TAIWAN AND THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN

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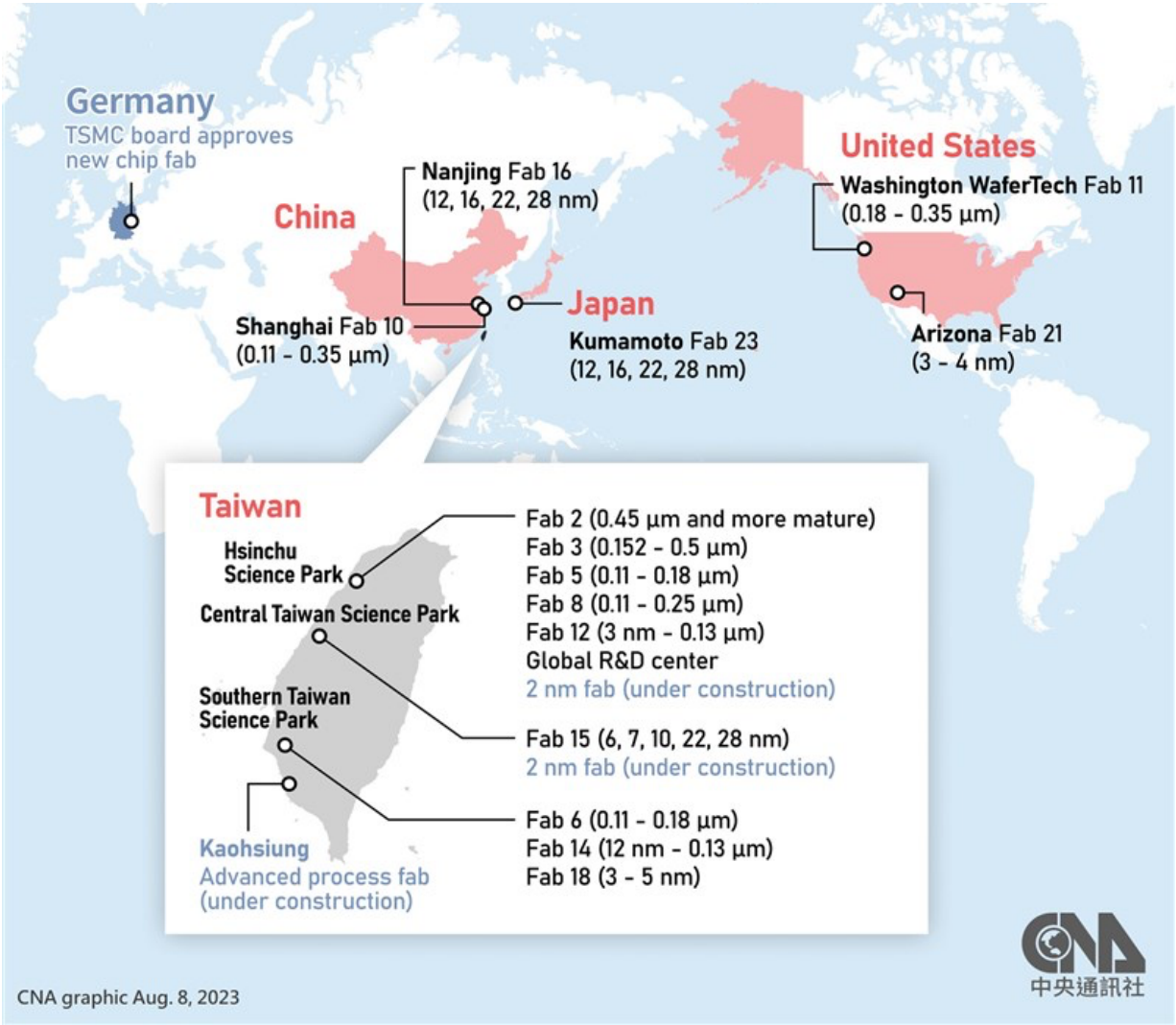
SCAN ME

IN THE SPOTLIGHT

TSMC's Expanding Global Manufacturing Footprint

- **TSMC expands fabs in Taiwan, the U.S.A., Japan and Germany**

Figure 1: TSMC's Global Expansion



Source: Focus Taiwan, August 8, 2023

Taiwan Semiconductor Manufacturing Company (TSMC) is the world's largest contract chipmaker and plays an important role in the global semiconductor supply chain. The expansion of TSMC to Japan, the U.S.A. and Germany is a major event in the global semiconductor industry. It is a sign of the growing demand for semiconductors and is also seen as a key to strengthening the resilience of the global semiconductor supply chain.

For over thirty years, TSMC has established deep roots in Taiwan, employing a large workforce of engineers, research and development scientists, technicians, and production workers. TSMC currently has a global R&D center and nine fabs in operation in Taiwan (five fabs in Hsinchu Science Park, one fab in Central Taiwan Science Park and three fabs in the Southern Taiwan Science Park). It has three fabs under construction – in Hsinchu Science Park, Central Taiwan Science Park and Kaohsiung – that will be using the 2 nanometer (nm) technology (see Figure 1).[1]

Arizona, U.S.A.

As part of its endeavor to advance economic and national security, the U.S. government wants chips that will be used for its critical applications and military equipment to be made in America. TSMC's investment of US$ 40 billion to build two mega wafer fabs in Phoenix expansion in Arizona is, therefore, welcomed by both the U.S. government and its U.S.-based long-time clients such as AMD, Apple, Intel, Nvidia, and Qualcomm. The first of the two fabs, Fab 21, will make chips using the 4 nm process in 2025, while the second will make chips using the 3 nm process in 2026.[2]

Earlier, TSMC had expected Fab 21 to start making 4 nm chips in 2024 but that goal has been pushed to 2025 due to delays with equipment installation and various workforce-related issues. Despite the delay of mass production at Fab 21, AMD recently reiterated that it would be one of its early adopters when the fab begins operations in 2025.[3]

To get construction back on track, TSMC is working to send skilled technicians from Taiwan to facilitate the training of their counterparts in Arizona. Labor groups in the U.S.A., however, oppose TSMC's plan to bring in Taiwanese workers.[4]

[1] Chang Chien-chung and Matthew Mazzetta, "TSMC's planned Kaohsiung plant to produce advanced 2nm chips," *Focus Taiwan*, August 8, 2023.
[2] Taiwan Semiconductor Manufacturing Company (TSMC), "TSMC Announces Updates for TSMC Arizona," June 12, 2022.
[3] Anton Shilov, "TSMC's Troubled Arizona Fab Gets Vote of Confidence From AMD," *Tom's Hardware*, September 6, 2023.
[4] Aaron Butler, "My View: TSMC should not blame US workers for Phoenix construction delays", *Phoenix Business Journal*, July 26, 2023.

In response, TSMC has reiterated that the incoming Taiwanese workers will not pose a threat to any US jobs and will only be there to support the construction process. TSMC has also reached out to the local union and community and promised that Americans will be prioritized in its hiring process for jobs relating to its cutting-edge wafer fab construction in Arizona. [5]

Kumamoto, Japan

In addition to Arizona, TSMC is building a wafer fab in Japan's Kumamoto Prefecture. According to TSMC, the Kumamoto plant will start commercial production at the end of 2024 as scheduled, mainly using the 16 nm, 22 nm and 28 nm processes.

The Kumamoto foundry is a unique, joint venture formally known as Japan Advanced Semiconductor Manufacturing (JASM). The Sony Group, under the subsidiary of Sony Semiconductor Solutions Corporation, will invest around US$ 500 million into the plant, representing an equity stake of under 20 percent. In February 2022, the Japanese automobile parts maker Denso and a key supplier for Toyota, joined as a third investor. Foreseeing continuing increased demand for high-end chips in the global car industry, Denso will invest US$ 350 million and take a minority stake of over 10 percent. With Denso's investment, this project is now valued at over US$ 8.5 billion.[6]

According to Taiwan's media, TSMC's first chip plant in the Kumamoto Prefecture has reached full capacity for bookings, despite not having commenced mass production. The new plant has already secured a number of prominent customers, with automaker Honda confirming that it has placed an order for automotive semiconductors directly with TSMC for the first time. Another key customer is Sony Semiconductor, who jointly built the Kumamoto plant with TSMC.[7]

TSMC is planning to build a second wafer fab in Japan's Kumamoto Prefecture, with construction scheduled to start in April 2024, according to

[5] Chang Chien-chung and Frances Huang, "TSMC pledges U.S.-based hiring first in Arizona investment," *Focus Taiwan*, August 2, 2023.
[6] Bonny Ling, "TSMC in Japan is significant for business and human rights in Taiwan," *Commonwealth Magazine*, May 23, 2022.
[7] 黃淑玲、鐘惠玲, "台積熊本廠 產能預訂一空," 經濟日報 (Money, *United Daily News*), June 24, 2023.

Japan's media.[8] It is scheduled to mass produce chips starting in 2026 using TSMC's mature 12 nm process.

Dresden, Germany

On August 8, 2023, TSMC approved the investment of up to EUR€ 3.499 billion (US$ 3.834 billion) as part of a joint venture to build a semiconductor fab in Dresden, Germany.[9] Germany's auto parts maker Bosch and semiconductor maker Infineon, and the Netherlands' NXP, will build the plant together with TSMC, with a total investment exceeding EUR€ 10 billion (US$ 10.91 billion).

The project, called the European Semiconductor Manufacturing Company (ESMC), is planned under the framework of the European Chips Act. The European Union's goal is to bring its market share in the global semiconductor value chain to 20 percent (from 9 percent now). The goal was set because of pandemic-era shortages, but geopolitical tensions have since become the bloc's main driver.[10]

ESMC will be 70 percent owned by TSMC, while investment partners Bosch, Infineon Technologies and NXP Semiconductors will each have a 10 percent stake. Additionally, according to its media, Germany has agreed to pitch in with EUR€ 5 billion (US$ 5.49 billion) from the government's climate and transformation fund to support the construction of the factory.[11]

The planned Dresden plant will be operated by TSMC and will focus on the production of industrial and automotive chips. It will have a monthly production capacity of 40,000 12-inch wafers, and produce 22/28 nm and 12/16 nm chips for the automotive and industrial sectors.[12]

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[8] *Nikkan Kogyo Shimbun*, "TSMC、来年 4 月に熊本第 2 工場着工　12 ナノ半導体を 26 年製造開始 (TSMC to construct second chip plant in Kumamoto, aims to start production of 12 nanometer chips in 2026)," July 11, 2023.
[9] Chang Chien-chung and Matthew Mazzetta, "TSMC approves joint venture to build plant in Dresden, Germany," *Focus Taiwan*, August 8, 2023.
[10] Pieter Haeck and Gian Volpicelli, "Taiwanese chips giant moves ahead with German plant investment," *Politico*, August 8, 2023.
[11] Ashutosh Pandey, "Taiwan's TSMC to build semiconductor factory in Germany," *DW News*, August 8, 2023.
[12] Taiwan Semiconductor Manufacturing Company (TSMC), "TSMC, Bosch, Infineon, and NXP Establish Joint Venture to Bring Advanced Semiconductor Manufacturing to Europe," August 8, 2023.

SEMICONDUCTOR STATISTICS AT A GLANCE

TAIWAN

In 2022, Taiwan's semiconductor output value saw growth in areas including integrated circuit (IC) industry, IC design, wafer foundry, IC testing and IC product, except in IC memory manufacturing and IC product. Taiwan's IC industrial output value is expected to continue its upward trends in the same areas in 2023 to 2025 (see Table 1). The growth in Taiwan's IC industrial output value from 2019 to 2023 is supported by an increase in the number of companies, researchers and employees and increased R&D expenditure in the semiconductor industry (see Table 2).

Table 1: Taiwan's IC Industrial Output Value: 2021-2025

	2021	2022	2023(e)	2024(e)	2025(e)
IC Industry	40,820	48,370	42,495	46,440	49,819
IC Design	12,147	12,320	10,760	12,400	13,700
IC Manufacturing	22,289	29,203	26,060	27,940	29,836
Wafer Foundry	19,410	26,847	24,380	26,220	28,082
Memory	2,879	2,356	1,680	1,720	1,754
IC Packaging	4,354	4,660	3,770	4,000	4,120
IC Testing	2,030	2,187	1,905	2,100	2,163
IC Product	15,026	14,676	12,440	14,120	15,454

Note: Figures of year 2023-2025 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 5-2.

Table 2: Major Indicators of Taiwan's IC Industry: 2019-2023

	2019	2020	2021	2022	2023(e)
Number of companies	290	288	300	314	314
Output value (NTD 100 million)	26,656	32,222	40,820	48,370	42,495
Growth rate of output value (%)	1.7	20.9	26.7	18.5	-12.1
Value-added (NTD 100 million)	14,297	18,189	23,840	29,908	26,233
Rate of value-added (%)	53.6	56.4	58.4	61.8	61.7
Number of researchers	43,047	47,107	54,720	60,221	61,576
R&D Expenditure (NTD 100 million)	2,607	3,170	4,085	4,591	4,334
R&D Expenditure / Output value (%)	9.8	9.8	10	9.5	10.2
Number of employees	225,159	256,526	294,254	320,298	318,374
Average output value of per employee (NTD million)	11.8	12.6	13.9	15.1	13.3

Note: Figures of year 2023 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 5-2.

GLOBAL TRENDS

Global semiconductor market size is expected to continue to grow across product categories, applications and geographical markets from 2023 to 2025 (see Tables 3, 4 and 5).

Table 3: Global Semiconductor Market Size (by product): 2021-2025

Unit: US$ million

	2021	2022	2023(e)	2024(e)	2025(e)
Sensor	19,149	21,782	22,857	23,771	24,898
Discrete	30,337	33,993	34,699	26,145	38,026
Optoelectronic	43,404	43,908	44,888	46,177	47,751
IC	463,002	474,402	448,328	489,416	520,348
Total	555,893	574,084	550,772	595,508	631,023

Note: Figures of year 2023-2025 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 2-14.

Table 4: Global Semiconductor Market Size (by application): 2021-2025

Unit: US$ million

	2021	2022	2023(e)	2024(e)	2025(e)
Defense	5,823	9,112	7,160	5,955	6,310
Industry	66,945	83,130	77,108	78,607	82,033
Automobile	69,103	78,349	82,616	87,540	94,022
Consumption	68,356	80,486	70,499	73,843	69,413
Communication	170,618	172,309	161,927	172,102	179,842
Information	175,048	150,698	151,462	177,462	199,403
Total	555,893	574,084	550,772	595,508	631,023

Note: Figures of year 2023-2025 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 2-14.

Table 5: Global Semiconductor Market Size (by area): 2021-2025

Unit: US$ million

	2021	2022	2023(e)	2024(e)	2025(e)
America	121,481	141,136	141,786	155,659	167,261
Europe	47,757	53,853	53,443	56,157	59,414
Japan	43,687	48,158	47,777	50,583	52,895
Asia-Pacific	342,967	330,937	307,766	333,109	351,452
Total	555,893	574,084	550,772	595,508	631,023

Note: Figures of year 2023-2025 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 2-15.

Across the globe, semiconductor product output value is expected to fall in 2023 but rise again in 2024 and 2025 (see Table 6). The sub-industries of the global semiconductor industry, namely, companies in semiconductor fabrication, fabless design, integrated device manufacturing (IDM), packaging and testing, equipment and materials, are expected to experience a fall in their respective market size in 2023, but are likely to grow their market size in 2024 and 2024 (see Table 7).

Table 6: Global Semiconductor Product Output Value (by area) : 2021-2025

Unit: US$ million

	2021	2022	2023(e)	2024(e)	2025(e)
America	283,505	290,487	279,792	303,709	321,191
Europe	50,030	55,686	53,976	57,764	59,947
Japan	55,589	51,093	47,917	51,809	54,268
Asia-Pacific	166,768	176,818	169,087	182,226	195,617
Total	555,893	574,084	550,772	595,508	631,023

Note: Figures of year 2023-2025 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 2-15.

Table 7: Global Semiconductor Market Size (by sub-industry) : 2021-2025

Unit: US$ million

	2021	2022	2023(e)	2024(e)	2025(e)
Semiconductor	555,893	574,084	550,772	595,508	631,023
Fabless	176,500	194,224	188,915	212,001	226,806
IDM	379,393	379,860	361,857	383,507	404,217
Packaging and Testing	39,600	42,610	36,218	38,572	39,537
Equipment	101,900	108,014	90,732	108,878	119,766
Materials	39,996	43,802	42,707	44,031	44,955

Note: Figures of year 2023-2025 are estimated by IEK, ITRI, May 2023.
Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 4-2, 4-22, 4-32, 4-40, 4-47.

Taiwan's TSMC, MediaTek and United Microelectronics Corporation (UMC) are among the top 25 major IC corporations in the world for the period of 2021 to 2022. Ranked second, eleventh and twentieth respectively, all three have seen their revenues increase from 2021 to 2022. TSMC, in particular, saw its revenue grow by a spectacular 33.4% in 2022, while UMC's revenue grew substantially by 22.7% and MediaTek's revenue grew by 4.7% (see Table 8).

Table 8: Global Major IC Corporations: 2021-2022

Unit: US$ Million

Ranking	Name	Type	2021 Revenue	2022 Revenue	Growth Rate
1	Samsung	IDM	82,019	76,845	-6.3%
2	TSMC	Foundry	56,840	75,851	33.4%
3	Intel	IDM	76,742	61,534	-19.8%
4	Qualcomm	Fabless	29,333	36,722	25.2%
5	SK Hynix	IDM	37,433	34,905	-6.8%
6	Broadcom	Fabless	21,026	26,633	26.7%
7	Micro	IDM	30,016	25,637	-14.7%
8	Nvidia	Fabless	23,168	24,503	5.8%
9	AMD	Fabless	16,434	23,601	43.6%
10	Texas Instruments	IDM	17,315	18,993	9.7%
11	MediaTek	Fabless	17,667	18,506	4.7%
12	Apple	Fabless	14,778	17,824	20.6%
13	STMicroelectronics	IDM	12,761	16,128	26.4%
14	Infineon	IDM	13,685	15,776	15.3%
15	NXP	IDM	10,843	12,954	19.5%
16	Analog Devices	IDM	8,560	12,388	44.7%
17	Renenas	IDM	8,896	11,318	27.2%
18	Kioxia	IDM	12,528	10,595	-15.4%
19	SONY	IDM	9,574	9,858	3.0%
20	UMC	Foundry	7,627	9,362	22.7%
21	onsemi	IDM	6,740	8,327	23.5%
22	GlobalFoundries	Foundry	6,585	8,108	23.1%
23	WD/SanDisk	IDM	9,705	8,022	-17.3%
24	Microchip	IDM	6,314	7,883	24.8%
25	SMIC	Foundry	5,443	7,273	33.6%

Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 4-2~4-4.

Taiwan's TSMC, UMC, Powerchip and Vanguard are among the top ten largest foundry corporations in the world for the period of 2021 to 2022. With a 53.4% market share and a revenue of US$ 75,851 million in 2022, TSMC leads as the world's largest foundry corporation. UMC (market share of 6.6% and revenue of US$ 9,362 million), Powerchip (market share of 1.8% and revenue of US$ 2,553 million) and Vanguard (market share of 1.2% and revenue of US$ 1,747 million) came in third, seventh and eighth, respectively (see Table 9).

Table 9: Global Ten Largest Foundry Corporations (Including IDM foundry and pure foundry): 2021-2022

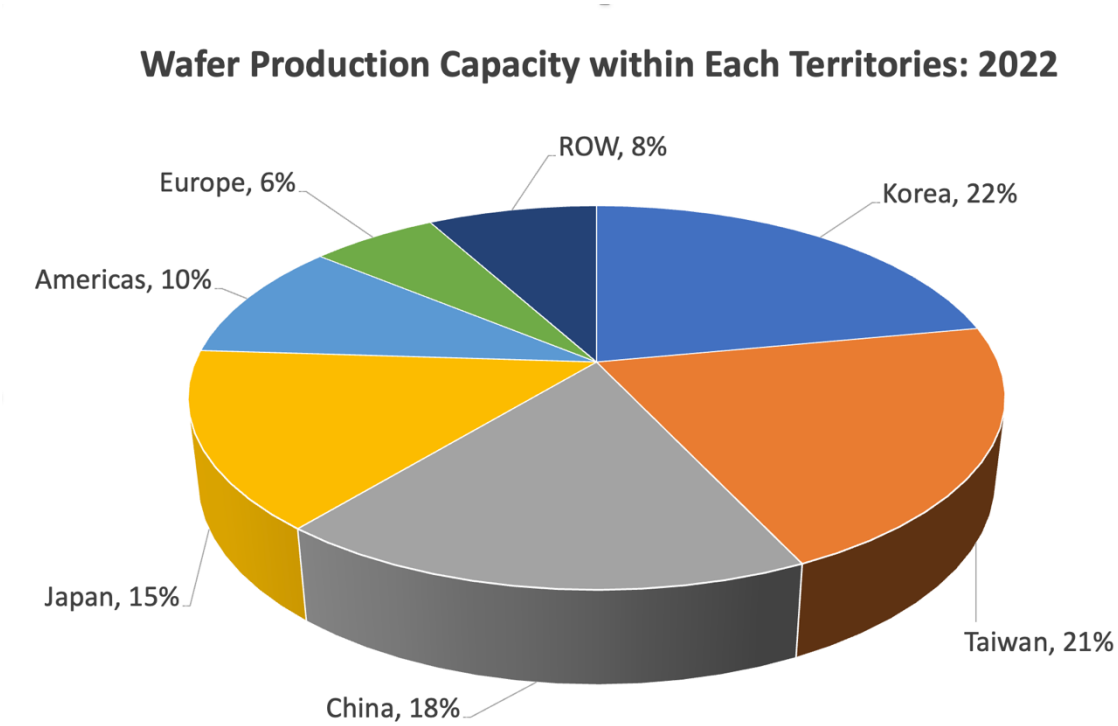
Unit: US$ million

Ranking	Name	Type	Head-quarter	2021 Revenue	2022 Revenue	Growth Rate	Market share
1	TSMC	Foundry	Taiwan	56,840	75,851	33%	53.4%
2	Samsung	IDM	Korea	18,785	23,359	24%	16.4%
3	UMC	Foundry	Taiwan	7,627	9,362	23%	6.6%
4	GlobalFoundries	Foundry	USA	6,585	8,108	23%	5.7%
5	SMIC	Foundry	China	5,443	7,273	34%	5.1%
6	Huahong Group	Foundry	China	2,921	4,030	38%	2.8%
7	Powerchip	Foundry	Taiwan	2,351	2,553	9%	1.8%
8	Vanguard	Foundry	Taiwan	1,574	1,747	11%	1.2%
9	Tower	Foundry	Israel	1,508	1,678	11%	1.2%
10	DB HiTek	Foundry	Korea	1,057	1,297	23%	0.9%
	Total			104,691	135,258	29%	95.1%

Source: Hui-Hsiu Huang, "Review of Global Semiconductor Manufacturing Industry Development in 2022 and Outlook for 2023," IEK, ITRI, June 17, 2023, p.4.

Taiwan, South Korea, China and Japan, are the biggest semiconductor players in Asia Pacific. In 2022, Korea accounted for 22% of the wafer production capacity in the world, followed closely by Taiwan (21%), China (18%) and Japan (15%). Together, all four countries accounted for 76% of the wafer production capacity in the world (see Figure 2).

Figure 2: Wafer Production Capacity within Each Territories: 2022



Source: Hui-Hsiu Huang, "Global Wafer Fab Overview in 2022 and Future Expansion Plans," IEK, ITRI, August 28, 2023