singapore over the next five years. This will go towards furthering R&D capabilities in next-generation System on Chip (SoC) technologies.

Note: () indicates headquarter location.
Currency Exchange Rate: SG$ 1 is approximately US$ 0.76.
Source: Economic Development Board, Singapore, Press Release: "New Growth Strategies to Drive Advanced Manufacturing Across Five Sectors in Singapore," October 18, 2022; Chan Yiu Kei, "Singapore Advanced Manufacturing," International Trade Administration, Department of Commerce, U.S.A., August 28, 2022; "Global Semiconductor Incentives," Semiconductor Industry Association, February 2022; Economic Development Board, Singapore, Factsheet: "International Headquarters Award," https://invest.edb.gov.sg/find-government-support/international-headquarters-award; Accessed on September 30, 2024.

Incentives

With the increasing push towards digitalization and worldwide demand for chips growing rapidly, semiconductors are at the center of strong geostrategic interests, and of the global technological race. To energize its semiconductor industry, Singapore focuses on collaboration and increasing the presence of several key players, including major semiconductor equipment companies, wafer foundries, and integrated device manufacturers with production bases in Singapore.

As major countries increasingly race to control chip production and technology, the contest to attract high-end semiconductor investments has also heated up — huge government subsidies are being offered to attract chip makers. While not able to match the sheer scale of subsidies provided by larger players, Singapore offers targeted financial incentives and leverages several strategic advantages to remain competitive in the semiconductor industry.

To incentivize semiconductor investments, Singapore offers tax incentives, significant subsidies that lower land procurement and development costs, grants for talent development and tax benefits for R&D and registration of related intellectual property (IP).[80] In addition, the government supports special economic zones and science parks, enabling other members of the semiconductor supply chain to operate within the same facility as the fab that they support. The U.S. Department of Commerce's analysis of the global semiconductor supply chain notes that Singapore's semiconductor subsidies and incentives reduce the cost of facility ownership by 25-30%.[81]

Singapore's support goes beyond financial aid, as it also helps with working visas and regulation issues, which significantly improves project efficiency for chip companies.

[80] "Incentives and Schemes for Businesses," Economic Development Board Singapore, at https://www.edb.gov.sg/en/how-we-help/incentives-and-schemes.html, Accessed on September 30, 2024.
[81] The White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based: 100-Day Reviews under Executive Order 14017".

TAIWAN'S PARTNERSHIP WITH SINGAPORE

Taiwan and Singapore have a very close partnership in the semiconductor industry.

Systems-on-Silicon Manufacturing Company (SSMC) – A Joint Venture between TSMC and NXP Semiconductors

Founded in 1988, Systems-on-Silicon Manufacturing Company (SSMC) is a joint venture between Philips Semiconductors, an affiliate of Royal Philips Electronics, TSMC and the Economic Development Board Investments (EDBI) of Singapore. The partners' US$ 1.2 billion investment led to the creation of a state-of-the-art wafer fabrication facility in Singapore's Pasir Ris Wafer Fab Park. Over time, the partnership evolved, and now SSMC is a joint venture between NXP Semiconductors and TSMC. SSMC is an 8-inch wafer fabrication facility which offers flexible and cost-effective semiconductor fabrication solutions, focusing on technologies ranging from 0.25 to 0.11 microns.[82] It has grown to be the preferred source of wafer fabrication solutions for the mobile communication market and is fast becoming the preferred supplier to major automotive OEMs and vehicle manufacturers in the automotive industry where reliability and trust are two key requisites.[83]

UMC and Infineon Technologies

UMC has run pure play semiconductor foundries in Singapore for more than 20 years. In 2000, Germany's Infineon Technologies AG and Taiwan's UMC announced their plans to form a 300 mm silicon foundry company (Fab 12i) in Singapore. The total capitalization of the venture was US$ 3.6 billion.[84] The venture focused on making system-on-a-chip products based on 0.13- to 0.10-

[82] TSMC, Press Release: "SSMC Yields First Silicon at Singapore Fab," September 26, 2000.

[83] Ministry of Education of Singapore, Singapore-Industry Scholarship Sponsoring Organization in Electronics Industry: Systems on Silicon Manufacturing Company Pte Ltd, January 16, 2023. https://www.moe.gov.sg/sgis/sponsoring-organisations/industries/electronics/systems-on-silicon-manufacturing-company-pte-ltd#:~:text=SSMC%20offers%20flexible%20and%20cost,0.25%20to%200.11%20micron%20technology. Accessed on July 16, 2024.

[84] UMC, Press Release: "UMC Announces Plan to Establish the World's Most Advanced 300-mm Semiconductor Foundry in Singapore," December 15, 2000.

micron technologies. The process technology, dubbed “Worldlogic”, was jointly developed by UMC, Infineon and IBM.[85]

In 2022, UMC announced its plans to invest US$ 5 billion in the phase 3 expansion of its Fab12i, or Fab12i P3, to produce 22 and 28 nm chips.[86] The new fab was backed by customers including Infineon and the U.S. Qualcomm.[87] Mass production in Fab12i P3 has been set for early 2026.[88]

With the growing trend of vehicle electrification and automation, Infineon Technologies and UMC announced a long-term strategic cooperation agreement to multiply capacity for the production of Infineon automotive microcontroller on March 7, 2023. [89] The multi-year supply agreement leverages Infineon’s proprietary eNVM (embedded non-volatile memories) technology. The high-performance microcontroller product will be manufactured at UMC’s Fab 12i in Singapore on its 40 nm process. This agreement further strengthens UMC’s long-standing partnership with Infineon across various automotive, Artificial Intelligence of Things (AIoT), and 5G market segments. [90]

VIS and NXP Semiconductors

On June 5, 2024, VIS, an affiliate of TSMC, and NXP Semiconductors announced their plan to create a manufacturing joint-venture VisionPower Semiconductor Manufacturing Company Pte Ltd (VSMC), which will build a new 300 mm semiconductor wafer manufacturing facility in Singapore.[91] The joint-venture fab will support 130 nm to 40 nm mixed-signal, power management and analog products, targeting the automotive, industrial, consumer and mobile end markets. The underlying process technologies are planned to be licensed and transferred to the joint venture from TSMC. The fab will be operated by VIS.

[85] EETimes, “UMC, Infineon form $3.6 billion, 300-mm foundry venture in Singapore,” EETimes, December 15, 2000.
[86] UMC, Press Release: “UMC announces new 22nm wafer fab in Singapore,” February 24, 2022.
[87] Ben Blanchard, “Taiwan's UMC to spend $5 bln on new chip plant in Singapore,” Reuters, February 24, 2022.
[88] Chang Chien-chung and Frances Huang, “UMC's new fab in Singapore sees first equipment tools move in,” Focus Taiwan, May 21, 2024.
[89] United Microelectronics Corporation, Press Release: “Infineon and UMC Extend Automotive Partnership with Long-Term Agreement for 40nm eNVM Microcontroller Production,” March 7, 2023.
[90] Lisa Wang, “UMC signs production deal with Infineon,” Taipei Times, March 8, 2023.
[91] NXP, Press Release: “VIS and NXP to Establish a Joint Venture to Build and Operate a 300mm Fab,” June 5, 2024.

The total cost of the initial build out is anticipated to be US$ 7.8 billion. VIS will inject US$ 2.4 billion representing a 60% equity position in the joint venture and NXP will inject US$ 1.6 billion for the remaining 40% equity position. Both VIS and NXP have agreed to contribute an additional US$ 1.9 billion, which will be utilized to support the long-term capacity infrastructure. The remaining funding including loans will be provided by third parties to the joint venture.[92]

The joint venture will operate as an independent, commercial foundry supplier, providing assured proportional capacity to both equity partners, with an expected output of 55,000 300 mm wafers per month in 2029.[93]

ASE Singapore Pte. Ltd.

Advanced Semiconductor Engineering (ASE) Singapore was established in 1998 with an investment of about US$ 30 million.[94] It is part of the Advanced Semiconductor Engineering Group, the world's largest provider of independent semiconductor manufacturing services in assembly and testing.[95] It employs over 750 people and was amongst the top 200 companies on the list of 'Singapore's Best Employers 2023'.[96] ASE Singapore works closely with ASE Malaysia, forming a total semiconductor manufacturing supply chain from front-end testing to back-end IC packaging and testing.[97]

MediaTek Singapore Pte. Ltd.

MediaTek, the world's third largest fabless semiconductor company, has a presence in Singapore since 2004.[98] Starting its Singapore operations with 7 people initially, MediaTek has quickly expanded to today's team of more than 400 employees.[99]

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[92] Ibid.
[93] Ibid.
[94] ASE Technology Holding Co., Ltd. (2024). Annual Report 2024. Retrieved from https://media-aseholdco.todayir.com/20240606175626480089321_en.pdf.
[95] "Company Profile," ASE Singapore, https://www.aseglobal.com.sg/index.php/about-us/company-profile/, Accessed on October 9, 2024.
[96] "Singapore's best employers 2023," Straits Time and Statista, April 18, 2023,
[97] Advanced Semiconductor Engineering, Press Release: "ISE Labs Singapore renaming to ASE Singapore," October 14, 2003.
[98] "Company Highlights: MediaTek"EDB, Singapore, https://www.edb.gov.sg/en/our-industries/company-highlights/mediatek.html, Accessed on October 9, 2024.
[99] Ibid; MediaTek, Press Release: "MediaTek Expands Research & Development Centre," March 4, 2011.

Over the years, MediaTek has committed to investing various sums to expand its R&D operations in Singapore. Between 2004 and 2013, the company had invested over S$ 180 million (US$ 138.6 million).[100] In 2014, MediaTek committed over S$ 250 million (US$ 192.5 million) for R&D spending by 2020.[101] This year, it announced an additional S$ 500 million (about US$ 374.1 million) investment over the next five years.[102]

MediaTek Singapore's R&D center is one of the company's most advanced centers globally. The company focuses on developing highly-integrated, ultra-low-power system-on-chip devices, which are crucial for a variety of applications, including smartphones, home entertainment, network connectivity, automated driving, and the IoT.

MediaTek has strong research collaboration with local universities and has also set up a new MediaTek Endowment Professorship in IC Design with Nanyang Technological University (NTU) in 2011 to build up a strong base of technical talent in Singapore.[103] In addition, MediaTek announced earlier this year that it has signed a Memorandum of Understanding (MoU) with the Singapore University of Technology and Design (SUTD) for collaboration on 6G technology research. The MoU marks the first time MediaTek will set up an advanced wireless technology collaboration in Singapore, as well as the first 6G R&D technology investment in the country. The research will be part of Singapore's national 6G program, called the Future Communications R&D Program (FCP).[104]

Singapore also serves as MediaTek's regional hub for logistics and manufacturing operations, as well as its IT operations and management center for the Asia Pacific region.[105]

[100] Tan Weizhen, "MediaTek's S$250m injection boosts local semicon sector," Today, July 2, 2014.
[101] MediaTek, Press Release: "MediaTek Marks 10th Year Anniversary in Singapore With Additional Financial Investment In Research and Academia," July 1, 2014.
[102] MediaTek, Press Release, "MediaTek and Singapore University of Technology and Design sign MoU on 6G Technology Research Collaboration," June 25, 2024.
[103] "Company Insights: MediaTek," Economic Development Board, https://www.edb.gov.sg/en/our-industries/company-highlights/mediatek.html, Accessed on October 9, 2024.
[104] MediaTek, Press Release, "MediaTek and Singapore University of Technology and Design sign MoU on 6G Technology Research Collaboration," June 25, 2024.
[105] Ibid.

Other Taiwanese Suppliers and Vendors

In addition, a number of Taiwan's companies specializing in semiconductor materials, sewage treatment, and factory construction have a presence in Singapore. Wholetech System Hitech (S) Pte. Ltd, for example, is a Taiwanese semiconductor equipment company that specializes in providing a range of equipment and services for the semiconductor manufacturing industry, including wafer processing, testing, and assembly equipment. It counts companies such as SSMC, UMC, GlobalFoundries, VIS, and Micron as its clients.

Overall, the collaboration between Taiwan and Singapore in the semiconductor industry is a significant driver for both economies. Taiwan's expertise in semiconductor manufacturing, particularly through companies like TSMC and UMC, and Singapore's strategic position as a global tech hub create a powerful synergy. For instance, Taiwan's exports to Singapore are heavily dominated by semiconductor-related products, accounting for about 80% of the total in 2022. Similarly, around 60% of Singapore's exports to Taiwan were also semiconductor-related in 2022. This mutual exchange not only strengthens their respective semiconductor sectors but also enhances global supply chain resilience.

CONCLUSION

Historical factors, combined with Singapore's commitment to a business-friendly environment and continual alignment with industry trends, have enabled Singapore to become an integral part of the global semiconductor supply chain. It accounts for 10% of all chips produced worldwide and approximately 20% of global semiconductor manufacturing equipment production.

Singapore has a critical mass of leading companies based here which cover the entire value chain, from design to wafer fabrication, to assembly and testing. Its semiconductor industry is heavily influenced by foreign companies. Major global players like Micron, GlobalFoundries, UMC, ASE, MediaTek and VIS have significant operations in Singapore. These companies have

established manufacturing facilities and R&D centers, leveraging Singapore's strategic location and supportive business environment. This foreign presence has been instrumental in positioning Singapore as an important node in the global semiconductor industry. It also brings in substantial investments, technology transfers, and job opportunities, contributing to the country's economic growth.

Singapore's strategic approach and proactive policies have made it a prime destination for semiconductor investments, especially in the context of current geopolitical tensions and supply chain realignments. Major global players have chosen to set up their operations in the country, and this has strengthened Singapore's reputation as a hub for legacy chip manufacturing. Singapore's focus on legacy chips, which are essential components for various applications like automotive, industrial, and IoT devices, has allowed it to carve out a unique niche in the global market.

Singapore and Taiwan have been actively collaborating in the semiconductor industry, leveraging their respective strengths to enhance global supply chains. Their semiconductor partnership not only enhances the semiconductor industries in both countries but also adds resilience to the global semiconductor supply chain.

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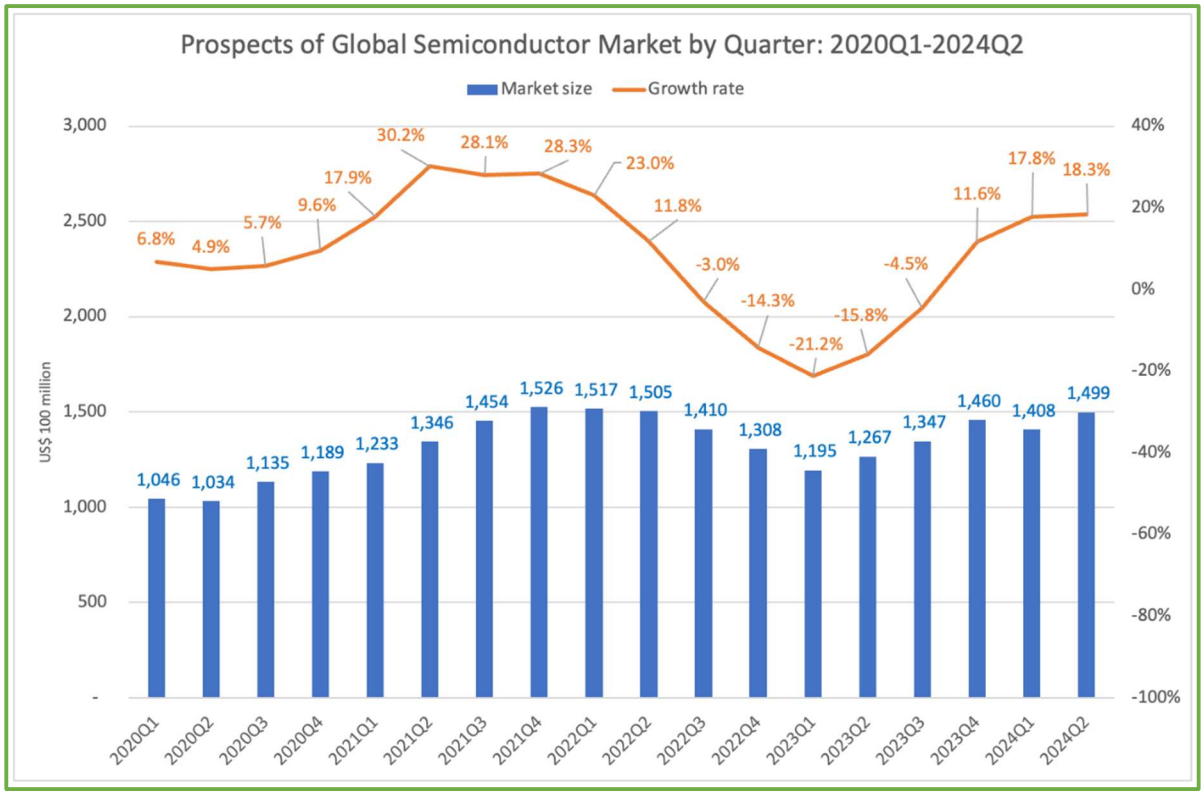
Semiconductor Statistics

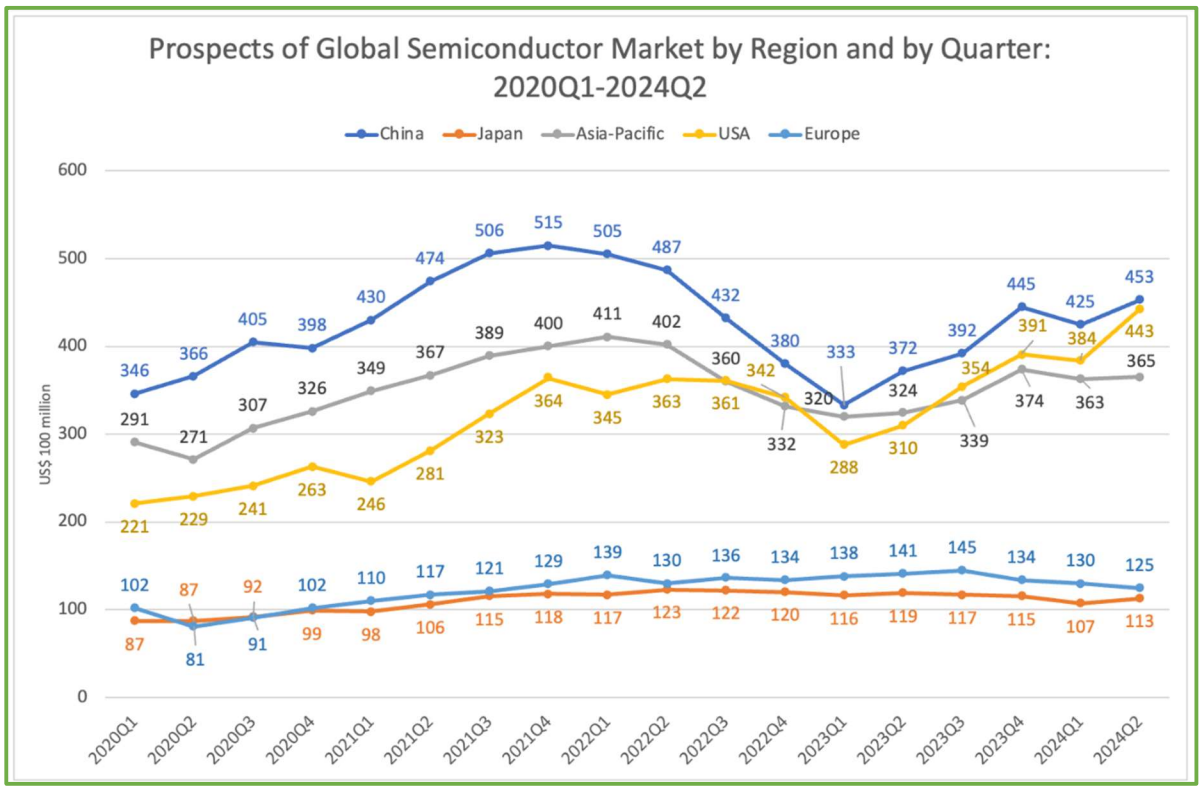
Figure 14: Prospects of Global Semiconductor Market by Quarter: 2020Q1-2024Q2



Source: Chia-Chen Lee, "Global Economy and Semiconductor Market Trends in the Second Quarter of 2024," IEK, ITRI, September 23, 2024, p. 9.

Figure 14 shows the prospects of the global semiconductor market by quarter, from the first quarter of 2020 to the second quarter of 2024. The size of the global semiconductor market has fluctuated over the period, from US$ 103.4 billion in the second quarter of 2020, and generally increasing, with some dips, to about US$ 149.9 billion in the fourth quarter of 2022. The growth rate of the global semiconductor market has witnessed significant variability, with a high peak growth rate of 30.2% in the second quarter of 2021 and a plunging negative growth rate of 21.2% in the first quarter of 2023.

Figure 15: Prospects of Global Semiconductor Market by Region and by Quarter: 2020Q1-2024Q2

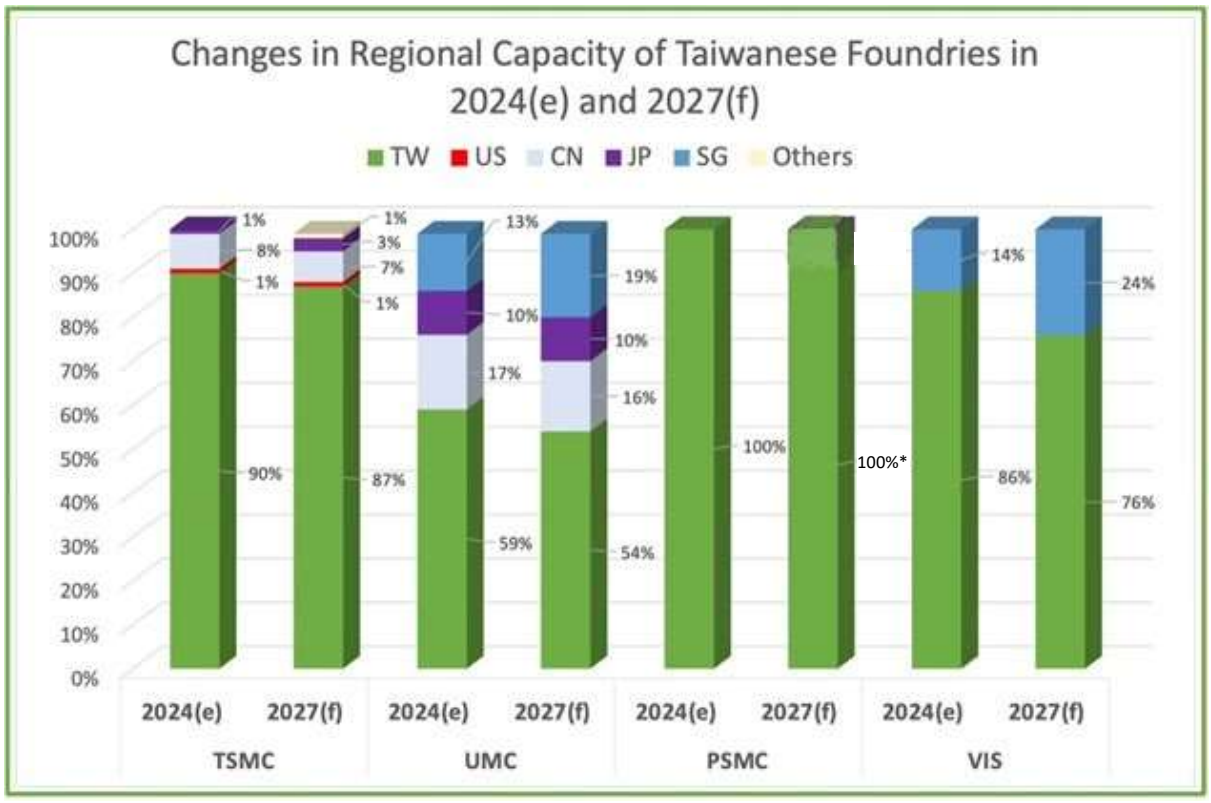


Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2024Q2," IEK, ITRI, September 23, 2024, p. 3.

Figure 15 shows the projected revenue from the semiconductor market in billions of U.S. dollars for five different regions: China, Japan, Asia-Pacific, USA, and Europe.

Other than Europe, all the regions saw a growth in semiconductor revenue from the first quarter of 2024 to the second quarter of 2024. China's market is projected to hit US$ 45.3 billion in the second quarter of 2024, which indicates a significant lead compared to other regions. This lead can be attributed to various factors, including increased demand for electronics, advancements in technology, and substantial investments in semiconductor manufacturing.

Figure 16: Changes in Regional Capacity of Taiwanese Foundries in 2024 and 2027



*SBI Holdings announced on September 27, 2024 the dissolution of its partnership with Taiwan's Powerchip Semiconductor Manufacturing Corp. for the construction of a chip factory in Miyagi Prefecture.
Source: TrendForce, "Taiwanese Chipmakers Expand Overseas to Capitalize on Geopolitical Shifts and De-Sinicization Benefits, Says TrendForce," June 5. 2024.

Taiwan's semiconductor factories are actively investing overseas to expand, but it is estimated that more than four-fifths of production capacity will still be concentrated in Taiwan within these four years.

In recent years, due to the influence of geopolitics and various countries' semiconductor policies, Taiwan's semiconductor foundries have begun to actively invest overseas and set up factories in various countries.

TSMC’s investment in the United States is mainly concentrated in new semiconductor factories in Arizona. It has invested US$ 40 billion in two semiconductor factories and will invest US$ 25 billion in a third semiconductor factory in the future. In addition, TSMC's total investment in Kumamoto, Japan, exceeds US$ 20 billion, and its investment in Germany is concentrated in Dresden, with an amount of more than US$ 10.6 billion.

In addition to TSMC, UMC will invest US$ 5 billion in Singapore in 2022, and Power Semiconductor Manufacturing Co., Ltd. will invest US$ 5.6 billion in Japan. This year (2024), VIS will invest US$ 2.8 billion in Singapore. These semiconductor factories will start production in the next few years.

Faced with the large-scale foreign investment and construction of Taiwan's semiconductor factories, the regional distribution of Taiwan's semiconductor foundry production capacity will change, according to estimates released by TrendForce in early June this year. By 2027, the proportion of Taiwan's four major semiconductor foundries in production in Taiwan will decrease, the proportion in Japan will increase slightly, the proportion in China will decrease slightly, the proportion in Singapore will increase significantly, and the proportion in the United States will remain unchanged.

In turn, this means that TSMC's share of production in Taiwan will drop from 90% this year to 87% in 2027, mainly because Japan's share will increase by 2 percentage points, and elsewhere (probably Germany) will increase by 1 percentage point. China’s share will decrease by 1 percentage point.

UMC's share of production in Taiwan will drop from 59% this year to 54% in 2027, mainly because Singapore's share will increase by 6 percentage points and China's share will decrease by 1 percentage point.

PSMC's share of production in Taiwan, which was anticipated by TrendForce to drop from 100% this year to 93% in 2027, will remain at 100% following the dissolution of its planned tie-up with SBI Holdings in September 2024 to build a semiconductor plant in Japan’s Miyagi Prefecture.[106] Instead, PSMC will be shifting its focus on providing technology for a chip plant to be built in India by Tata Group in India. This move will keep PSMC’s production

[106] Masayuki Shikata, Hideaki Ryugen and Ryosuke Hanada, “Taiwan chipmaker PSMC abandons Japan plans after India deal,” Nikkei Asia, September 28, 2024.

entirely in Taiwan for now, while it transfers mature process technologies and train local employees as part of the partnership.[107]

The proportion of the VIS products produced in Taiwan will drop from 86% this year to 76% in 2027. In contrast, the proportion of the VIS products produced in Singapore will increase by 10 percentage points from 14% this year to 24% in 2027.

While the production proportions are shifting, the overall revenue and scale of operations for semiconductor companies can vary greatly. Larger companies with advanced technologies may still dominate the market, even if their production share changes.

In the first quarter of this year, TSMC accounted for 61.7% of global semiconductor foundry revenue (revenue of US$ 18.85 billion). The total revenue of the four foundries (TSMC, UMC, PSMC, and VIS) was US$ 21.2 billion, which was almost the entire semiconductor foundry output value in Taiwan.

Based on TrendForce's estimated production capacity change ratio, weighted by the global production revenue share of Taiwan's four major semiconductor companies in the first quarter of this year, Taiwan's semiconductor factories account for 87.5% of Taiwan's production capacity. By 2027, the proportion of Taiwan's semiconductor factories' production capacity in Taiwan is expected to drop to 84.2%.

In summary, even though Taiwan's semiconductor factories have made large-scale overseas investments of more than US$ 100 billion in the past few years and expanded overseas production bases, more than four-fifths of Taiwan's semiconductor foundries' production capacity is expected to still be concentrated in Taiwan in 2027 because Taiwan’s semiconductor factories’ investment in Taiwan is also expanding rapidly.

[107] TrendForce, Press Release: “Taiwan’s PSMC Denies Rumors that Financial Troubles Caused the End of Partnership with Japan’s SBI,” September 30, 2024.

Special Feature: TSMC’s Global Market Share Reached a New High

- **Global foundry revenue increased by 9.6% in the second quarter of this year, and TSMC’s global market share reached a new high**

According to the latest statistics from TrendForce, global foundry revenue reached US$ 32 billion in the second quarter of this year, an increase of 9.6%. Among the top ten wafer foundries in the world, TSMC still dominates, with its global market share reaching a record high of 62.3%, leaving other wafer foundries far behind.

The total market share of the world's top ten wafer foundries in the second quarter of this year remained at 96%, and the ranking of the world's top ten wafer foundries has not changed much. Except for VIS, which moved up two places to eighth in the world, the rankings of other foundries have not changed. In particular, TSMC is far ahead of other foundries in terms of global market share.

In the second quarter of this year, TSMC's performance was still impressive, with revenue increasing by 10.5% to US$ 20.8 billion, and its global market share reaching 62.3%. Samsung's revenue increased by 14.2%, and its global market share reached 11.5%, which was slightly higher than the first quarter's market share by 0.5 percentage points. The revenue, global market share and ranking of other foundries have not changed much, and their global market share were only between 5.7% and 0.9%.

From an annual perspective, TSMC's global market share of revenue continues to rise, increasing from 55.4% in 2022 to 58.9% in 2023, and further to 62.0% in the first half of this year, a significant increase every year. The most obvious decline is Samsung, whose global revenue market share fell from 16.0% in 2022 to 12.0% in 2023, and then slightly dropped to 11.3% in the first half of this year.

In contrast, the global market share of UMC, GlobalFoundries, and Huahong Group has declined significantly, with a decline of 0.9-1.3 percentage points from 2022 to the first half of this year. The global market share of other wafer foundries has not changed much, maintaining relatively stable competitiveness.

Table 5: Ranking and Market Share of Global Top 10 Foundries by Revenue: 2022Q1-2024Q2

Ranking	Company	Market Share									
		2024Q2	2024Q1	2023Q4	2023Q3	2023Q2	2023Q1	2022Q4	2022Q3	2022Q2	2022Q1
1	TSMC (TW)	62.3%	61.7%	61.2%	57.9%	56.4%	60.1%	58.5%	56.1%	53.4%	53.6%
2	Samsung (KR)	11.5%	11.0%	11.3%	12.4%	11.7%	12.4%	15.8%	15.5%	16.4%	16.3%
3	SMIC (CN)	5.7%	5.7%	5.2%	5.4%	5.6%	5.3%	4.7%	5.3%	5.6%	5.6%
4	UMC (TW)	5.3%	5.7%	5.4%	6.0%	6.6%	6.4%	6.3%	6.9%	7.2%	6.9%
5	GlobalFoundries (USA)	4.9%	5.1%	5.8%	6.2%	6.7%	6.6%	6.2%	5.8%	5.9%	5.9%
6	Huahong Group (CN)	2.1%	2.2%	2.0%	2.6%	3.0%	3.0%	2.6%	3.3%	3.1%	3.2%
7	Tower (IL)	1.1%	1.1%	1.1%	1.2%	1.3%	1.3%	1.2%	1.2%	1.3%	1.3%
8	VIS (TW)	1.0%	1.0%	1.0%	1.1%	1.2%	1.0%	0.9%	1.2%	1.5%	1.5%
9	PSMC (TW)	1.0%	1.0%	1.0%	1.0%	1.2%	1.2%	1.2%	1.6%	1.9%	2.0%
10	Nexchip (CN)	0.9%	1.0%	1.0%	1.0%	n.a.	n.a.	n.a.	1.0%	1.4%	1.4%
Total of Top 10		96.0%	96.0%	95%	95%	94%	98%	98%	97%	98%	98%

Source: TrendForce, Press Releases.

Table 6: Ranking and Market Share of Global Top 10 Foundries by Revenue: 2022-2024

Ranking	Company	Market Share		
		2024H1	2023	2022
1	TSMC (TW)	62.0%	58.9%	55.4%
2	Samsung (KR)	11.3%	12.0%	16.0%
3	SMIC (CN)	5.7%	5.4%	5.3%
4	UMC (TW)	5.5%	6.1%	6.8%
5	GlobalFoundries (USA)	5.0%	6.3%	6.0%
6	Huahong Group (CN)	2.2%	2.7%	3.1%
7	Tower (IL)	1.1%	1.2%	1.3%
8	VIS (TW)	1.0%	1.1%	1.3%
9	PSMC (TW)	1.0%	1.1%	1.7%
10	Nexchip (CN)	1.0%	1.0%	1.3%

Source: TrendForce, Press Releases.

Profile: WholeTech System Hitech

WHOLETECH SYSTEM HITECH (S) PTE. LTD founded on April 25th, 1996, under the leadership of a group of elites from headquarters WHOLETECH SYSTEM HITECH LIMTIED (Taiwan). Our company has undertaken engineering projects of semiconductor companies such as SSMC, UMC, GF, VIS, and Micron. During these projects, our employees provided excellent engineering quality to customers with their experience, expertise and superior professional skills, and earning unanimous praise from our customers. With a staff that has the technical skill and practical experience, Wholetech specializes in the following areas of service:

W1 - Gas Engineering Division

W2 - Clean Room Construction & MEP Division

W3 - High Vacuum Division

W4 - Specialty Gas Supply System & Monitor System integration Division

W5 - Advanced Products Division

W6 - System Software Development Division

W7 - Wet Process & Chemical System Division

At Wholetech, we deliver on our promise of turnkey solutions with code compliances and quality guarantee. Moreover, we continuously strive for our clients' satisfaction and provide uncompromising integrity.

In recent years, the demand for localized production in the semiconductor industry and the development trends driven by applications in ESG, AI, and high-performance computing have emerged. In order to serve customer needs, WHOLETECH has strengthened from team organization and expanded capital investment to continuously enhance R&D design capabilities, after-sales service, technical support, talent training, and digital technology integration within the company.

WHOLETECH aims to maintain flexible adaptability, focusing on improving engineering quality while emphasizing the importance of safety and health. In response to global climate change and industry transformation challenges, WHOLETECH continues to invest in the research and development of energy-saving and high-efficiency new technologies, providing customers with the highest quality engineering and equipment solutions, offering customers more services aligned with green sustainability and responsibility, moving together toward the vision of sustainability.

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2024/08/30
Taiwan Talks

Did Taiwan Steal the U.S.' Chip Business?

On at least two public occasions, when Republican U.S. Presidential Nominee Donald Trump was asked whether he would defend Taiwan if China invaded, he responded by saying Taiwan "took [the U.S.'] chip business from [them]." In his latest interview with Bloomberg Businessweek in August, he said Taiwan "should pay [the U.S.] for defense" adding that Taiwan "doesn't give [the U.S.] anything." So, with the U.S. presidential election just over two months away, is there any truth to these allegations about Taiwan?

2024/09/11
Taiwan Talks

Xi Acknowledges Economic Challenges Amid Moves To Boost Chip Investment

China's state-run Xinhua News Agency has reported that Xi Jinping acknowledged difficulties in the country's economy. With the Chinese government investing US$47 billion in its semiconductor industry, can China overcome both foreign and domestic challenges to reach its 5% GDP growth target? In this episode of "Taiwan Talks," we examine the significance of Xi's admission, pullout of foreign direct investment from China, and responses to the country's Third Plenum. Furthermore, we discuss internal and external challenges for China's economy, the viability of Xi's proposed economic policies, and whether China's semiconductor investment fund could help the sector regain a competitive edge.

2024/09/14 **Name of Show: Connected with Divya Gopalan** **How Are Semiconductor Startups Changing the Industry?**	 In our second episode from SEMICON we take a look at what startups are doing in the semiconductor field. From groundbreaking research to cutting-edge commercialization, we took to the floor, speaking with the companies that are driving innovation. Guests: Blumind Co-founder and COO, Niraj Mathur and Silicon Box Head of Business, Mike Han, imec President and CEO, Luc Van den hove
2024/09/07 **Name of Show: Connected with Divya Gopalan** **SEMICON Taiwan 2024 with imec President Luc Van de hove**	 We're here with leaders in the semiconductor industry for SEMICON Taiwan 2024 in Taipei. We discuss highlights from the event including advances in artificial intelligence (AI), modular computing, chiplets and the sustainability of chip manufacturing and design. Guests: imec President and CEO, Luc Van den hove, Blumind Co-founder and COO, Niraj Mathur and Silicon Box Head of Business, Mike Han

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