# TAIWAN AND THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN

## - Europe's Semiconductor Industry

Edited by:
Chen-Yuan Tung, Ph.D.
Representative
Taipei Representative Office in Singapore

Please feel free to reach out to the Economic Division of the Taipei Representative Office in Singapore should you have any enquiries or are seeking partnership opportunities of investment or collaboration in the field of semiconductors in Taiwan.

Email: singapore@sa.moea.gov.tw
Telephone: +65 6500-0128

Published: Taipei Representative Office in Singapore
Address: 460 Alexandra Road, #23-00 mTower, Singapore 119963
Email: sgp@mofa.gov.tw
Telephone: +65 6500-0100

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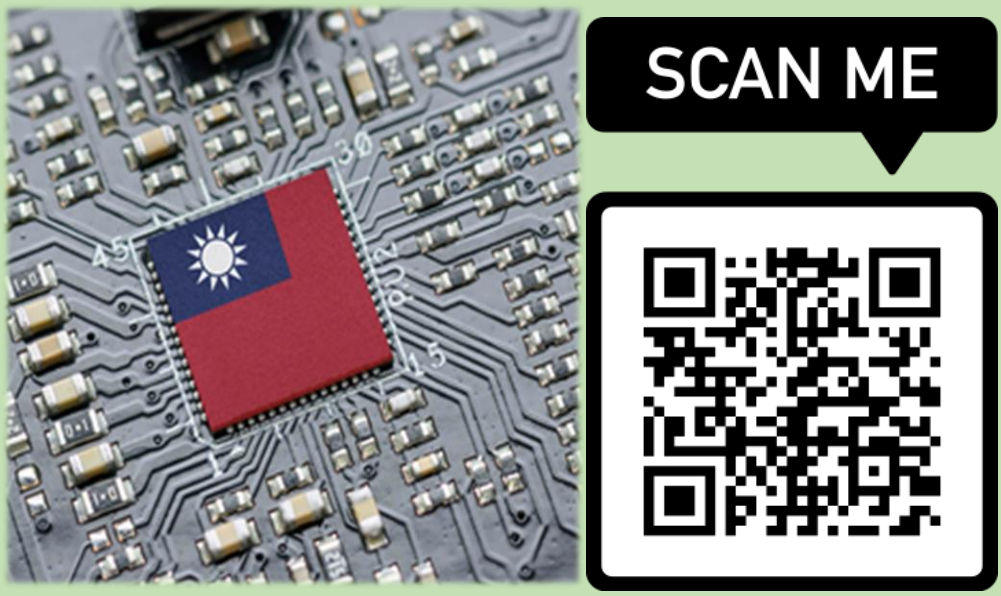

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## IN THE SPOTLIGHT

# Europe's Semiconductor Industry

- **Europe plays a vital role in semiconductor research and development activities, advanced materials, and manufacturing equipment in the global semiconductor ecosystem.**
- **To foster a robust semiconductor ecosystem aligned with its economic and technological objectives, the EU aims to increase its global market share to 20% by 2030, up from 10.6% in 2023.**
- **TSMC and ASE are among Taiwan's semiconductor companies playing an active role in the revitalization of Europe's semiconductor industry.**

Source: Shutterstock

## OVERVIEW

Semiconductors are viewed as a strategic resource by many countries, and have been described as "an indispensable component in Europe's sustainable and digital future" by Ursula von der Leyen, President of the European Commission.[1]

The European Union (EU) and European countries outside the EU, such as Switzerland and the United Kingdom, play a crucial role in the global semiconductor ecosystem. Europe excels in the areas of research and

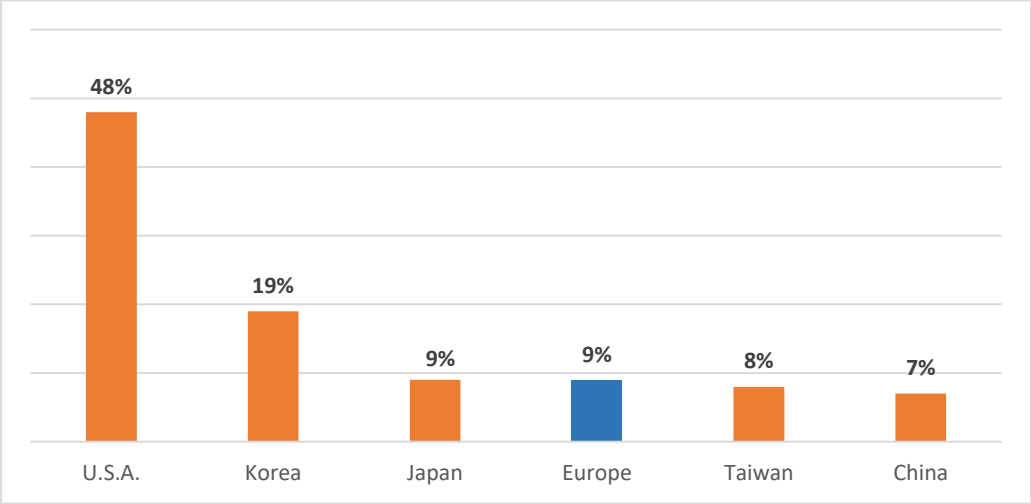
[1] European Commission, Press Release: "Speech by President von der Leyen at the groundbreaking ceremony for a new plant of Infineon Technologies AG," May 2, 2023.

development, advanced materials, and semiconductor manufacturing equipment but its role in global semiconductor production is relatively modest compared to other regions. By prioritizing domestic production, addressing supply chain vulnerabilities, and fostering international collaboration with like-minded partners like Taiwan, Europe aims to strengthen its semiconductor supply chain resilience and support technological advancements.[2]

## Europe's Share of Global Semiconductor Revenue

Europe's share of global semiconductor revenue has experienced a decline over the years. In the 1990s, Europe held a substantial 20% share but stiff competition from North America and Asia (including Taiwan, South Korea, and Japan) has led to the decline in the market share of the European semiconductor industry. By 2022, Europe's share of global semiconductor revenue has fallen to 9% (see Figure 1).

***Figure 1: Global Market Share: 2022***




Source: Semiconductor Industry Association, "State of Industry Report," July 27, 2023.

Innovations in semiconductor manufacturing and the need for critical mass across the value chain continue to transform the global semiconductor market. Semiconductor companies in North America and Asia are particularly strong in areas like innovation, cost efficiency, and scaling production quickly. In the face of stiff competition, Europe has seen its market share eroded over

[2] European Cluster Collaboration Platform, News Release: "EU-Taiwan Investment Partnership Forum on Semiconductor Clusters," September 15, 2023.

time.[3] In terms of the share of internationally filed patents since 2000, for example, East Asia outpaced the rest of the world.[4]

Despite Europe's relatively smaller global market share, it is an important player in the global semiconductor supply chain. Europe has established itself as a leader in optoelectronics, producing components essential for communication technologies, healthcare and lighting solutions.[5] European companies also excel in developing sensors for automotive, industrial, and consumer applications.[6]

Table 1 shows global semiconductor revenue by region and product type from 2023 to 2025. In 2023, the global semiconductor market totaled US$ 526.9 billion in revenue. Logic integrated circuit (IC) was the largest semiconductor category by sales at US$ 178.6 billion (33.9% of 2023 total market revenue). Memory (US$ 92.3 billion) and analog ICs (US$ 81.2 billion) rounded out the top three product categories in terms of total sales.

### *Table 1: Semiconductor Revenue by Region and Product Type: 2023 to 2025*

*Unit: US$ million*

| Spring 2024 | Amounts | | | Year on Year Growth in % | | |
|---|---|---|---|---|---|---|
| | 2023 | 2024(f) | 2025(f) | 2023 | 2024(f) | 2025(f) |
| **Americas** | 134,377 | 168,062 | 192,941 | -4.8 | 25.1 | 14.8 |
| **Europe** | 55,763 | 56,038 | 60,901 | 3.5 | 0.5 | 8.7 |
| **Japan** | 46,751 | 46,254 | 50,578 | -2.9 | -1.1 | 9.3 |
| **Asia Pacific** | 289,994 | 340,877 | 382,961 | -12.4 | 17.5 | 12.3 |
| **Total World** | **526,885** | **611,231** | **687,380** | **-8.2** | **16.0** | **12.5** |
| **Discrete Semiconductors** | 35,530 | 32,773 | 35,310 | 4.5 | -7.8 | 7.7 |
| **Optoelectronics** | 43,184 | 42,736 | 44,232 | -1.6 | -1.0 | 3.5 |
| **Sensors** | 19,730 | 18,265 | 19,414 | -9.4 | -7.4 | 6.3 |
| **Integrated Circuits** | 428,442 | 517,457 | 588,425 | -9.7 | 20.8 | 13.7 |
| Analog | 81,225 | 79,058 | 84,344 | -8.7 | -2.7 | 6.7 |
| Micro | 76,340 | 77,590 | 81,611 | -3.5 | 1.6 | 5.2 |
| Logic | 178,589 | 197,656 | 218,189 | 1.1 | 10.7 | 10.4 |
| Memory | 92,288 | 163,153 | 204,281 | -28.9 | 76.8 | 25.2 |
| **Total Products** | **526,885** | **611,231** | **687,380** | **-8.2** | **16.0** | **12.5** |

[3] Andrew Johnston and Robert Huggins, "Europe's semiconductor industry at a crossroads: Industrial policy and regional clusters," Euro Commentary, European Urban and Regional Studies, 2023, Vol. 30(3).

[4] Friedrich Dornbusch, "Global competition in microelectronics industry from a European perspective: Technology, markets and implications for industrial policy," March 2018.

[5] Osram, https://ams-osram.com/.

[6] Andreas Cornet, Ruth Heuss, Patrick Schaufuss, and Andreas Tschiesner, "A road map for Europe's automotive industry," McKinsey, August 31, 2023.

Note: Figures for 2023 are actual billings while figures for 2024 and 2025 are forecasted(f). Numbers in the table are rounded to whole millions of dollars, which may cause totals by region and totals by product group to differ slightly.

Source: World Semiconductor Trade Statistics, Press Release: "The World Semiconductor Trade Statistics (WSTS) has released its latest forecast for the global semiconductor market, anticipating robust growth in 2024 and 2025," June 4, 2024.

In 2023, Europe's semiconductor industry revenue reached about US$ 55.8 billion or 10.6% share of global semiconductor industry revenue.[7] Despite a decline in global semiconductor sales due to global inflation and geopolitical risks, Europe stood out as the only regional market that experienced annual growth in 2023, with sales there increasing 3.5% year-over-year.[8] The Asia Pacific region posted the steepest decline of 12.4%. In the Americas, the market contracted 4.8%.

Robust growth, however, is anticipated for the global semiconductor market in 2024 and 2025. The updated market valuation for 2024 is estimated at US$ 611.2 billion.[9] This revision reflects stronger performance in the last two quarters of 2023, particularly in computing end-markets. Two IC categories are anticipated to drive the growth for the year with double digit increase, namely, Logic with 10.7% and Memory with 76.8 % while Discrete, Optoelectronics, Sensors, and Analog Semiconductors are expected to experience single-digit declines.[10]

Europe is expected to show marginal growth of 0.5% in 2024, and account for 9.2% share of the global semiconductor revenue. The Americas and Asia Pacific regions are projected to see spectacular growth in 2024, with increases of 25.1% and 17.5%, respectively while Japan is forecasted to see a slight decline of 1.1%.[11]

Looking ahead to 2025, the World Semiconductor Trade Statistics (WSTS) forecasts a 12.5% growth in the global semiconductor market, reaching an estimated valuation of US$ 687.3 billion. This growth is expected to be driven primarily by the Memory and Logic sectors, which are on track to soar

[7] WSTS, Historical Billings Report: "36 Years WSTS Blue Book Data" (1986 to April 2024)," June 2024. https://www.wsts.org/esraCMS/extension/media/f/WST/6571/WSTS-Historical-Billings-Report-Apr2024.xlsx. Accessed on June 25, 2024.

[8] World Semiconductor Council, "Joint Statement of The 28th Meeting of The World Semiconductor Council (WSC)," June 6, 2024.

[9] European Semiconductor Industry Association, Press Release: "Worldwide semiconductor market expected to recover strongly and hit $611 billion in 2024," June 6, 2024.

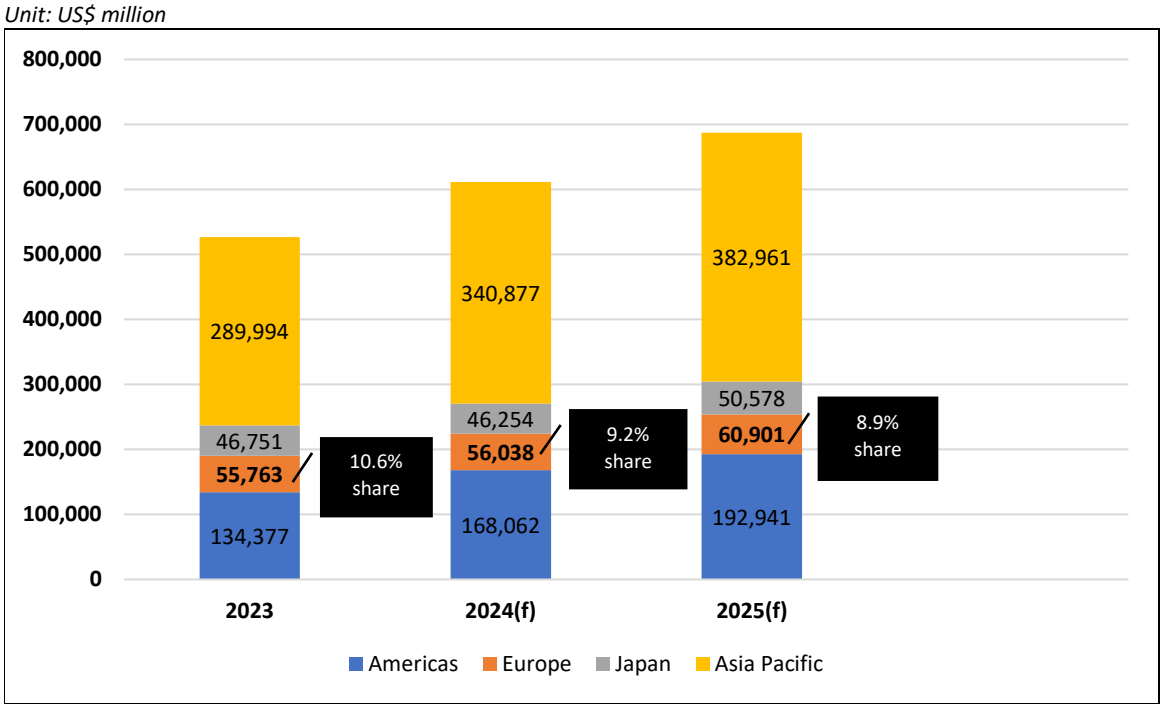
[10] Ibid.

[11] European Semiconductor Industry Association, Press Release: "Worldwide semiconductor market expected to recover strongly and hit $611 billion in 2024," June 6, 2024.

to over US$ 200 billion in 2025 each, representing an upward trend of over 25% for Memory and over 10% for Logic from the previous year. All other segments are anticipated to record single-digit growth rates. For this round, semiconductor revenue in Europe is expected to grow 8.7% but this will account for only 8.9% share of the global semiconductor revenue in 2025 (see Table 1).

### *Figure 2: Semiconductor Revenue by Region: 2023 to 2025*

*Unit: US$ million*




Source: World Semiconductor Trade Statistics, Press Release: "The World Semiconductor Trade Statistics (WSTS) has released its latest forecast for the global semiconductor market, anticipating robust growth in 2024 and 2025," June 4, 2024.

In a nutshell, the WSTS forecasts indicate a decline in Europe's share of the global semiconductor revenue. Specifically, Europe's share is expected to decrease from 10.6% in 2023 to 9.2% in 2024, and further fall to 8.9% in 2025. This trend highlights the competitive pressures and challenges Europe faces in maintaining its position in the global semiconductor market. Despite efforts to boost local production and innovation, other regions like the Americas and Asia Pacific are projected to experience more significant growth (see Figure 2).

Moreover, European semiconductor companies have ranked in the top 10 world wide semiconductor vendors for many years. Philips, for example, was in the list for many years, including 1990 and 2000. In more recent years, with the demand for automotive semiconductors and power electronics rising

globally, companies like STMicroelectronics and Infineon, which are at the forefront of this growth, are gaining in prominence (see Table 2).

### *Table 2: Top 10 Semiconductor Vendors by Revenue: 1990-2023*

| | 1990 | 2000 | 2010 | 2020 | 2023 |
|---|---|---|---|---|---|
| 1 | NEC (Japan) | Intel (U.S.) | Intel (U.S.) | Intel (U.S.) | Intel (U.S.) |
| 2 | Toshiba (Japan) | Toshiba (Japan) | Samsung (South Korea) | Samsung (South Korea) | Samsung (South Korea) |
| 3 | Hitachi (Japan) | NEC (Japan) | Toshiba (Japan) | SK Hynix (South Korea) | Qualcomm (U.S.) |
| 4 | Intel (U.S.) | Samsung (South Korea) | Texas Instruments (U.S.) | Micron (U.S.) | Broadcom (U.S.) |
| 5 | Motorola (U.S.) | Texas Instruments (U.S.) | Reneasas* (Japan) | Qualcomm (U.S.) | NVIDIA (U.S.) |
| 6 | Fujitsu (Japan) | Motorola (U.S.) | SK Hynix (South Korea) | Broadcom (U.S.) | SK Hynix (South Korea) |
| 7 | Mitsubishi (Japan) | STMicroelectronics (Europe) | STMicroelectronics (Europe) | NVIDIA (U.S.) | Advanced Micro Devices (U.S.) |
| 8 | Texas Instruments (U.S.) | Hitachi (Japan) | Micron (U.S.) | Texas Instruments (U.S.) | STMicroelectronics (Europe) |
| 9 | Philips (Europe) | Infineon (Europe) | Qualcomm (U.S.) | Apple (U.S.) | Apple (U.S.) |
| 10 | Matshishita (Japan) | Philips (Europe) | Elpida** (Japan) | Infineon (Europe) | Texas Instruments (U.S.) |
| | **Dropped out of top 10:** | • Fujitsu<br>• Mitsubishi<br>• Matsushita | • Motorola<br>• Hitachi<br>• Infineon<br>• Philips*** | • Renesas<br>• STMicroelectronics<br>• Elpida | • Micron<br>• Infineon |

Note: Ranking based on global semiconductor sales excluding pure-play foundries.
* Post NEC/Renesas merger.
** Combination of NEC, Hitachi, and Mitsubishi DRAM business.
*** Philips spun off its semiconductor business in 2006, creating a new independent company called NXP Semiconductors.

Source: Ramiro Palma, Raj Varadarajan, Jimmy Goodrich, Thomas Lopez, and Aniket Patil, "The Growing Challenge of Semiconductor Design Leadership," Boston Consulting Group, November 30, 2022. P. 12; Gartner, Press Release: "Gartner Says Worldwide Semiconductor Revenue Declined 11% in 2023," January 16, 2024.

Table 3 lists the world's 30 largest semiconductor companies in 2022 as per a U.S. Bureau of Industry and Security (BIS) report. These 30 largest semiconductor companies accounted for approximately US$ 684.5 billion or 75 % of global semiconductor and semiconductor manufacturing service revenue in 2022.[12] Three European IDMs, namely, STMicroelectronics, Infineon and NXP Semiconductors, are among the top 30 ranks, accounting for a share

[12] 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.

of 6.6% of the world's 30 largest semiconductor companies, or US$ 45.1 billion in total revenue in 2022.

### *Table 3: World's 30 Largest Semiconductor Companies by Revenue: 2022*

| Company | Primary Segment | Process Role | Country of Headquarters | Revenue (US$ billions) |
|---|---|---|---|---|
| Samsung* | Memory | IDM | South Korea | $76.2 |
| TSMC | Foundry | Foundry | Taiwan | $75.9 |
| Intel | Micro | IDM | U.S.A. | $63.1 |
| Qualcomm | Logic | Fabless | U.S.A. | $43.0 |
| Apple** | Logic | Fabless | U.S.A. | $40.0 |
| SK Hynix | Memory | IDM | South Korea | $34.0 |
| Broadcom | Logic | Fabless | U.S.A. | $33.2 |
| Nvidia | Logic | Fabless | U.S.A. | $29.6 |
| Micron Technology | Memory | IDM | U.S.A. | $27.2 |
| Advanced Micro Devices | Micro | Fabless | U.S.A. | $23.6 |
| Advanced Semiconductor Engineering | AT&P | AT&P | Taiwan | $22.2 |
| Texas Instruments | Analog | IDM | U.S.A. | $19.6 |
| MediaTek | Logic | Fabless | Taiwan | $18.4 |
| Western Digital | Memory | IDM | U.S.A. | $16.4 |
| STMicroelectronics | Analog | IDM | Switzerland | $16.1 |
| Infineon | Discretes | IDM | Germany | $15.8 |
| Murata | Sensors | IDM | Japan | $14.0 |
| NXP Semiconductors*** | Micro | IDM | Netherlands | $13.2 |
| Analog Devices | Analog | IDM | U.S.A. | $12.0 |
| Kioxia | Memory | IDM | Japan | $11.7 |
| Renesas | Analog | IDM | Japan | $11.3 |
| United Microelectronics Corporation | Foundry | Foundry | Taiwan | $9.2 |
| Sony-Imaging and Sensing Solutions**** | Optoelectronics | IDM | Japan | $9.1 |
| onsemi | Discretes | IDM | U.S.A. | $8.3 |
| GlobalFoundries | Foundry | Foundry | U.S.A. | $8.1 |
| Microchip Technology Incorporated | Micro | IDM | U.S. | $8.1 |
| Semiconductor Manufacturing International Corporation (SMIC) | Foundry | Foundry | China | $7.2 |
| Amkor Technology | AT&P | AT&P | U.S.A. | $7.1 |
| Marvell Semiconductor, Inc. | Logic | Fabless | U.S.A. | $5.8 |
| Skyworks Solutions | Analog | IDM | U.S.A. | $5.3 |
| **Europe Total** | | | | **$45.1** |
| **Top 30 Total** | | | | **$684.5** |

Data is based on annual and quarterly financial filings via company websites and U.S. Securites and Exchange Commission.
*Data is for Samsung's Semiconductor (DS) segment.
**Estimated value of Apple's semiconductor production based on publicly reported share of TSMC's revenue.
***NXP Semiconductors is spun off from Philips in 2006. Philips Semiconductors became NXP Semiconductors, a separate, stand-alone company.[13]
****Data is for Sony's Imaging and Sensing Solutions segment.

Source: 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, p. 15.

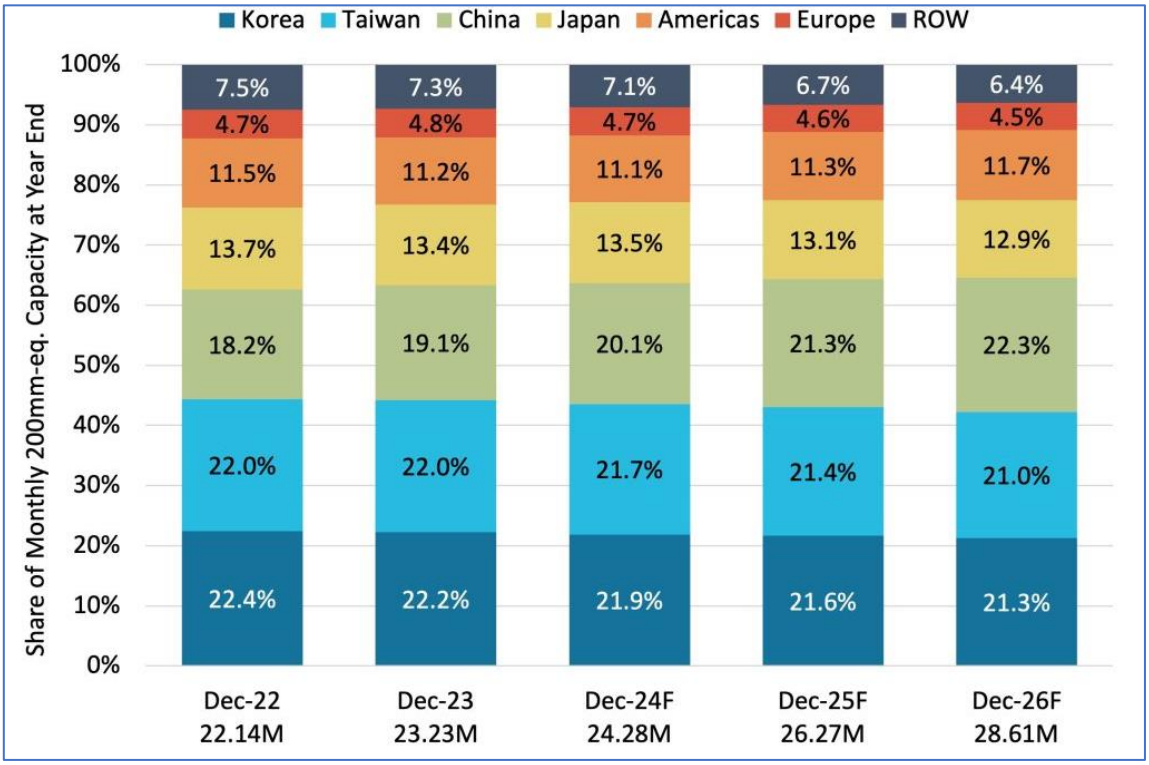
[13] NXP Semiconductors, Annual Report 2006, NXP Semiconductors, 2006.

## Europe's Share of the Global Semiconductor Production Capacity

A rebound in demand for ICs began in the later part of 2023 and is expected to continue in 2024 to 2026. According to figures from Knometa Research, global wafer capacity for IC production is projected to grow 4.5% year-to-year by December 2024 followed by growth of 8.2% and 8.9% in 2025 and 2026, respectively.[14]

Power and compound semiconductors, which are vital for the consumer, automotive and industrial sectors, are the biggest drivers of investment in 8-inch equivalent semiconductor production.[15] Figure 3 shows the share of monthly IC production capacity for 8-inch equivalent wafers by region.

### *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.

Europe's share of global IC wafer manufacturing capacity saw a slight increase from 4.7% in December 2022 to 4.8% in December 2023. However, projections indicate a decline back to 4.7% in December 2024 and further

[14] Peter Clarke, "Europe sinks as China rises to lead in IC wafer capacity by 2026," eeNews, April 9, 2024, citing 2024 edition of the Global Wafer Capacity Report from Knometa Research.

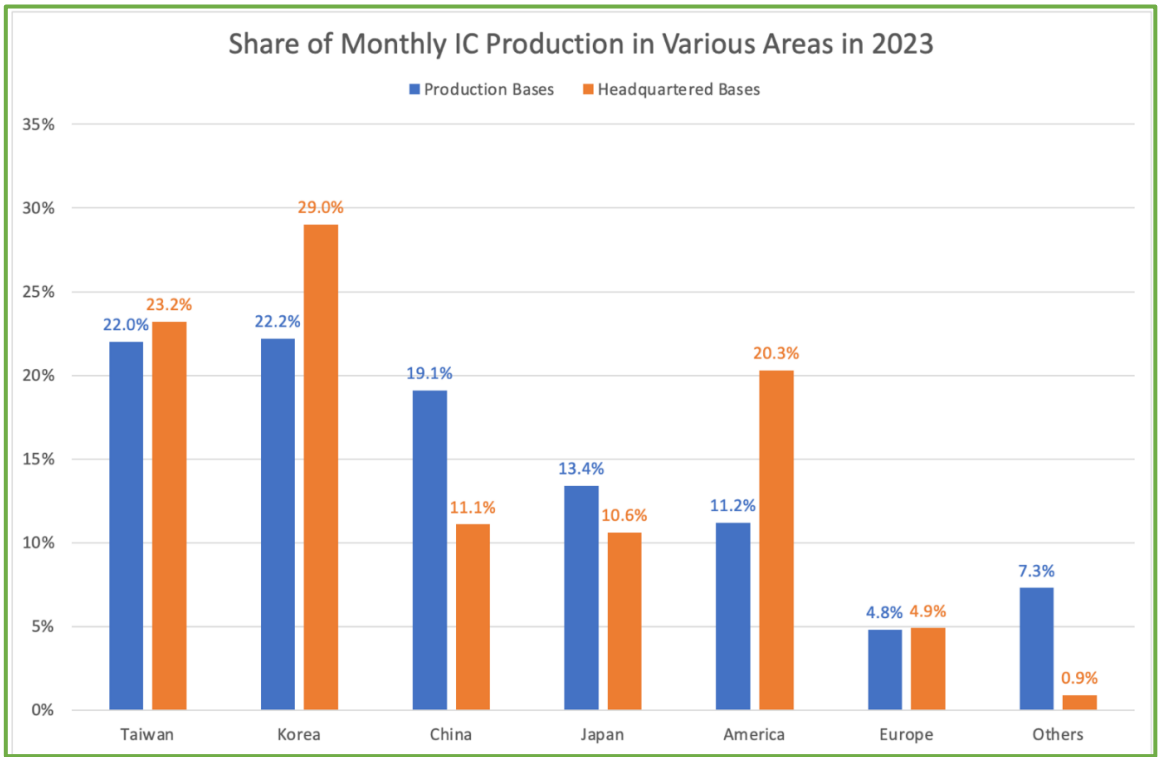
[15] SEMI, Press Release: "Global 200mm Fabs To Reach Record High Capacity By 2026, SEMI Reports," September 19, 2023.

down to 4.5% by December 2026 (see Figure 3). This anticipated decline is despite announcements of significant investment plans by leading semiconductor companies. There is a delay in seeing the impact of these investments because many of the new fabs and expansions are expected to become operational only after 2026.

Taiwan (22.0%), South Korea (22.2%), and China (19.1%) possessed approximately 63.3% of the world's global chip manufacturing capacity for 8-inch equivalent wafers as of December 2023. These countries have been investing heavily in semiconductor manufacturing and are expected to continue to maintain their leadership in global chip production from 2024 to 2026.

Figure 4 shows the global distribution of monthly production capacity of 8-inch equivalent ICs of pure-play foundries, IDMs and other types of semiconductor companies by geography in 2023.

***Figure 4: Share of Monthly IC Production Capacity of 8-Inch Equivalent by Geography: 2023***



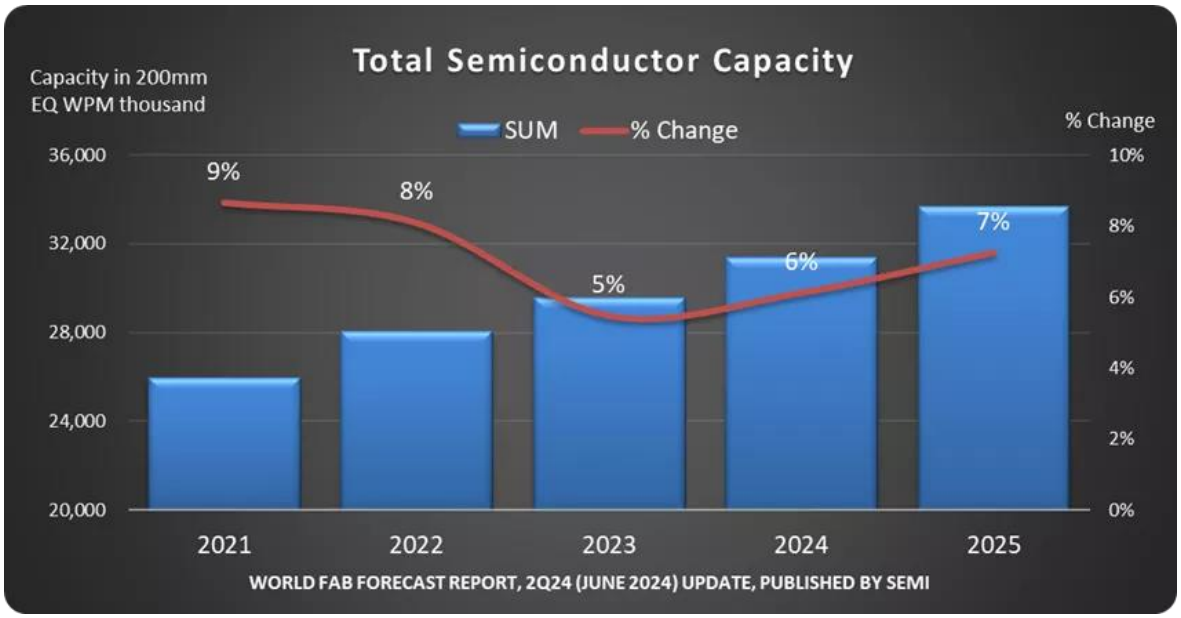

Source: Chia-Chen Lee, "Policy-Driven Regional Semiconductor Manufacturing development," IEK, ITRI, March 20, 2024, p. 1.

Although Europe's demand for semiconductors for industrial and automotive applications is high, its current share of global semiconductor

production capacity is relatively small compared to other regions. In 2023, Europe's contribution to global 8-inch equivalent semiconductor production is less than 5%, both in terms of production bases (include fabs of domestic and foreign-invested companies in the country) and also in terms of headquartered bases (include fabs in home country and various host countries of multinational semiconductor companies). This segment of the semiconductor industry has seen significant growth in other regions, particularly Asia, which dominates the market with major players in countries like Taiwan, South Korea, and China (see Figure 4).

According to SEMI's latest World Fab Forecast report, the global chip manufacturing industry is projected to boost capacity by 6% in 2024 and 7% in 2025, reaching US$ 33.7 million 8-inch equivalent wafer per month (wpm) (see Figure 5).[16]

### *Figure 5: 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. Europe and Mideast are expected to grow 4% year-on-year (YoY), with semiconductor manufacturing capacity of 2.7 million wpm. Chinese chipmakers

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

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 Southeast Asia are expected to grow semiconductor manufacturing capacity by 4.7 million wpm (3% YoY), 3.2 million wpm (5% YoY), and 1.8 million wpm (4% YoY), respectively (see Table 4).[17]

Europe and the Middle East together is projected to have roughly 8.5% share of the industry measured by capacity of 8-Inch equivalent wafers in 2024. This share falls to 8.0% of global capacity in 2025 (see Table 4). In fact, according to the Semiconductor Industry Association, Europe's share of the global wafer fabrication capacity of 8-Inch equivalent wafers is projected to remain at 8% in 2032.[18]

***Table 4: 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 and 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.

While Europe has a strong history in semiconductor research and development, it has struggled to compete with North America and Northeast Asia (Taiwan, South Korea, Japan and China) in terms of manufacturing capacity.

[17] Ibid.

[18] Raj Varadarajan et al, "Emerging Resilience in The Semiconductor Supply Chain," Boston Consulting Group, May 2024.

## Major Players in the European Semiconductor Industry

As a prominent hub for research and development, Europe's cutting-edge research facilities including the Interuniversity Microelectronics Centre (IMEC) in Belgium, CEA-Leti in France and the Fraunhofer-Gesellschaft in Germany are the origin of many industrial innovations in nanoelectronics and semiconductor technologies.[19] The close ties between the knowledge institutes with universities, industry partners, and other research organizations, fosters Europe's position as a hub for cutting-edge technology.[20] For example, Europe has played a leading role in the development of the Fully Depleted Silicon on Insulator (FDSOI) technology, a wafer fabrication process that offers ultra-low power consumption and sets new standards in automotive, internet of things (IoT) and mobile applications.[21]

Netherlands' ASML plays a vital role in advancing semiconductor technology. ASML was founded as a joint venture between Philips and ASM International in 1984.[22] In 1995, ASML became a fully independent company and has since grown to become Europe's largest technology company by market capitalisation.[23] As of June 2024, ASML, with a market value of € 377 billion (US$ 411 billion), is not only Europe's top tech firm but also its second most valuable company.[24] ASML manufactures extreme ultraviolet (EUV) systems which enable major semiconductor companies such as TSMC and Samsung to mass produce the smallest chips.[25] In fact, Intel CEO Pat Gelsinger has described ASML, the most advanced lithography, and IMEC, the most advanced semiconductor research in the world, as the two jewels of Europe.[26]

Arm Holdings plc, headquartered in the United Kingdom, is the world's leading semiconductor intellectual property (IP) company.[27] Its IP solutions are used in 99% of the world's smartphone central processing unit (CPU) cores,

[19] Sujai Shivakumar, Charles Wessner, and Thomas Howell, "The French Model for Cooperative Semiconductor Research: Lessons from CEA-Leti," Center for Strategic and International Studies, February 16, 2024.
[20] IMEC, Press Release: "Crucial role for IMEC in EU Chips Act,"
[21] GlobalFoundries, Press Release: "STMicroelectronics and GlobalFoundries to advance FD-SOI ecosystem with new 300mm manufacturing facility in France," July 11, 2022.
[22] ASML, "Our History," ASML, https://www.asml.com/en/company/about-asml/history. Accessed on July 23, 2024.
[23] Reuters, "ASML to hire 100 researchers leaving Philips," Reuters, July 19, 2023.
[24] Henry Ren and Kit Rees, "ASML Surpasses LVMH as Second-Biggest Stock in Europe," Bloomberg, June 6, 2024.
[25] ASML corporate website. https://www.asml.com/en. Accessed on June 24, 2024.
[26] Alan Crawford, "The U.S.-China Tech Conflict Front Line Goes Through Belgium," Bloomberg, July 13, 2021.
[27] Morrison & Foerster LLP, Press Release: "MoFo Represents Arm on Largest IPO of 2023," September 18, 2023.

and it also has high market share in other battery-powered devices like wearables, tablets, or sensors.[28] In addition, Europe's other world-leading companies in semiconductor chemicals (Germany's Merck KGaA and BASF SE), materials (Germany's Siltronic AG), and Electronic Design Automation (Germany's Siemens EDA) also contribute to the global semiconductor ecosytem.[29]

Europe is home to a number of semiconductor manufacturers that specialize in supplying its automotive, healthcare and industrial equipment sectors. It also represents a massive market of equipment purchasers, especially in the automotive industry and aeronautics. Unsurprisingly, Europe's three largest Integrated Device Manufacturers (IDMs) – STMicroelectronics, Infineon and NXP – are named the top three vendors in the global automotive semiconductor landscape in 2023.[30]

From manufacturing powerhouse Germany to research-driven Belgium, European countries play pivotal roles across various domains of the global semiconductor industry.

## Europe'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 5).[31] Each sector plays a crucial role in the semiconductor ecosystem, contributing to the advancement of technology and innovation.

Semiconductor supply chains include research and development (R&D), production, production inputs, and distribution for end-use. R&D underpins all production and its inputs. Semiconductor production includes three segments, namely, design, manufacturing, and assembly, testing, and packaging (ATP).

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[28] Arm Holdings corporate website. https://www.arm.com/company Accessed on June 28, 2024.

[29] Michael Nienaber, Jenny Leonard and Kamil Kowalcze, "Germany in Talks to Limit Export of Chip Chemicals to China," Bloomberg, April 27, 2023; Siltronic corporate website. https://www.siltronic.com/en/index.html. Accessed on June 24, 2024.

[30] Tech Insights, "2023 Automotive Semiconductor Vendor Share: STMicroelectronics Closing in on NXP and Infineon," April 2024; Infineon, Press Release: "Infineon expands its leading market position in automotive semiconductors – World market leader in automotive MCUs for the first time," April 9, 2024.

[31] 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.

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.

***Table 5: 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

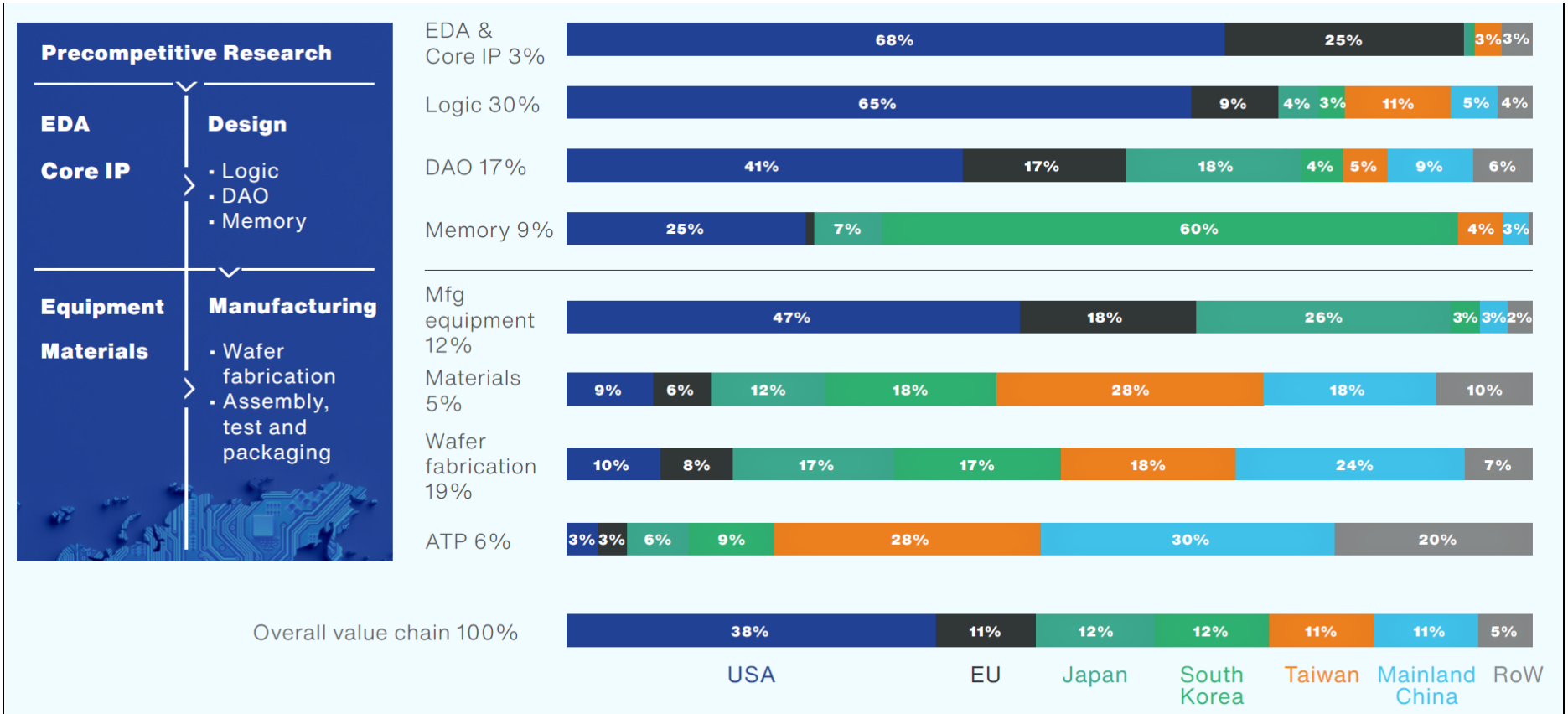
In addition, the semiconductor manufacturing ecosystem is a global network characterized by its complexity and specialization (see Figure 6). The semiconductor industry is highly concentrated, with companies headquartered in the United States, Taiwan, South Korea, Japan, China and the EU accounting for nearly all semiconductor revenue.[32] 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 EU held 11% share of the overall semiconductor value chain in 2022, as does Taiwan and China. The U.S.A., with a 38% share in global semiconductor value chain, remains a powerhouse. Japan and South Korea each held 12% share of the global semiconductor value chain (see Figure 6).

[32] 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.

## *Figure 6: Semiconductor industry value-added by activity and region: 2022 (%)*



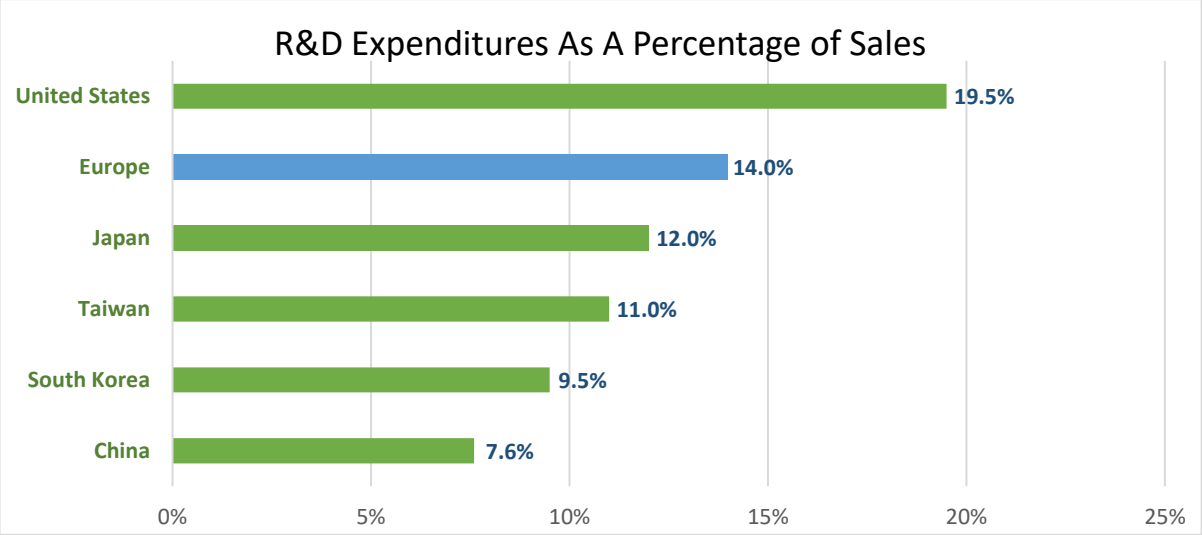

Notes on regional breakdown:

- 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 Israel, Singapore 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.

## IC Research & Development

***Figure 7: Semiconductor Industry R&D Spending Across Regions: 2022***




Source: Semiconductor Industry Association, SIA 2024 Factbook, May 14, 2024, p. 18.

According to the Semiconductor Industry Association, European semiconductor companies invested 14% of the total sales in R&D in 2022, putting them behind their U.S. counterparts (19.5%) but ahead of semiconductor companies in Japan (12.0%) , Taiwan (11.0%), South Korea (9.5%) and China (7.6%) (see Figure 7).

The United States' dominance in semiconductor R&D is largely due to the fact that most of the world's fabless companies are U.S.-based. Fabless companies devote on average 20% of their revenues to R&D. By focusing heavily on innovation and design, fabless companies can stay competitive and push the boundaries of semiconductor technology. According to the U.S. Bureau of Industry and Security, U.S.-based companies account for 73% of the world's fabless companies and 78% of global R&D carried out by fabless companies.[33] NVIDIA, Advanced Micro Devices (AMD), and Qualcomm, for example, are renowned IC design companies with heavier R&D costs that are over 20% of their revenues (see Figure 8).

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

### *Figure 8: Semiconductor R&D Expenditures of Leading Firms: 2022*

Unit: US$ billion

| Company Name | Headquarters | Sales | R&D Expenditure | R&D Intensity (%) |
|---|---|---|---|---|
| Intel | U.S.A. | 63.1 | 17.5 | 28% |
| Qualcomm | U.S.A. | 43.0 | 8.5 | 20% |
| NVIDIA | U.S.A. | 29.6 | 6.9 | 23% |
| Samsung | Korea | 76.2 | 6.0* | 8% |
| TSMC | Taiwan | 75.9 | 5.5 | 7% |
| AMD | U.S.A. | 23.6 | 5.0 | 21% |
| Broadcom | U.S.A. | 33.2 | 4.9 | 15% |
| MediaTek | Taiwan | 18.4 | 3.9 | 21% |
| SK Hynix | Korea | 34.5 | 3.7 | 11% |
| ASML | Netherlands | 21.9 | 3.5 | 16% |
| Micron | U.S.A. | 27.2 | 3.3 | 12% |
| Western Digital | U.S.A. | 18.8 | 2.3 | 12% |
| NXP | Netherlands | 13.2 | 2.1 | 16% |
| Infineon | Germany | 15.8 | 2.0 | 13% |
| STMicroelectronics | Switzerland | 16.1 | 1.9 | 12% |
| Marvell | U.S.A. | 5.9 | 1.7 | 29% |
| Analog Devices | U.S.A. | 12.0 | 1.7 | 14% |
| Texas Instruments | U.S.A. | 20.0 | 1.7 | 9% |
| Microchip | U.S.A. | 8.1 | 1.1 | 14% |
| Realtek | Taiwan | 3.8 | 1.0 | 26% |

Note: Data is based on company annual reports.
*Samsung R&D figure is estimated based on ICInsights 2020 estimate

Source: U.S. Department of Commerce, Bureau of Industry and Security, Office of Technology Evaluation, "Assessment of the Status of The Microelectronics Industrial Base In The United States," December 2023, p.73; ASML, 2022 Annual Report; Kuo-Hua Chou, "Are the world's tech behemoths getting more bang for their lavishly splurged R&D bucks in 2022?" Digitimes Asia, March 20, 2023.

Europe is a significant player in semiconductor R&D, coming in second in terms of spending. In fact, the semiconductor industry has been ranked as the most R&D-intensive sector by the European Commission for some time.[34] ASML's R&D spending of € 3.3 billion (US$ 3.5 billion) in 2022, for example, was 16% of its revenue for the year.[35] NXP's US$ 2.1 billion spending on R&D in 2022 represented 16% of its revenue.[36] Infineon's R&D expenses were € 1,798 million (US$ 2 billion) in the 2022 fiscal year, or 13% of revenue.[37] Likewise,

[34] European Semiconductor Industry Association, Press Release: Worldwide semiconductor market expected to hit $520 billion in 2023, revival in 2024, November 28, 2023.
[35] ASML, 2022 Annual Report. https://www.asml.com/en/investors/annual-report/2022. Accessed July 4, 2024.
[36] NXP, Annual Report for The Financial Year Ended December 31, 2022. https://www.nxp.com/docs/en/supporting-information/2022-IFRS-SAR.pdf. Accessed on July 4, 2024.
[37] Infineon, Annual Report 2023. https://www.infineon.com/dgdl/IFX+Annual+Report+2023+-+Research+and+development.pdf?fileId=8ac78c8b8b657de2018bfcdedda90090. Accessed on July 3, 2024.

STMicroelectronics invested about US$ 1.9 billion in R&D in 2022, or 12% of revenue (see Figure 8).[38]

In addition, Europe is the world's centre for semiconductor research and its semiconductor industry benefits extensively from a rich R&D ecosystem present across EU Member States.[39] EU's four leading research and technology organizations (RTOs), France's CEA-Leti, Germany's Fraunhofer-Gesellschaft, Belgium-headquartered IMEC and Finland's VTT Technical Research Centre, for example, are collaborating on a networked, multi-hub platform providing prototype chip fabrication capability in advanced artificial intelligence technology to EU stakeholders.[40]

Facing stiff competition from the U.S.A. and Asia, Europe continues to invest in R&D to catch up in the semiconductor industry. Top chipmakers such as Taiwan's TSMC, U.S.A's Intel and South Korea's Samsung are launching 2 nm chips this year (2024) and next year in commercial plants, or fabs, which cost as much as € 20 billion (US$ 21.8 billion) each.[41] To help the European industry, academics and start-ups access chip manufacturing technology that would otherwise be too expensive for any one of them to test or use in development, IMEC will be hosting a pilot line for sub-2 nm chips.[42] The European R&D line is intended to help develop future generations of even more advanced chips, and will be outfitted with equipment from European and global equipment and materials firms.

Because of the combined dynamism of its world-class R&D centers, education institutes, and key end-user industries, European innovation continues to be driven by long-term partnerships, symbiotic value-added chains, academic networks and collaborative projects forming together a productive research ecosystem.

[38] STMicroelectronics, STMicroelectronics Sustainability Report 2023. https://sustainabilityreports.st.com/sr23/_assets/downloads/ST-Sustainability-report-2023.pdf. Accessed July 3, 2024.
[39] European Commission, "A Chips Act for Europe," February 8, 2022.
[40] Fraunhofer, Press Release: "EU Consortium Developing Next-Gen Edge-AI Technologies Is Accepting Design Proposals," March 11, 2024.
[41] Toby Sterling, "European labs led by IMEC to receive $2.7 billion in Chips Act funding," Reuters, May 21, 2024.
[42] Ibid.

### *Table 6: Market Share of Process Roles by Location of Company Headquarters: 2022*

| | Fabless | IDM | Total Semiconductor Providers | Foundry | OSAT | Total Outsourced Manufacturing |
|---|---|---|---|---|---|---|
| **Total (US$ billion)** | **248** | **412** | **660*** | **139** | **50** | **190** |
| United States | 72% | 42% | 53% | 6% | 15% | 8% |
| Taiwan | 14% | 2% | 6% | 65% | 58% | 63% |
| South Korea | 1% | 22% | 14% | 16% | 1% | 12% |
| Japan | 1% | 17% | 11% | 1% | 0% | 0% |
| China | 12% | 2% | 6% | 9% | 20% | 12% |
| Germany | 0% | 5% | 3% | 1% | 0% | 0% |
| Switzerland | 0% | 4% | 3% | 0% | 0% | 0% |
| Netherlands | 0% | 4% | 2% | 0% | 0% | 0% |

BIS's data is based on publicly reported sales and estimates of the revenues of major non-public companies

* The BIS estimates may exceed those of the Semiconductor Industry Association (US$ 574 billion, via SIA 2023 Factbook) and Gartner (US$ 600 billion, April 26 2023 press release) in part because it is revenue focused, and thus may not have fully accounted for non-semiconductor revenue or integration of semiconductors into other semiconductor devices. Foundry and ATP revenue are not part of these vendor-specific reports.

Source: 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.

Companies based in the United States are particularly strong in design processes, accounting for 72% of all fabless revenue, 42% of revenue among companies that do both design and manufacturing, and 53% of global semiconductor revenue in 2022.[43] Taiwan- and China-based companies account respectively for the second and third largest share of the fabless market. Taiwan, in particular, has developed extensive expertise and infrastructure in semiconductor manufacturing and its strong OSAT industry offers competitive pricing and scalability, attracting more fabless companies to outsource their manufacturing needs. In 2022, Taiwan accounted for 63% of total outsourced manufacturing revenue (see Table 6).[44]

While European semiconductor companies may not dominate in IC design in sheer volume compared to other regions, their impact is substantial.

[43] 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.
[44] Ibid.

Europe is strong in selected specific areas, such as in the design of components for power electronics, radio frequency and analogue devices, sensors, and microcontrollers that are widely used in the automotive and manufacturing industries.[45] IDMs based in Germany, the Netherlands, and Switzerland accounted for 5%, 4% and 4% of the IDM market share, or a combined 13% of all IDM revenue among companies that do both design and manufacturing (see Table 6).

According to TrendForce, the supply of EDA tools is largely controlled by Synopsys, Cadence, and Siemens EDA, three major players with deep technical expertise across the entire spectrum of EDA tools.[46] Siemens EDA (formerly Mentor Graphics) has its roots in the United States but is now part of Siemens, a German conglomerate.[47] Its EDA tools, which focus on areas like printed circuit board (PCB) design, field-programmable gate array (FPGA) development and automotive electronics, find extensive use in automotive and aerospace sectors.[48] Mentor Graphics was the third largest of the Big Three EDA vendors by revenue, behind Synopsys and Cadence, but its acquisition by Siemens in 2017 has made it part of one of the world's largest multinational companies.

In the semiconductor intellectual property (IP) arena, Europe is home to two global vendors, namely, ARM and Imagination Technologies, which account for around 40% of global intellectual property development in the sector.[49]

## Frontend Manufacturing: Wafer Fabrication

Europe's share with regard to the value added in the area of wafer fabrication in the global semiconductor industry is 8% in 2022 (see Figure 6).

As a result of strategic choices, the major IDMs in EU – Infineon, NXP and STMicroelectronics – make chips mainly for profitable niche segments such as the automotive and industrial sectors.

[45] European Commission, "A Chips Act for Europe," February 8, 2022.
[46] TrendForce, Press Release: "China's EDA Industry Enters a Period of Consolidation amidst Rapid Growth," October 10, 2023.
[47] Siemens, "Electronic Design Automation." https://www.sw.siemens.com/en-US/technology/electronic-design-automation-eda/. Accessed on July 9, 2024.
[48] Ed Sperling, "EDA Looks Beyond Chips," Semiconductor Engineering, April 25, 2024.
[49] Jim Pickard and Anna Gross, "UK must cut chip imports from risky parts of world, review finds," Financial Times, April 20 2023.

European firms remain competitive in the specialised areas of sensors, power and radio frequency chips, where the focus is on materials innovation, not size reductions.[50] Other chips for these industries may be designed by EU companies, but Infineon, NXP and STMicroelectronics outsource their chip production to TSMC and other foundries.[51] U.S.-headquartered GlobalFoundries, for example, stands out as Europe's largest and one of the most advanced semiconductor manufacturing services company, based in Dresden, Germany.[52]

Additionally, the absence of a large consumer electronics industry in Europe means there is no large scale domestic demand for advanced, leading-edge logic chips today. As a result, the share of the EU in manufacturing capacity has dropped from around a quarter at the start of the century to only 4.8% in 2023.[53]

Meanwhile, as innovations find their way into products, demand for leading-edge chips will increase. According to ING Think, the share of semiconductors with nodes below 10 nm in automotive is forecasted to grow from 2% today to 10% in 2030.[54] Recently, the Semiconductor Equipment and Materials International (SEMI) announced that it is expected that both TSMC and Intel will potentially complete the construction of 2 nm wafer fabs by the end of this year.[55] Meanwhile, Intel's 1 nm-class fab near Magdeburg, Germany, which is set to be the most advanced semiconductor production facility in Europe and the world when it becomes operational, has pushed the start of its contruction timeline to May 2025 due to black soil removal issues and delays in subsidy approvals.[56]

One important European initiative is the NanoIC pilot line, led by IMEC, for the development and testing of sub-2 nm chips, which go beyond the current 2 nm chips from companies like TSMC, Intel, and Samsung. The EU's

[50] Jan Frederik Slijkerman, "EU Chips Act to boost Europe's technological prowess and strengthen economy," ING Think, February 8, 2022.
[51] Lauly Li and Cheng Ting-Fang, "Taiwan asks TSMC and other chipmakers to help ease global crunch," Nikkei April 27, 2023.
[52] Amkor, Press Release: "Amkor and GlobalFoundries to Provide At-scale Semiconductor Test and Assembly Services in Europe," February 16, 2023.
[53] Peter Clarke, "Europe sinks as China rises to lead in IC wafer capacity by 2026," eeNews, April 9, 2024, citing 2024 edition of the Global Wafer Capacity Report from Knometa Research.
[54] Jan Frederik Slijkerman, "EU Chips Act to boost Europe's technological prowess and strengthen economy," ING Think, February 8, 2022.
[55] TrendForce, Press Release: "Global Acceleration in the Construction of 2nm Wafer Plants," April 3, 2024.
[56] Agenda da Microeletrónica, Press Release: "Europe is set to get the world's most advanced chip fab," January 25, 2024; TrendForce, Press Release: "Intel's 1nm-class Fabs in Germany Reportedly Delayed Due to Black Soil Concerns and Pending EU Subsidy Approval," May 31, 2024.

goal is to support diverse industries, including automotive, telecommunications, and health, by creating future-proof products that leverage the latest chip innovations.[57]

## Backend Manufacturing: Assembly, Testing and Packaging

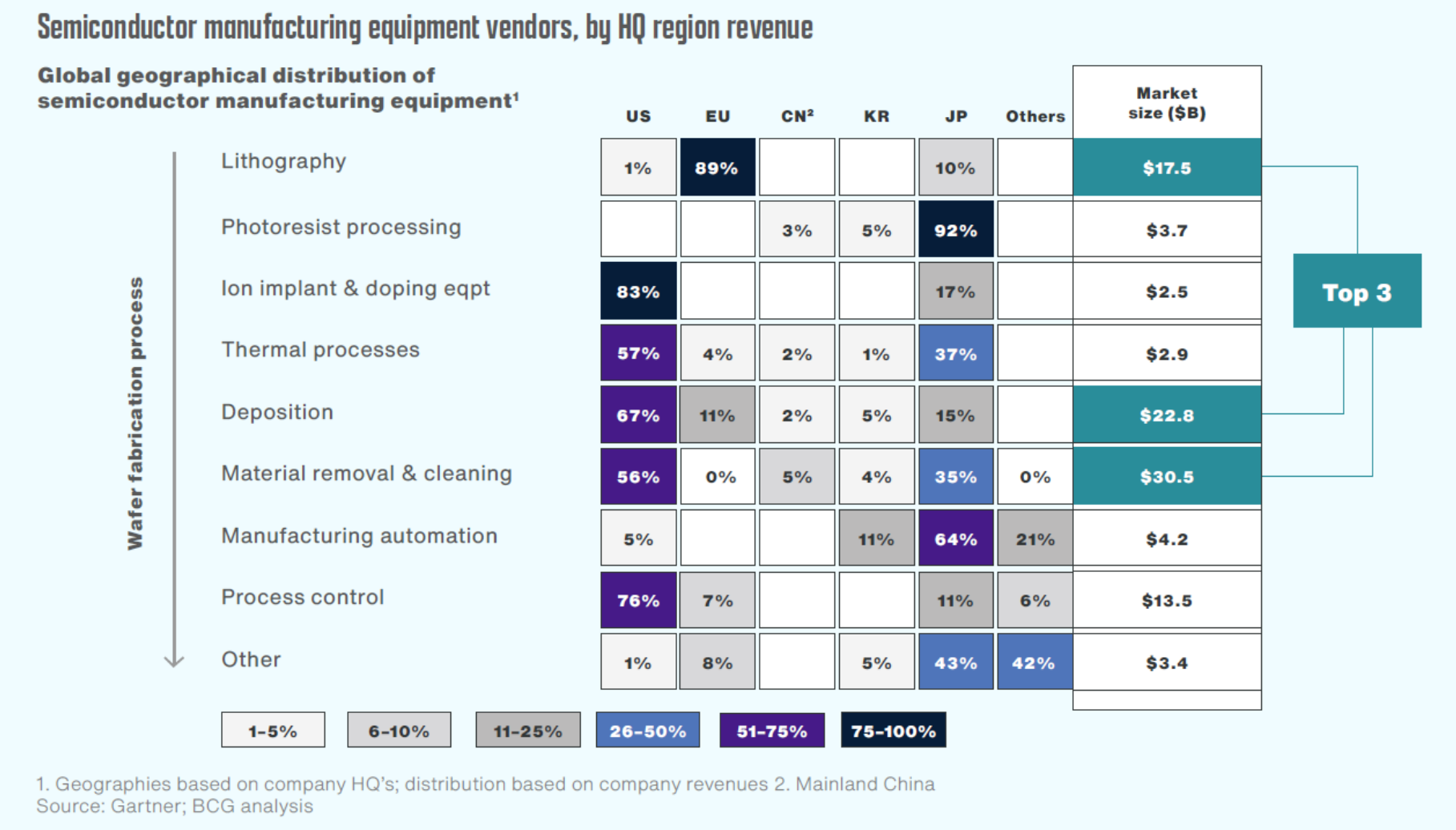
Most European chipmakers outsource their semiconductor fabrication to external foundries, with chip testing, assembly and packaging traditionally occurring in East Asia. In 2017, Portugal-based Nanium S.A., Europe's largest outsourced semiconductor assembly and test services (OSAT) company, was acquired by U.S.- headquartered Amkor Technology, Inc.[58] As of January 2024, Amkor is the only high-volume, advanced packaging, Tier 1 OSAT vendor in Europe.[59]

## Semiconductor Manufacturing Equipment

The US$ 110 billion semiconductor equipment market is diverse, covering more than 50 types of specialized equipment, but concentration is significant in some areas.[60] Three segments—lithography, deposition, and materials removal & cleaning—comprise 70% of the market, each dominated by a handful of key vendors. One single European firm, Netherlands' ASML makes up 87% of the lithography market. In deposition as well as materials removal and cleaning, three companies—two based in the United States and one based in Japan— comprise 70%–80% of the market (see Figure 9).

[57] Vish Gain, "Tyndall among EU research labs to share €2.5bn chips funding," Silicon Republic, May 21, 2024.
[58] ZACKS, "Amkor Completes Semiconductor Packaging Firm Nanium's Buyout," Nasdaq, May 24, 2017.
[59] Amkor, Press Release: "Amkor and GlobalFoundries to Provide At-scale Semiconductor Test and Assembly Services in Europe," February 16, 2023.
[60] 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.

## *Figure 9: Semiconductor Manufacturing Equipment Vendors: 2022*




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. 18.

ASML produces both Deep Ultraviolet (DUV) and Extreme Ultraviolet (EUV) lithography equipment. DUV lithography machines are used for older generations of chips while EUV lithography machines are essential for producing the most cutting-edge chips. In the realm of DUV lithography equipment, ASML faces significant competition from Nikon and Canon.[61] In the realm of EUV lithography machines, however, ASML has maintained its leadership as the first and only company to make a lithography tool using extreme ultraviolet (EUV), or 13.5 nm wavelength light.[62]

More recently, ASML developed its next-generation lithography system, namely, the High Numerical Aperture (High NA) Extreme Ultraviolet (EUV) lithography system, following decades of collaboration with Intel.[63] The High NA EUV equipment increases the numerical aperture from 0.33 to 0.55, providing higher-resolution imaging capabilities.[64] This improvement enhances precision and clarity, simplifies the manufacturing process, reduces production time, and boosts production efficiency.

According to an ASML spokesperson, TSMC and Intel will get the high-NA EUV machine by the end of this year.[65] In April 2024, Intel Foundry reported that it has received and assembled the industry's first High NA EUV lithography system.[66] As of July 2024, TSMC has not publicly disclosed any information regarding the purchase of an NA EUV lithography system. TSMC, however, has indicated in May 2024 that it could continue to develop next-generation chips without immediately relying on these new machines.[67]

Pushing technology to new limits, ASML and IMEC have started feasibility studies of Hyper-NA EUV.[68] The Hyper-NA EUV tools are expected to further increase the numerical aperture from the current 0.55 to an even higher NA of 0.75-0.85.[69] According to media reports, ASML is expected to introduce Hyper-NA EUV lithography machines by 2030.[70]

[61] Toby Sterling, "ASML's next chip challenge: rollout of its new $350 mln 'High NA EUV' machine," Reuters, February 10, 2024.
[62] Ibid.
[63] Intel, Press Release: "High NA EUV at Intel," April 18, 2024.
[64] TrendForce, Press Release: "Intel to Adopt New High-NA EUV, High Costs Could Lead to Increased Losses," May 21, 2024.
[65] Cagan Koc, "ASML to Ship Its $380 Million Chip Machine to TSMC This Year," Bloomberg, June 5, 2024.
[66] Intel, Press Release: "High NA EUV at Intel," April 18, 2024.
[67] Toby Sterling, "TSMC says can make next generation chips without ASML's new machine," Reuters, May 14, 2024.
[68] Steven Scheer, "Entering the High NA EUV Lithography era," IMEC, July 12, 2024.
[69] Ibid.
[70] Daniel Chiang and Andrew Yeh, "Hyper-NA EUV to debut in 2030, primes foundry market for transformation," DIGITIMES Asia, June 28, 2024.

## Semiconductor Materials

The US$ 64 billion semiconductor materials market comprises chemicals and materials used in the frontend (US$ 40 billion) and back-end (ATP) (US$ 24 billion) of the supply chain. Companies headquartered in Japan, the United States, and the EU lead in materials (see Figure 10).[71] Germany-headquartered BASF SE is a leading supplier of process chemicals and solutions for semiconductor processes, including cleaning, etching, photolithograpy, chemical mechanical planarization (CMP), and wet deposition.[72] Henkel, also headquartered in Germany, supplies chemicals for semiconductor packaging and has earned the Material Supplier of the Year distinction from the 3D InCites community in 2023.[73]

[71] 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.

[72] BASF, "Chemical Solutions for Semiconductors." https://electronics-electric.basf.com/global/en/electronics/semiconductors_solutions.html. Accessed on July 10, 2024.

[73] Henkel, Press Release: "Henkel semiconductor packaging innovations earn Material Supplier of the Year Award," April 4, 2023.

*Figure 10: Market Size and Number of Major Vendors by Semiconductor Materials Segment*


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. 19.

## EUROPE'S SEMICONDUCTOR STRATEGY AND POLICIES

With the increasing push towards digitalization and worldwide demand for chips growing rapidly, semiconductors are at the centre of strong geostrategic interests, and of the global technological race. Europe is taking proactive measures to strengthen European competitiveness and resilience in the global semiconductor supply chain.[74] The European Commission, along with various national governments, has introduced ambitious plans and investment programs to boost semiconductor manufacturing and research and development within the region.

The European Chips Act, introduced in February 2022 and in effect since September 2023, includes up to € 43 billion (US$ 47 billion) in targeted support for Europe's semiconductor sector (see Figure 11).[75] It brings together three policies into one single Act, structured in three pillars:

- The first pillar sets up the Chips for Europe Initiative in order to build on Europe's strengths in research and innovation and translate them into new production capabilities.
- The second pillar sets up a new framework to ensure security of supply by attracting investments and enhanced production capacities.
- The third pillar puts in place a coordination mechanism between the Member States and the Commission, for monitoring the supply of semiconductors, estimating demand and anticipating future shortages.

The semiconductor sector is both capital and knowledge intensive. The aim of the Chips Fund is to address challenges faced by companies in accessing capital. It is also intended to accelerate investment in semiconductor manufacturing technologies and chip design and improve security of supply for the semiconductor value chain.[76] As of July 2024, the European Chips Act is reportedly on track to help attract more than € 100 billion (US$ 108.4 billion) worth of private investment to the European semiconductor industry by 2030.[77]

[74] The European Chips Act - Regulation 2023/1781, https://www.european-chips-act.com/. Accessed on July 10, 2024.
[75] European Commission, "European Chips Act." https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en. Accessed on July 10, 2024.
[76] European Commission, "European Chips Act - Questions and Answers," November 30, 2023.
[77] Toby Sterling, "European Commission official sees $100 bln in private chip investment by 2030," Reuters, May 22, 2024. (US$1 = € 0.9224)

Companies including STMicroelectronics, GlobalFoundries, TSMC, Intel, Onsemi, Infineon and Wolfspeed announced plans for European chip plants after the EU launched its Chips Act in 2022 (see Figure 11).

***Figure 11: European Union's Semiconductor Policy***

| | | |
|---|---|---|
| Guidance | **Target** | Gain 20% of global semiconductor market share (in terms of revenue) by 2030. |
| | **Policy** | **European Chips Act**<br>• Aims to strengthen Europe's semiconductor ecosystem<br>• Five strategic objectives:<br>1. Strengthen research and technological leadership;<br>2. Build and reinforce Europe's capacity to innovate in the design, manufacturing and packaging of advanced chips;<br>3. Put in place an adequate framework to increase production by 2030;<br>4. Address skills shortage and attract new talent; and<br>5. Develop an in-depth understanding of global semiconductor supply chains.<br><br>**2030 Digital Compass**<br>• Sets the course for Europe's digital decade<br>• Three goals specific to semiconductors:<br>1. Capacity Building: Increasing Europe's semiconductor production of cutting-edge and sustainable semiconductors, including processors.<br>2. Innovation: Fostering technological advancements and innovation in semiconductor technologies.<br>3. Resilience: Enhancing Europe's resilience in semiconductor supply chains . |
| Measures | **Key Incentive Amounts** | Up to € 43 billion (US$ 47 billion) |
| | **Key Initiatives** | • Grants and loans under EU Chips Act<br>• Tax credits<br>• Member State aid allowances |

| | | |
|---|---|---|
| Outcome | **Announcements on Key Investments To Boost Domestic Production** | • **STMicroelectronics (Switzerland)**: EU approval for a € 5 billion (US$ 5.4 billion) silicon carbide plant in Italy.<br>• **STMicroelectronics (Switzerland) and GlobalFoundries (U.S.A.)**: EU approval for a € 7.4 billion (US$ 8.0 billion) fab plant in Crolles, France by STMicroelectronics and GlobalFoundries. Targeted to reach full capacity by 2026, with up to 620,000 of 300mm diameter wafers per year of production at a size of 18 nm.<br>• **TSMC (Taiwan)**: Plans for € 7.4 billion (US$8.0 billion) fab plant in Dresden, Germany, together with car chip makers Robert Bosch, NXP, and Infineon. The plant is expected to have a monthly production capacity of 40,000 300 mm (12-inch) wafers on TSMC's 28/22 nm planar CMOS and 16/12 nm FinFET process technology.<br>• **Intel (U.S.A)**: Plans for € 30 billion euros (US$ 32.5 billion), including US$ 11 billion in state aid, to develop two chip-making plants in Magdeburg, Germany. Intel's German fab is poised to be the most advanced in the world and make 1.5 nm chips.<br>• **Onsemi (U.S.A.)**: Plans to invest up to US$ 2 billion in expanding its operations to produce intelligent power semiconductors in the Czech Republic, pending EU approval.<br>• **Infineon (Germany)**: on track to complete a € 5 billion (US$ 5.4 billion) power chip plant in Dresden by 2026, despite not yet having EU aid approval.<br>• **Wolfspeed (U.S.A.)**: Plans to invest US$ 3 billion on a 200 mm silicon carbide (SiC) wafer fab and an R&D center with German automotive supplier ZF in Saarland, Germany. Automotive supplier ZF Friedrichshafen will invest US$ 185 million for a stake in the chip fab and will take a majority stake in the research centre. |

Note: () indicates headquarter location.
Currency Exchange Rate: US$ 1 = € 0.9224
Source: European Commission, The European Chips Act - Regulation 2023/1781, https://www.european-chips-act.com/; TSMC, Press Release: "TSMC, Bosch, Infineon, and NXP Establish Joint Venture to Bring Advanced Semiconductor Manufacturing to Europe," August 8, 2023; Intel, Press Release: "Intel, German Government Agree on Increased Scope for Wafer Fabrication Site in Magdeburg," June 19, 2023; Anton Shilov, "Intel's German fab will be most advanced in the world and make 1.5nm chips, CEO says," Tom's Hardware, January 19, 2024;
European Commission, Press Release: "State aid: Commission approves French measure to support STMicroelectronics and GlobalFoundries to set up new microchips plant," April 28, 2023; Associated Press News: "US chipmaker onsemi will invest $2 billion in a chip production facility in the Czech Republic," June 19, 2024; Wolfspeed, Press Release: "Wolfspeed Announces Plan to Construct World's Largest, Most Advanced Silicon Carbide Device Manufacturing Facility in Saarland, Germany," February 1, 2023; Reuters and Neil Gerrard, "Construction of $3 billion chip plant in Germany delayed by 2 years," Construction Breifing, June 20, 2024.

In July 2023, Germany's economy ministry announced the country's plans to invest around € 20 billion (US$ 22.15 billion) in the semiconductor industry in the coming years.[78] With its big spending, Germany is expected to host the largest semiconductor factories. In Dresden, TSMC will set up its first European factory by 2027, in collaboration with Dutch NXP Semiconductors and German Infineon and Bosch.[79] With German state subsidies, TSMC committed US$ 3.8 billion for the US$ 11 billion factory.[80]

Likewise, Germany did not hesitate to subsidize U.S. Intel with another € 9.9 billion (US$ 11 billion) for a total investment of € 30 billion (US$ 33.2 billion) in Magdeburg.[81] Intel's factory will be the largest semiconductor production facility in Europe and, if the construction and tool installation are expedited, is expected to be operational by late 2027 or early 2028.[82]

After failing to convince Intel's CEO Pat Gelsinger to invest in France, French President Emmanuel Macron, granted € 2.9 billion (US$ 3.1 billion) for the construction of a new semiconductor factory by STMicroelectronics near Grenoble. The total cost of this investment reaches € 7.4 billion (US$ 7.9 billion), with the remainder covered by U.S.-headquartered GlobalFoundries.[83]

Despite the various announcements of investments in Europe, there are doubts about whether the current level of investment in Europe will be sufficient to achieve the ambitious goal of capturing 20% of the global semiconductor market by 2030. According to Peter Wennink, CEO of Dutch semiconductor company ASML, the goal is "totally unrealistic". On the same note, Kurt Sievers, chief executive officer of NXP Semiconductors, said "we would need € 500 billion (US$ 525.8 billion) investment in Europe to reach the 20% market share goal formulated in the EU Chips Act."[84]

[78] Riham Alkousaa and Supantha Mukherjee, "Germany earmarks 20 billion euros in subsidies for chip industry," Reuters, July 26, 2023. (U$ 1 = € 0.9029)

[79] TSMC, Press Release: "TSMC, Bosch, Infineon, and NXP Establish Joint Venture to Bring Advanced Semiconductor Manufacturing to Europe," August 8, 2023.

[80] Ben Blanchard and Thomas Escritt, "Germany spends big to win $11 billion TSMC chip plant," Reuters, August 8, 2023.

[81] Friederike Heine , Supantha Mukherjee and Andreas Rinke, "Intel spends $33 billion in Germany in landmark," Reuters, July 26, 2023. (US$ 1 = € 0.9150)

[82] TrendForce, Press Release: "Intel's 1nm-class Fabs in Germany Reportedly Delayed Due to Black Soil Concerns and Pending EU Subsidy Approval," May 31, 2024.

[83] European Commission, Press Release: "State aid: Commission approves French measure to support STMicroelectronics and GlobalFoundries to set up new microchips plant," April 28, 2023; France24, "France to invest nearly €3 billion in semiconductor factory to boost local production," June 5, 2023.

[84] Tristan Fiedler, "NXP warns EU microchips funding falls far behind 2030 targets," Politico, September 30, 2022. (U$ 1 = € 0.951)

Meanwhile, other countries are also ramping up their efforts in the semiconductor industry. The United States, for example, has introduced the CHIPS and Science Act, which provides US$ 39 billion in direct incentives to boost semiconductor manufacturing in the United States.[85] Likewise, China is on track to spend more than US$ 142 billion in its semiconductor sector as part of its "Made in China 2025" strategy.[86] According to the SEMI World Fab Forecast report, China is expected to construct a staggering 18 new fabs in 2024 alone.[87] Japan is also enhancing its semiconductor capabilities with ¥ 3.9 trillion (approximately US$ 25.7 billion) over the next three years (2024-2026) for domestic chipmakers.[88]

Consequently, while Europe's efforts are significant, they may not match the pace of growth seen in some other parts of the world. This dynamic highlights the intensely competitive nature of the semiconductor industry and the importance of continuous investment and innovation. Based on Europe's 10.6% share of the global semiconductor market in 2023 and the projected decline in Europe's share of the global semiconductor revenue by WSTS, Europe faces significant competitive pressures and challenges in expanding its share of the global semiconductor market.

[85] The White House, Fact Sheet: "One Year after the CHIPS and Science Act, Biden-Harris Administration Marks Historic Progress in Bringing Semiconductor Supply Chains Home, Supporting Innovation, and Protecting National Security," August 9, 2023.

[86] Mackenzie Hawkins, Ian King, Jillian Deutsch, Yoshiaki Nohara, and Yuan Gao, "Global Chips Battle Intensifies With $81 Billion Subsidy Surge," Bloomberg, May 13, 2024.

[87] SEMI, Press Release: "Global Semiconductor Capacity Projected To Reach Record High 30 Million Wafers Per Month In 2024, Semi Reports," January 2, 2024.

[88] Kazuhiro Ogawa, "Japan outspends U.S., Germany on chip subsidies as share of GDP," Nikkei Asia, April 10, 2024.

# TAIWAN'S PARTNERSHIP WITH EUROPE

## Taiwanese Investments in EU

### TSMC

On August 8, 2023, TSMC, Robert Bosch GmbH, Infineon Technologies AG, and NXP Semiconductors N.V. announced a plan to jointly invest in European Semiconductor Manufacturing Company (ESMC) GmbH, in Dresden, Germany under the framework of the European Chips Act. The planned joint venture will be 70% owned by TSMC, with Bosch, Infineon, and NXP each holding 10% equity stake, subject to regulatory approvals and other conditions. Total investments are expected to exceed US$ 11 billion consisting of equity injection, debt borrowing, and strong support from the European Union and German government.

ESMC aims to begin construction of the fab in the second half of 2024 with production targeted to begin by the end of 2027. The planned fab is expected to have a monthly production capacity of 40,000 300mm (12-inch) wafers on TSMC's 28/22 nanometer planar CMOS and 16/12 nanometer FinFET process technology. The fab will be operated by TSMC. The project marks a significant step towards strengthening Europe's semiconductor manufacturing ecosystem, particularly EU's fast-growing automotive and industrial sectors.

### ASE Subsidiary Universal Scientific Industrial Co. (USI)

Universal Scientific Industrial Co. (USI), an electronic manufacturing services (EMS) subsidiary of Advanced Semiconductor Engineering (ASE), operates 13 sites in continental Europe, with four sites in Germany, seven in France, one in Czech Republic, and one in Poland. Its specialization in System-in-Package (SiP) modules is crucial for various electronic applications. As of 2022, USI boasted US$ 10.1 billion in revenue, almost half of ASE's 2022 revenue of US$ 22.5 billion.[89]

USI acquired France-based Asteelflash, a global electronic manufacturing services company dedicated to the automotive, energy management, Internet of Things (IoT), industrial, consumer, defense, aerospace and data processing

[89] Misha Lu, "ASE subsidiary USI sees Poland as first step of EMEA strategy," DigiTimes Asia, September 7, 2023.

industries in 2020.[90] With 17 manufacturing sites spread across 8 countries including France, Germany, the UK, the Czech Republic, China, Tunisia, the United States and Mexico, Asteelflash recorded US$ 1 billion revenue in 2018, ranking as the second largest EMS Company in Europe.

## EU Investments in Taiwan

### Philips

Royal Philips Electronics NV and TSMC have had a mutually beneficial relationship since 1987. TSMC was founded in 1987 as a joint venture of Philips, the government of Taiwan, and private investors.[91] Philips, which was the world's fifth largest semiconductor maker at the time, invested more than NT$ 2 billion (US$ 74 million) in TSMC.[92] The deal included the transfer of some Philips patents, which gave TSMC a head start and protected it against competitors. In addition, Philips was also an early customer, and had its Philips chips manufactured by TSMC.[93] By 2008, Philips had sold its final shares in TSMC as it shifted its focus on the lighting, appliances and healthcare businesses.[94]

### Infineon

German Infineon Technologies has a significant presence in Taiwan since 1999, primarily through partnerships and joint ventures. One notable collaboration is Inotera Memories, which was formed in 2003 as a 50:50 joint venture for technology development and production in Taiwan between Nanya Technology Corporation and Infineon.[95] The company provides DRAM memory

[90] Nasdaq, Press Release: "ASE Technology Holding's Subsidiary, USI Shanghai, Announces Completion of Acquisition of Asteelflash," December 3, 2020; Chambers & Partners, Press Release: "Advising the sellers and Asteelflash on the sale to Universal Scientific Industrial of Asteelflash," March 24, 2021.

[91] Morningstar, "Taiwan Semiconductor Manufacturing Co Ltd ADR," Morningstar. https://www.morningstar.com/stocks/xnys/tsm/quote. Accessed on July 24, 2024.

[92] Liang-rong Chen, "The Late Y.C. Lo: A Catalyst of Taiwan's Electronics Industry," CommonWealth Magazine, May 29, 2015. (1 NT$ = US$ 0.037)

[93] Dan Nystedt, "Original TSMC Investor Philips Sells off Final Shares," PCWorld, August 14, 2008.

[94] Bloomberg, "Philips to book gain from TSMC sale," Bloomberg, Aug 15, 2008.

[95] Infineon Technologies, Press Release: "Infineon and Nanya Seal DRAM Cooperation by Founding Production Joint Venture and Agreeing Technology Development Collaboration," November 13, 2002; Infineon Technologies Fact Sheet, March 2002. https://www.infineon.com/dgdl/fact_sheet_2.pdf?fileId=db3a304412b91b910112baac62d220e5. Accessed on July 12, 2024.

foundry services, especially on 300 mm silicon wafers.[96] In 2009, Micron bought Infineon's share in Inotera.[97]

On June 17, 2024, Taiwan's Ministry of Economic Affairs (MOEA) and Infineon jointly announced the establishment of Infineon's advanced automotive and wireless communication semiconductor R&D center in Taiwan.[98] The center will involve transferring Infineon's new generation of technology to Taiwan for next-generation bluetooth chip development and manufacturing, marking the first time a major European chipmaker has set up such a R&D facility in Taiwan.[99] The new R&D center is expected to help establish Taiwan as a major automotive chip development hub. The MOEA expects the new center to spur investment totaling NT$ 2.7 billion (US$ 83.4 million) and create output estimated at NT$ 60 billion (US$ 1.85 billion) for Taiwan's electric vehicle sector.[100]

## STMicroelectronics

STMicroelectronics has been in Taiwan for four decades, having started its operation in Taipei in 1984 and subsequently expanding to Hsinchu in 2010 with a plant located in the Hsinchu Science Park.[101] Over the years, STMicroelectronics has expanded its scale of operations in Taiwan from sales, services, sourcing to R&D. The STMicroelectronics Asia Pacific Motor Control Competence Center in Taipei focuses on various advanced technologies, including motor control solutions and industrial automation. The center is also part of STMicroelectronics's broader strategy to support customers in the Asia Pacific region with specialized expertise and resources.[102] STMicroelectronics Taiwan not only provides products and services for its global scale key accounts, but also works closely with those Taiwan-based contract

[96] Ibid.
[97] ZACKS, "Micron Technology (MU) Closes Buyout of Inotera Memories," Nasdaq, December 7, 2016.
[98] Liu Chien-ling and Evelyn Kao, "German chipmaker Infineon to set up R&D center in Taiwan," Focus Taiwan, June 17, 2024.
[99] Ibid.
[100] InvesTaiwan, Press Release: "MOEA, Infineon jointly announce new R&D center in Taiwan," June 17, 2024.
[101] InvesTaiwan, Success Stories: "Grounded on Taiwan's well-developed semiconductor industry cluster, STMicroelectronics expands its scale of operations from sales, services, sourcing to R&D in the island," undated. https://investtaiwan.nat.gov.tw/showSuccess110eng?lang=eng&search=&key=110. Accessed on July 12, 2024.
[102] Stephen Las Marias, "Exclusive Interview: ST's Muggeri Discusses Industrial Automation, WBG, and Sustainability," EE Times Asia, August 30, 2023.

manufacturers and distributors to serve customers all over the world, and jointly explore the future business of semiconductor.[103]

## Taiwan & EU Investments in Singapore

### Systems on Silicon Manufacturing Company Pte. Ltd. – A Joint Venture between TSMC and NXP Semiconductors

Founded in 1998, Systems on Silicon Manufacturing Company (SSMC) is a joint venture of NXP Semiconductors and TSMC.[104] Its fabrication facility has been operational since 2000. 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.[105] 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.[106]

### United Microelectronics Corporation and Infineon Technologies

In 2000, Germany's Infineon Technologies AG and Taiwan's United Microelectronics Corporation (UMC) announced their plans to form a 300 mm silicon foundry company in Singapore. The total capitalization of the venture was US$ 3.6 billion.[107] The venture focused on making system-on-a-chip products based on 0.13- to 0.10-micron technologies. The process technology, dubbed “Worldlogic”, was jointly developed by UMC, Infineon and IBM.[108]

[103] InvesTaiwan, Success Stories: “Grounded on Taiwan’s well-developed semiconductor industry cluster, STMicroelectronics expands its scale of operations from sales, services, sourcing to R&D in the island,” undated.
[104] TSMC, Press Release: “SSMC Yields First Silicon at Singapore Fab,” September 26, 2000.
[105] Ibid.
[106] 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.
[107] UMC, Press Release: “UMC Announces Plan to Establish the World's Most Advanced 300-mm Semiconductor Foundry in Singapore,” December 15, 2000.
[108] EETimes, “UMC, Infineon form $3.6 billion, 300-mm foundry venture in Singapore,” EETimes, December 15, 2000.

In 2022, UMC announced its plans to invest US$ 5 billion on a new microchip factory in Singapore to produce 22 and 28 nm chips.[109] The new fab was backed by customers including Infineon and the U.S. Qualcomm.[110]

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. [111] 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, AIoT, and 5G market segments. [112]

## Vanguard International Semiconductor Corporation and NXP Semiconductors

On June 5, 2024, Vanguard International Semiconductor (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.[113] 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.

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.[114]

[109] UMC, Press Release: "UMC announces new 22nm wafer fab in Singapore," February 24, 2022.
[110] Ben Blanchard, "Taiwan's UMC to spend $5 bln on new chip plant in Singapore," Reuters, February 24, 2022.
[111] United Microelectronics Corporation, Press Release: "Infineon and UMC Extend Automotive Partnership with Long-Term Agreement for 40nm eNVM Microcontroller Production," March 7, 2023.
[112] Lisa Wang, "UMC signs production deal with Infineon," Taipei Times, March 8, 2023.
[113] NXP, Press Release: "VIS and NXP to Establish a Joint Venture to Build and Operate a 300mm Fab," June 5, 2024.
[114] Ibid.

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.[115]

## CONCLUSION

Europe has experienced a decline in its presence within the global semiconductor supply chain over the past few decades. Consequently, the EU is looking to build semiconductor international partnerships with like-minded partners like Taiwan and the United States to strengthen its technology leadership and to increase its share of global market share to 20% by 2030, up from 10.6% in 2023.

To enhance its position in the global semiconductor supply chain, the EU's comprehensive approach to bolster its semiconductor industry includes leveraging its strengths in research and development, advanced materials, and manufacturing equipment; giving increased emphasis on semiconductor fabrication; and diversifying and strengthening all parts of the supply chain. This includes partnerships and joint ventures to bolster Europe's capabilities in areas such as automotive, industrial and healthcare markets, where there is already a strong demand for semiconductors.

The expansion of Taiwan's TSMC and ASE, the world's largest foundry and OSAT, respectively, into Europe is poised to usher in substantial economic benefits and create new business opportunities, benefiting the local economy, supply chain, infrastructure, and knowledge base. Similarly, the investments by Infineon and STMicroelectronics in Taiwan not only enhance Taiwan's semiconductor capabilities but also foster innovation and economic growth. In addition, the collaboration between European and Taiwanese semiconductor companies in Singapore, by combining Europe's advanced research capabilities with Taiwan's manufacturing expertise hold promise for both the semiconductor industry and the global tech landscape.

The EU Chips Act has sparked significant interest and investment in Europe's semiconductor industry. The substantial investments of leading semiconductor companies from Taiwan and the United States in Europe's semiconductor industry are making waves in Europe and globally. This wave of

[115] Ibid.

interest is likely to pave the way for more partnerships and investments, further boosting Europe's semiconductor industry and reaffirming Europe's potential to become a key player in the global semiconductor market once again.

Given the current projections and the rapid advancements in other regions, the EU's goal of doubling its current global market share to 20% by 2030 is particularly ambitious. While the challenges are significant, Europe's historical strengths in research, engineering, and collaboration serve as valuable assets. By fostering innovation, investing in R&D, and addressing supply chain resilience, Europe can continue to position itself as a vital actor in the global semiconductor supply chain.

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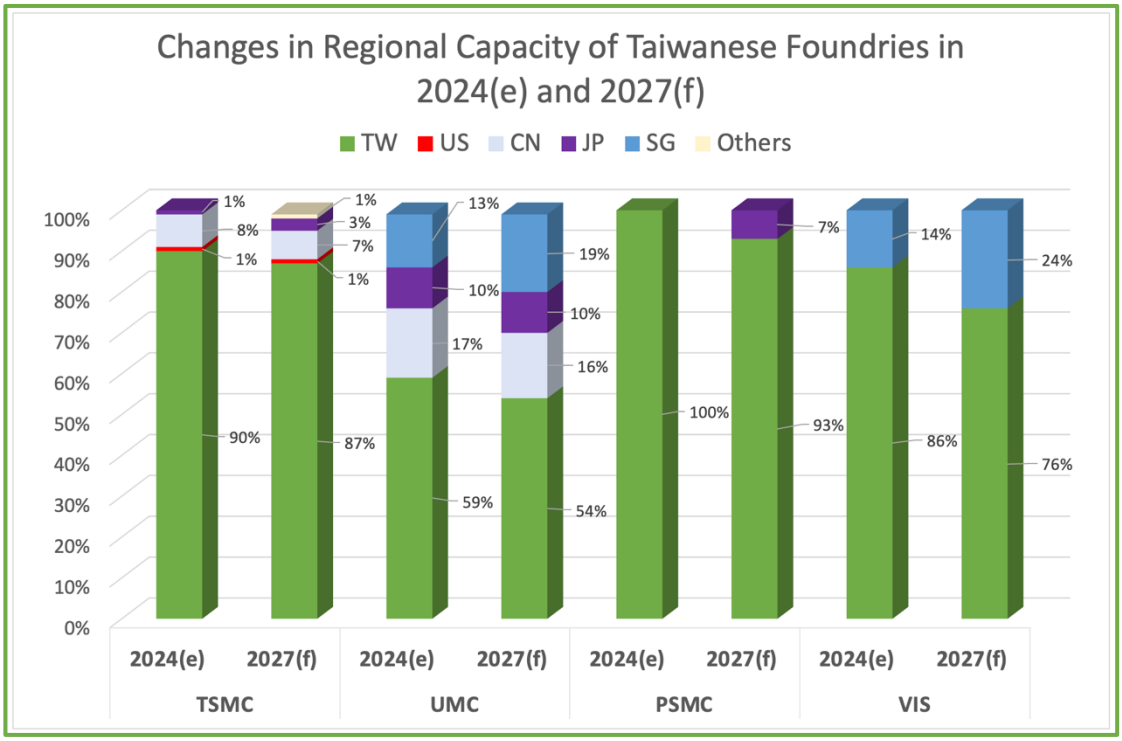
# SEMICONDUCTOR STATISTICS AT A GLANCE

***Figure 12: Changes in Regional Capacity of Taiwanese Foundries in 2024(e) and 2027(f)***




Source: TrendForce, "Taiwanese Chipmakers Expand Overseas to Capitalize on Geopolitical Shifts and De-Sinicization Benefits, Says TrendForce," June 5. 2024.

Figure 12 shows the expected regional capacity of Taiwanese foundries in 2024 and their forecasted capacity in 2027. Taiwan's semiconductor factories are actively investing overseas to expand production, but four-fifths of production capacity continues to be concentrated in Taiwan.

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.

Taiwan Semiconductor Manufacturing Company (TSMC)'s investment in the United States has mainly focused on 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, United Microelectronics Corporation (UMC) invested US$ 5 billion in Singapore in 2022, and Powerchip Semiconductor Manufacturing Corporation (PSMC) invested US$5.6 billion in Japan. This year, Vanguard International Semiconductor (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 overseas, according to estimates released by TrendForce in early June this year, the regional distribution of Taiwan's semiconductor foundry production capacity will change. By 2027, the proportion of production in Taiwan by Taiwan's four major semiconductor foundries 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.

More specifically, 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 will drop from 100% this year to 93% in 2027, mainly because Japan's share will increase by 7 percentage points.

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.

However, the production scale and revenue of each semiconductor company vary greatly, and the above data cannot reveal the integral trend. In the first quarter of this year, TSMC accounted for 61.7% of global semiconductor foundry revenue (US$ 18,847 million), UMC 5.7% (US$ 1,737

million), PSMC (US$ 316 million) and VIS (US$ 306 million) at 1% each. The total revenue of the four foundries is US$ 21,206 million, which was almost the entire semiconductor foundry output value in Taiwan.

According to 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 accounted for 87.5% of these four semiconductor factories wafer production capacity in Taiwan. By 2027, the proportion is expected to drop to 84.2%.

In a nutshell, 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, by 2027, more than four-fifths of Taiwan's semiconductor companies' production capacity for wafer foundry is expected to still be concentrated in Taiwan, because investment by Taiwanese semiconductor factories in Taiwan is also rapidly expanding.

***Figure 13: Prospects of Global Semiconductor Market: 2012-2027***


Source: Source: Chia-Chen Lee, "Global Economy and Semiconductor Market Trends in the First Quarter of 2024," IEK, ITRI, July 2, 2024, p. 9.

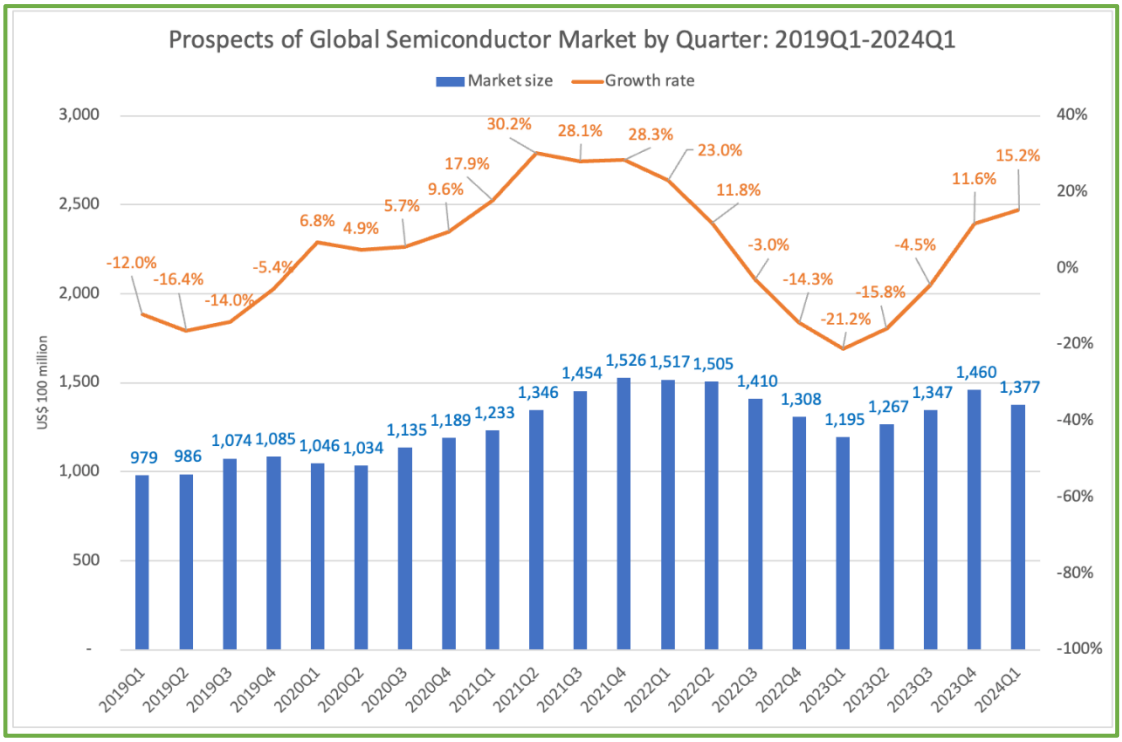
Figure 13 shows the global semiconductor market prospects from 2012 to 2027. According to the World Semiconductor Trade Statistics Organization (WSTS), as global inflation slows down and end market demand picks up, the

semiconductor industry is poised for strong recovery from 2024 onwards. The memory industry's inventory adjustment has come to an end in the fourth quarter of 2023, and with supply and demand approaching equilibrium, a more stable market is expected moving forward. In addition, with the booming demand for emerging applications such as artificial intelligence and high-performance computing, it is estimated that the global semiconductor market will reach US$ 611.2 billion in 2024, a growth of 16.0% compared to 2023.

In 2024, Taiwan's wafer foundry industry will see significant revenue growth driven by advanced processes. The recovery in demand for AI computing and terminal products is a key driver behind the anticipated growth in Taiwan's semiconductor industry. With an expected annual growth rate of 13.6% in 2024, the industry is projected to reach a substantial NT$ 4.46 trillion (US$ 137.2) billion. This positive momentum reflects the resilience and adaptability of Taiwan's semiconductor sector.

Looking ahead at 2025, the global semiconductor market will be mainly driven by the memory and logic fields, and the global semiconductor market is forecasted to grow by 12.5% to US$ 687.4 billion.

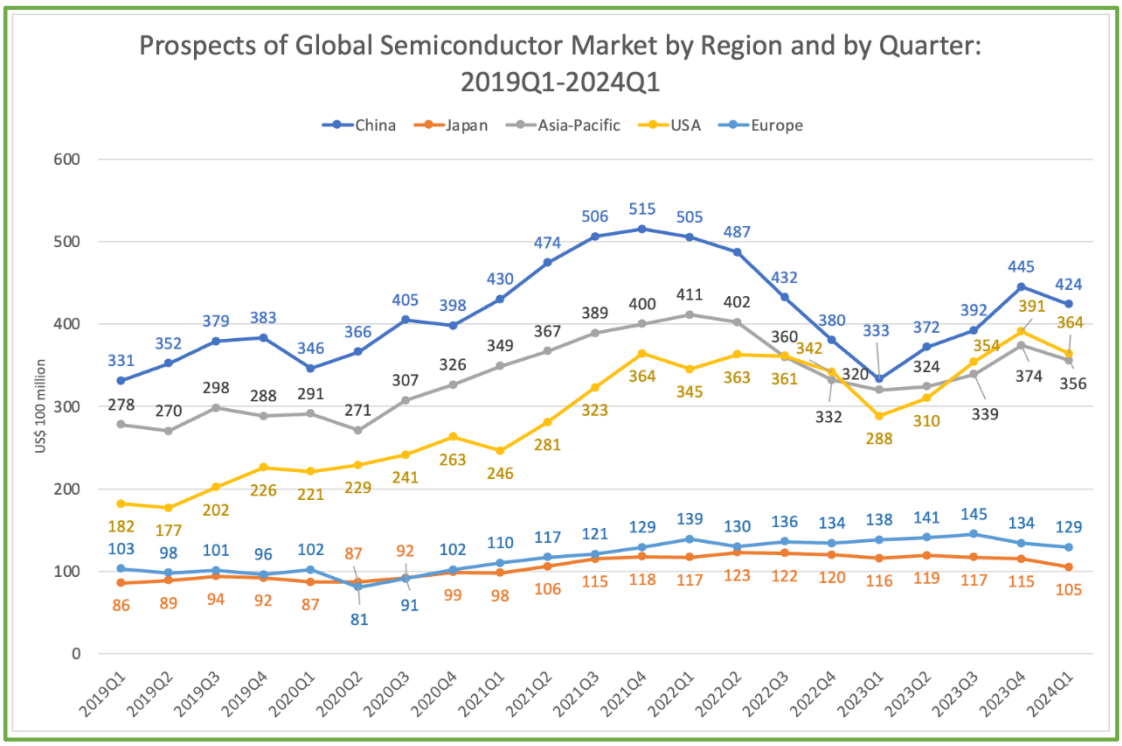
***Figure 14: Prospects of Global Semiconductor Market by Quarter: 2019Q1-2024Q1***




Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2024Q1," IEK, ITRI, July 2, 2024, p. 2.

Figure 14 shows the global semiconductor market prospects by quarter, from 2019Q1 to 2024Q1. According to the WSTS, the global semiconductor market sales value reached US$ 137.7 billion in 2024Q1, a 5.7% decline from the previous quarter (2023Q4) but a 15.2% increase from the same period in 2023Q1.

***Figure 15: Prospects of Global Semiconductor Market by Region and by Quarter: 2019Q1-2024Q1***



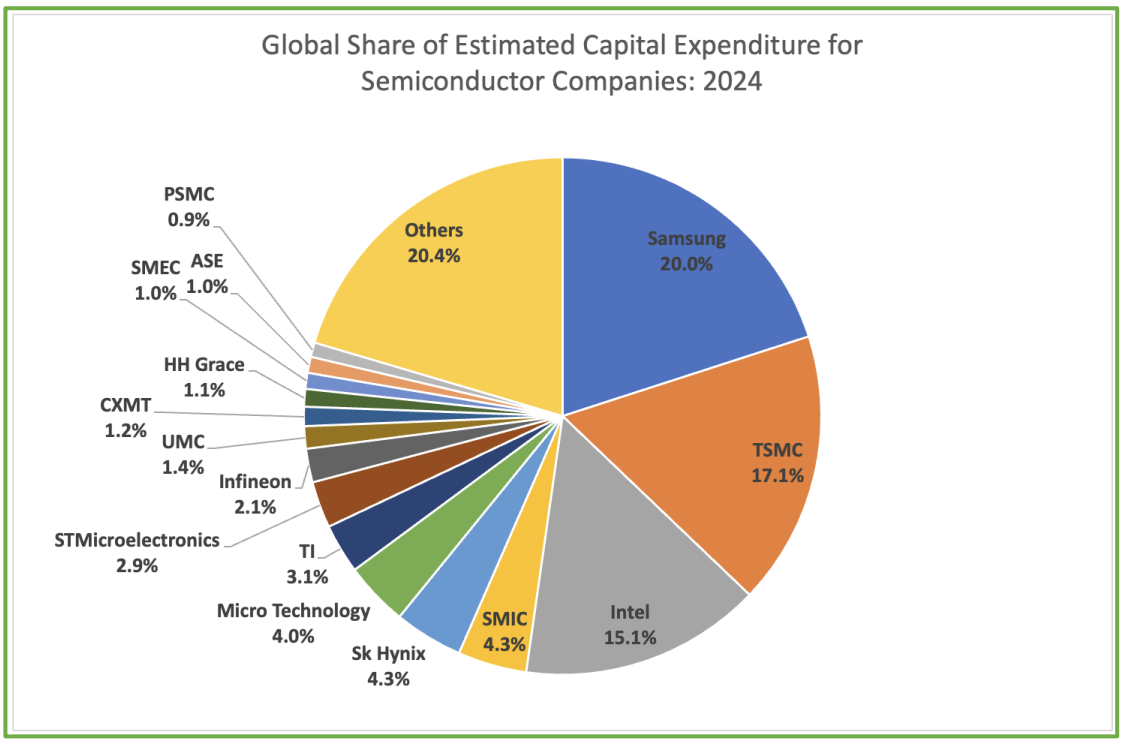

Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2024Q1," IEK, ITRI, July 2, 2024, p. 3.

Figure 15 shows the global semiconductor market prospects by region and by quarter, from 2019Q1 to 2024Q1.

The fall in semiconductor market sales value in 2024Q1 compared to the previous quarter (2023Q4) was experienced across the board by all the regions. The U.S. semiconductor market sales value reached US$ 36.4 billion, a decrease of 7.0% from the previous quarter (2023Q4), but an increase of 26.3% from 2023Q1. The sales value of the Japanese semiconductor market reached US$ 10.5 billion, a decrease of 8.8% from the previous quarter (2023Q4), and down 9.3% from 2023Q1. The European semiconductor market sales value reached US$ 12.9 billion, down 4.0% from the previous quarter (2023Q4), and down 6.8% from 2023Q1. China's semiconductor market sales value was US$ 42.4 billion, a decrease of 4.8% from the previous quarter (2023Q4), and an increase of 27.3% from 2023Q1. Meanwhile, the sales value

of the semiconductor market in the Asia-Pacific region reached US$ 35.6 billion, a decrease of 5.0% from the previous quarter (2023Q4), and an increase of 11.1% from 2023Q1.

***Figure 16: Global Share of Estimated Capital Expenditure for Semiconductor Companies: 2024***




Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2024Q1," IEK, ITRI, July 2, 2024, p. 5.

Figure 16 shows the global share of estimated capital expenditure for semiconductor companies in 2024.

According to Gartner's latest report, global semiconductor capital expenditures in 2024 will reach US$ 175.1 billion, an increase of 2.0% from US$ 171.8 billion in 2023. Looking at the top fifteen semiconductor capital expenditure manufacturers in the world, Samsung Electronics (Samsung) ranked first with US$ 35 billion, TSMC ranked second with US$ 30 billion, and Intel ranked third with US$ 26.5 billion. Semiconductor Manufacturing International Corporation (SMIC) ranked fourth with US$ 7.5 billion, and SK Hynix ranked fifth with nearly US$ 7.5 billion. Micron ranked sixth with US$ 7 billion, Texas Instruments ranked seventh with US$ 5.5 billion, STMicroelectronics ranked eighth with US$ 5 billion, and Infineon ranked ninth with US$ 3.6 billion. United Microelectronics (UMC) ranked tenth with US$ 2.5 billion, Changxin Memory (CXMT) ranked eleventh with US$ 2.1 billion, HH

Grace Semiconductor ranked twelfth with US$ 2 billion, and SMIC Semiconductor Manufacturing (Shaoxing) (SMEC) ranked thirteenth with US$ 1.8 billion, ASE Holdings (ASE) ranked fourteenth with US$ 1.75 billion, and Power Semiconductor Manufacturing Co. (PSMC) ranked fifteenth with US$ 1.6 billion.

In total, the semiconductor capital expenditure by the top fifteen global players are estimated to account for 79.6% of the total global expenditure.

***Figure 17: Output Value of Taiwan's IC Industry: 2020-2024(e)***

Output Value of Taiwan's IC Industry: 2020-2024(e)

NT$ 100 million

| | 2020 | | 2021 | | 2022 | | 2023 | | 2024(e) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Value | Growth Rate | Value | Growth Rate | Value | Growth Rate | Value | Growth Rate | Value | Growth Rate |
| IC Industry | 32,222 | 20.9% | 40,820 | 26.7% | 48,370 | 18.5% | 43,428 | -10.2% | 51,134 | 17.7% |
| IC Design | 8,529 | 23.1% | 12,147 | 42.4% | 12,320 | 1.4% | 10,965 | -11.0% | 12,617 | 15.1% |
| IC Manufacturing | 18,203 | 23.7% | 22,289 | 22.4% | 29,203 | 31.0% | 26,626 | -8.8% | 32,014 | 20.2% |
| Wafer Foundry | 16,297 | 2.1% | 19,410 | 19.1% | 26,847 | 38.3% | 24,925 | -7.2% | 29,932 | 20.1% |
| Memory and Others | 1,906 | 19.4% | 2,879 | 51.0% | 2,356 | -18.2% | 1,701 | -27.8% | 2,082 | 22.4% |
| IC Packaging | 3,775 | 9.0% | 4,354 | 15.3% | 4,660 | 7.0% | 3,931 | -15.6% | 4,344 | 10.5% |
| IC Testing | 1,715 | 11.1% | 2,030 | 18.4% | 2,187 | 7.7% | 1,906 | -12.8% | 2,159 | 13.3% |
| Global IC Industry (US$ 100 million) | 4,404 | 6.8% | 5,559 | 26.2% | 5,741 | 3.3% | 5,268 | -8.2% | 6,112 | 16.0% |

Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2024Q1," IEK, ITRI, July 2, 2024, p. 7.

Note: IC Industry = IC Design + IC Manufacturing + IC Packaging + IC Testing; IC Manufacturing = Wafer Foundry + Memory and Others; (e) = estimate.

Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2024Q1," IEK, ITRI, July 2, 2024, p. 7.
Currency Exchange Rate: US$ 1 = NT$ 31.2

Taiwan's Industrial Technology Research Institute (ITRI) estimates that the output value of Taiwan's IC industry will reach NT$ 5,113.4 billion (US$ 163.9 billion) in 2024, an increase of 17.7% from 2023 (see Figure 17).

Among the various sectors of the integrated circuit (IC) industry, the IC design industry output value is estimated to be NT$ 1,261.7 billion (US$ 40.4 billion), an increase of 15.1% compared with 2023. The output value of the IC manufacturing industry is estimated to be NT$ 3,201.4 billion (US$ 102.6 billion), an increase of 20.2% compared with 2023, of which wafer foundry revenue is estimated to be NT$ 2,993.2 billion (US$ 95.9B), an increase of 20.1% from 2023 while memory and other manufacturing account for NT$ 208.2 billion (US$ 6.7 billion), an increase of 22.4% from 2023. The output value of the IC packaging industry is estimated to be NT$ 434.4 billion (US$ 13.9 billion), an increase of 10.5% from 2023. Meanwhile, the output value of the IC testing industry is estimated to be NT$ 215.9 billion (US$ 6.9 billion), an increase of 13.3% from 2023 (see Figure 17).

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