TAIWAN AND THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN

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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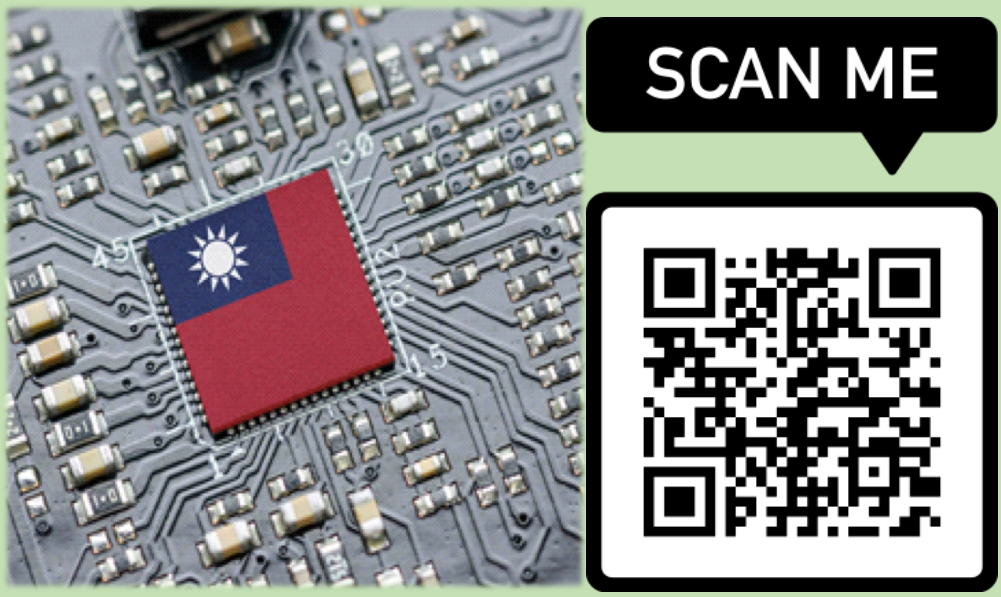
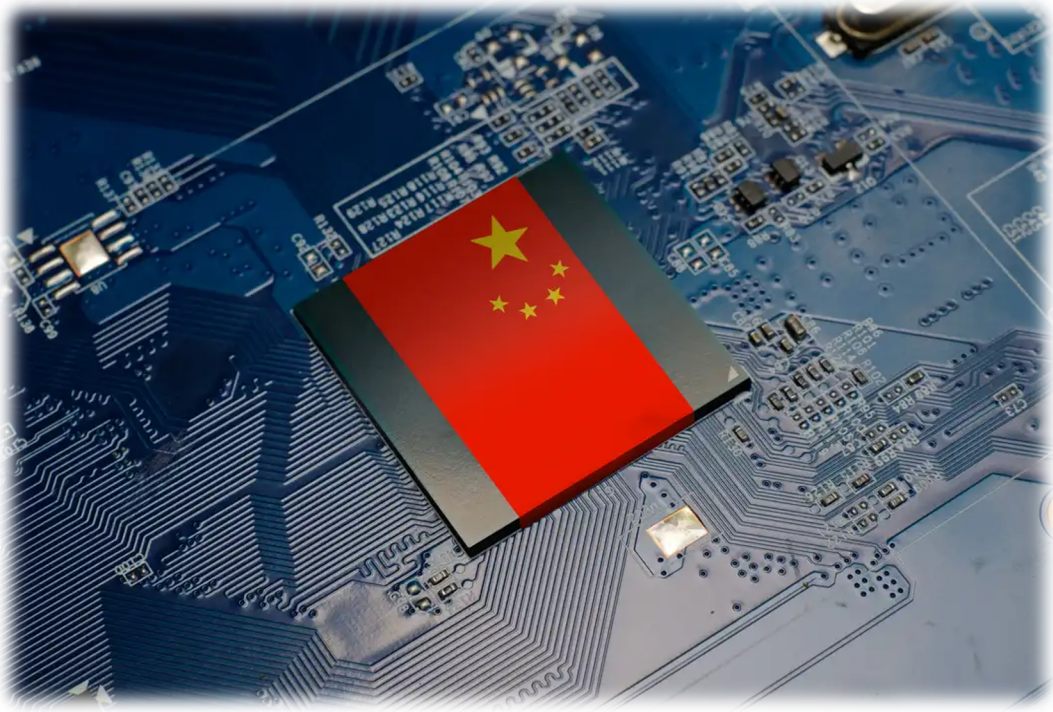


IN THE SPOTLIGHT

China's Semiconductor Industry

- **China is the world's largest market but its demand for semiconductors comes from both domestic and foreign-invested enterprises in China.**
- **Likewise, China's chip production capacity has been growing but published figures include both Chinese indigenous IC foundries and foreign IC foundries.**
- **China's attempt at self-sufficiency and technological advance in semiconductors is facing tremendous challenges and is thus fraught with uncertainties.**



Source: iStockPhoto.com

OVERVIEW

Semiconductors are the brains of digital devices, and are crucial to the technologies of today and tomorrow, including applications such as artificial intelligence (AI), internet of things (IoT), 5G communications, cloud computing, electric vehicles (EV), autonomous driving, healthcare, military systems, transportation and clean energy. By enabling technologies critical to economic growth, national security and global competitiveness, semiconductors are also of strategic importance to the world.

The manufacturing chain for any given semiconductor is immensely complex and relies on as many as 300 different inputs.[1] Firms involved in semiconductor manufacturing also rely on specialized suppliers of materials. Many of them also require advanced technology to produce semiconductors.[2] Consequently, the global supply chain of a semiconductor chip is complex and globalized, yet also extremely specialized.

Strong global interdependencies characterize the semiconductor supply chain: the U.S.A. leads in the most R&D-intensive activities for front-end chip design and semiconductor equipment; Taiwan hosts the world's most advanced process production foundries and leads in assembly, packaging and testing; Advanced Semiconductor Materials Lithography (ASML), a Dutch-based company, is the only company that manufactures high-tech extreme ultraviolet (EUV) lithography machines,[3] while China is playing a growing role in the production of earlier-generation integrated circuits—so-called "legacy chips"—and is one of the world leaders in the more labor-intensive processes of chip assembly, packaging, and testing.[4]

According to the SIA 2023 Factbook, semiconductor sales totaled US$ 574.1 billion worldwide in 2022, up from US$ 139 billion in 2001. In 2022, the U.S.A. had a 48% market share, South Korea had 19%, the E.U. and Japan each had 9%, Taiwan had 8%, and China had 7%.[5] Whilst the market size of the global semiconductor industry increased by 3.3% in 2022, it is expected to decline by 10.1% to US$ 516.1 billion in 2023, before rebounding by 12.6% to 580.9 billion in 2024, according to Taiwan's Industrial Economics and Knowledge Center (IEK).[6]

Figure 1 shows the semiconductor wafer production capacity by region as of 2022. South Korea ranked first in the world with 22% of global wafer production capacity. Taiwan ranked second, accounting for 21% of global wafer production capacity. Third place China (includes domestic and foreign-invested

[1] Semiconductor Industry Association, 'Comments of the Semiconductor Industry Association (SIA) on the Department of Commerce "Notice of Request for Public Comments on Risks in the Semiconductor Supply Chain", submitted November 8, 2021.

[2] Ibid.

[3] Antonio Varas, Raj Varadarajan, Jimmy Goodrich and Falan Yinug, "Strengthening the Global Semiconductor Value Chain in An Uncertain Era," Boston Consulting Group and Semiconductor Industry Association, April 2021.

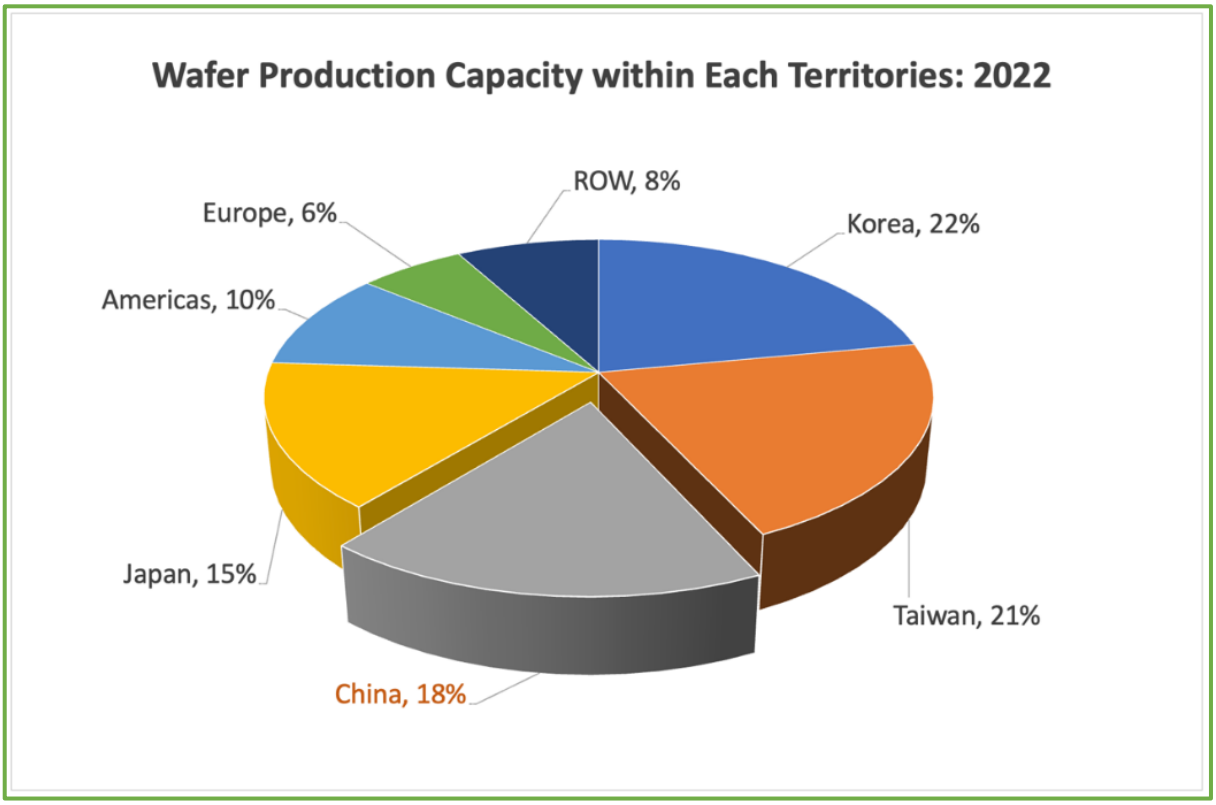
[4] Jeremy Mark and Niels Graham, "Relying on old enemies: The challenge of Taiwan's economic ties to China," Atlantic Council, November 17, 2023.

[5] Semiconductor Industry Association, "SIA 2023 Factbook," May 8, 2023

[6] Chia-Chen Lee, "Taiwan IC Industry Development in 2023Q3," Industrial Economics and Knowledge Center (IEK), Industrial Economics and Knowledge Center (ITRI), December 6, 2023.

companies in China) accounted for 18% of the world's capacity, surpassing the wafer capacity of Japan (15%), the Americas (10%), Europe (6%), and the ROW region[7] (8%).[8]

Figure 1: 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.

CHINA'S ROLE IN THE GLOBAL SEMICONDUCTOR INDUSTRY

Semiconductors are essential components of consumer and industrial electronic products like smartphones, computers, and telecommunication equipment.[9] As the world's largest manufacturing hub, China accounted for nearly 30% of global manufacturing output in 2022, and has been the world's largest consumer of semiconductors, both for domestic use and export since 2005.[10]

Additionally, for the year of 2022, China accounted for US$ 180.4 billion in semiconductor purchases, close to a third of the worldwide total of US$ 574.1

[7] The ROW region consists primarily of Singapore, Israel, and Malaysia, but also includes countries/regions such as Russia, Belarus, and Australia.
[8] Hui-Hsiu Huang, "Global Wafer Fab Overview in 2022 and Future Expansion Plans," IEK, ITRI, August 28, 2023.
[9] Ambassador Mark A. Green, "The Hot Pursuit of Semiconductors and Critical Minerals," Wilson Center, August 1, 2023.
[10] Fan Feifei, "Role of manufacturing in recovery hailed," China Daily, June 29, 2023.

billion,[11] and it also accounted for 36% of semiconductor sales for U.S. companies.[12]

China's IC Industry

China's semiconductor industry consists of a wide spectrum of companies, from integrated device manufacturers (IDM) to pure-play foundries, fabless semiconductor companies and outsourced semiconductor assembly and test (OSAT) companies.

According to statistics from the China Semiconductor Industry Association (CSIA), the sales revenue of China's semiconductor industry in 2022 amounted to RMB 1.2 trillion yuan (US$ 180.4 billion). Among them, the proportions of IC design industry, IC manufacturing industry, and IC packaging and testing industry in the total sales revenue were 43%, 32%, and 25%, respectively (see Table 1).[13]

Table 1: Sales Revenue of China's Semiconductor Industry in 2022

Industry	Proportion of Industry	Sales Revenue (billion)	
IC Design	43%	RMB 516	US$ 77.6
IC Manufacturing	32%	RMB 384	US$ 57.7
IC Packaging and Testing	25%	RMB 300	US$ 45.1
Total	100%	RMB 1,200	US$180.4

Source: Compiled based on statistics from the China Semiconductor Industry Association and Semiconductor Industry Association on China's semiconductor industry in 2022.

On China's list of top ten integrated circuit (IC) companies, pureplay foundries Semiconductor Manufacturing International Corp (SMIC) and Hua Hong Group take the top and second place. Fabless semiconductor companies – Bitmain, UNISOC, and Sanechips – take fifth, sixth and eighth place, respectively. IDMs – Yangtze Memory Technologies Corp (YMTC) and ChangXin Memory Technologies (CXMT) – rank ninth and tenth place, respectively. OSAT companies including JCET, Tongfu Microelectronics, and HT Tech, are also among the top ten (see Table 2).

[11] Semiconductor Industry Association, "Global Semiconductor Sales Increase 3.3% in 2022 Despite Second-Half Slowdown," February 3, 2023.
[12] Semiconductor Industry Association, "2023 State of the U.S. Semiconductor Industry," July 27, 2023.
[13] Fan Feifei and Ma Si, "Dutch chip curbs may spur R&D," China Daily, November 9, 2023.

Table 2: China's Ten Major IC Companies in 2022

Unit: US$ million

	Company	Type	Revenue
1	SMIC	Foundry	7,273
2	JCET	OSAT	4,977
3	Hua Hong Semiconductor Group	Foundry	4,030
4	Tongfu Microelectronics	OSAT	3,093
5	Bitmain	Fabless	2,135
6	UNISOC	Fabless	2,056
7	HT-tech	OSAT	1,318
8	Sanechips	Fabless	1,315
9	YMTC	IDM	840
10	CXMT	IDM	705
Total			**27,742**

Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 4-8.

Table 3 shows the top 25 IC corporations by revenue in the world in 2022. The Big Three – TSMC, Samsung, and Intel – are the world's three biggest IC corporations. According to the Industrial Economics and Knowledge Center (IEK) at Taiwan's Industrial Technology Research Institute (ITRI), Samsung was the world's largest IC corporation with a revenue of US$ 76.85 billion in 2022. TSMC, the world's largest foundry, ranked as the world's second IC corporation with a revenue of US$ 75.85 billion in 2022. Meanwhile, Intel Corporation came in third place with a revenue of US$61.53 billion in 2022. All three have a presence in China.[14]

China's SMIC came in as the world's 25th largest IC corporation in 2022 with a revenue of US$ 7.27 billion. The total revenue of the 25 largest IC corporations amounted to US$ 579.55 billion in 2022, of which China's share of the revenue amounted to only 1.3% (see Table 3).

[14] "Company Info", Taiwan Semiconductor Manufacturing Company, https://www.tsmc.com/english/aboutTSMC/company_profile; "China, Global Network", Samsung Semiconductor, https://semiconductor.samsung.com/support/contact-info/global-network/china/; "Support: How Many Manufacturing Fabs Does Intel Have?", Intel, https://www.intel.com/content/www/us/en/support/articles/000089875/programs/intel-corporation.html.

Table 3: 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	-6.30%
2	TSMC	Foundry	56,840	75,851	33.40%
3	Intel	IDM	76,742	61,534	-19.80%
4	Qualcomm	Fabless	29,333	36,722	25.20%
5	SK Hynix	IDM	37,433	34,905	-6.80%
6	Broadcom	Fabless	21,026	26,633	26.70%
7	Micron	IDM	30,016	25,637	-14.70%
8	Nvidia	Fabless	23,168	24,503	5.80%
9	AMD	Fabless	16,434	23,601	43.60%
10	TI	IDM	17,315	18,993	9.70%
11	MediaTek	Fabless	17,667	18,506	4.70%
12	Apple	Fabless	14,778	17,824	20.60%
13	STMicroelectronics	IDM	12,761	16,128	26.40%
14	Infineon	IDM	13,685	15,776	15.30%
15	NXP	IDM	10,843	12,954	19.50%
16	Analog Devices	IDM	8,560	12,388	44.70%
17	Renenas	IDM	8,896	11,318	27.20%
18	Kioxia	IDM	12,528	10,595	-15.40%
19	SONY	IDM	9,574	9,858	3.00%
20	UMC	Foundry	7,627	9,362	22.70%
21	onsemi	IDM	6,740	8,327	23.50%
22	GlobalFoundries	Foundry	6,585	8,108	23.10%
23	WD/SanDisk	IDM	9,705	8,022	-17.30%
24	Microchip	IDM	6,314	7,883	24.80%
25	SMIC (CN)	Foundry	5,443	7,273	33.60%
Total revenue of above companies				579,546	
China's share of above companies				1.3%	

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

China's Integrated Circuit Design Industry

The IC design (fabless manufacturing) sector in China has been growing rapidly. In 2022, the sales value of the integrated circuit design industry amounted to RMB 535 billion yuan (US$ 74.47 billion) in China.[15] The IC design industry's total revenue in 2023 is expected to reach RMB 557.4 billion yuan

[15] Daniel Slotta, "Value of the IC design industry sales in China 2017-2023," Statista, November 29, 2023.

(US$ 76.7 billion), up 8% from 2022.[16] Despite significant progress, China is not yet fully self-sufficient in IC design, and this gap is filled by foreign IC design companies.

The U.S. is the global leader in the most knowledge/R&D-intensive activities, including electronic design automation (EDA), and core intellectual property (IP), logic chip design, and semiconductor manufacturing equipment (SME).[17] Of the world's top 15 IC design companies in 2022, nine are American firms (Qualcomm, Nvidia, Broadcom, AMD, Apple, Marvell, Cirrus Logic, Monolithic Power and IBM). Leading U.S. firms Qualcomm, Nvidia and Broadcom have a substantial presence in the Chinese market.[18]

Taiwan, another important player in the global IC design industry, has three companies (MediaTek, RealTek and Novatek) in the world's top 15 IC design companies in 2022. These three companies also have a significant presence in the Chinese market.[19]

China's two leading IC design companies, Bitmain and UNISOC, also make it to the list of the 15 largest IC design companies in the world. Tenth-ranked Bitmain's revenue in 2022 was US$ 2.13 billion while that of eleventh-ranked UNISOC was US$ 2.06 billion. Unlike the U.S. and Taiwanese multinational companies that cater to markets in various countries, the Chinese companies cater only to the domestic Chinese market. Together, the total revenue of Bitmain and UNISOC totaled US$ 4.2 billion, and accounted for only 2.4% share of the total revenue of the IC design companies among the top 15 companies in 2022 (see Table 4).

However, whilst China's semiconductor industry has design capabilities, these companies mostly rely on U.S. design tools, and when designing leading-edge designs, need to use outside fabs such as TSMC and Samsung.[20]

[16] Daniel Slotta, "Value of the IC design industry sales in China 2017-2023," Statista, November 29, 2023.
[17] Research Institute for Global Value Chains at the University of International Business and Economics, Asian Development Bank, the Institute of Developing Economies–Japan External Trade Organization and the World Trade Organization, Global Value Chain Development Report 2023, Chapter 4: From Fabless to Fabs Everywhere? Semiconductor Global Value Chains in Transition, 2023.
[18] Efe Udin, "Mediatek Mobile Chip Floors Qualcomm, Apple and Others In China," GizChina, July 12, 2022.
[19] Corporate websites of MediaTek (corp.mediatek.com), Realtek (realtek.com) and Novatek(novatek.com.tw)
[20] Stewart Randall, "SILICON | China's chip design industry in 2022: the dawn of living with US sanctions," TechNode, February 9, 2023.

Table 4: Global 15 Largest IC Design Companies: 2022

Unit: US$ million

Ranking	Company	Country	2022 Revenue
1	Qualcomm	USA	36,722
2	Broadcom	USA	26,633
3	NVIDIA	USA	24,503
4	AMD	USA	23,602
5	MediaTek	Taiwan	18,506
6	Apple	USA	17,824
7	Marvell	USA	5,894
8	Realtek	Taiwan	3,774
9	Novatek	Taiwan	3,734
10	BitMain	China	2,135
11	Unisoc	China	2,056
12	Cirrus Logic	USA	2,015
13	Monolithic Power	USA	1,794
14	LX Semicon	Korea	1,654
15	IBM	USA	1,362
Total revenue of above companies			172,208
Total revenue of Chinese companies			4,191
China's share of above companies			2.4%

Source: Shu-Ting Chung, "Semiconductor Design Leads the Trend," IEK, ITRI, October 30, 2023, p. 11.

China's Foundry Business

China's foundry industry is split into two categories—domestic and multinational. SMIC, China's most advanced and largest domestic foundry, ranked 25th by revenue among the world's major IC corporations in 2022 (see Table 3). Its technology is several generations behind Taiwan Semiconductor Manufacturing Company (TSMC) and Samsung, as SMIC is only just getting to the 7 nm chip in limited quantities,[21] while the latter two are mass producing the 3 nm chip and are currently working on their 2 nm node.[22]

On the multinational front, TSMC, United Microelectronics Corporation (UMC), SK Hynix, Samsung and Intel have operated fabs in China for years. According to Knometa Research, roughly half of all IC wafer capacity in China is controlled by foreign companies.[23]

[21] Paul Alcorn, "China's SMIC Shipping 7nm Chips, Reportedly Copied TSMC's Tech", Tom's Hardware, July 21, 2022.
[22] Matthew Gooding, "Samsung to begin mass production of 2nm semiconductors in 2025", Tech Monitor, June 28, 2023.
[23] George Leopold, "China's Wafer Capacity Jumps", EE Times Asia, February 21, 2022.

TSMC, the world's largest foundry corporation by market size, recorded a market share of 53.4% while second-ranked Samsung occupied 16.4% of the market in 2022. China's SMIC and Huahong Group also ranked among the world's ten largest foundry corporations, coming in fifth and sixth respectively. However, of the total market share totaling US$ 135.3 billion held by the top ten largest foundry corporations in 2022, SMIC and Huahong held a combined market share of US$ 11.3 billion or only 7.9% in 2022.

All ten foundry corporations saw their revenue increase from 2021 to 2022, with SMIC and Huahong Group, which are producing mostly legacy chips (those made with 28 nm equipment or above),[24] posting the strongest growth rates at 34% and 38% respectively (see Table 5).

Table 5: Global Ten Largest Foundry Corporations (Including IDM foundry and pure foundry): 2021-2022

Unit: US$ million

Ranking	Name	Type	Headquarter	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%**
China's share				8,364	11,303	35%	7.9%

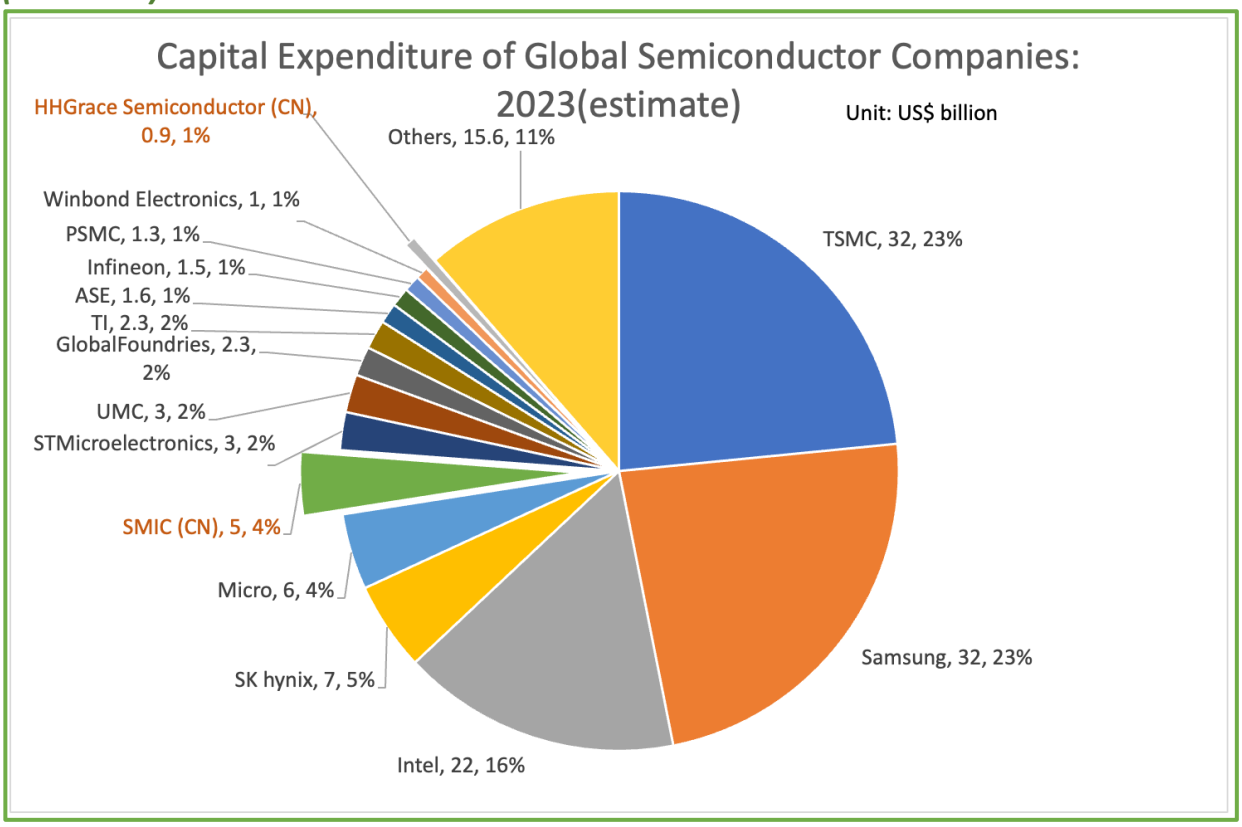
Source: Hui-Hsiu Huang, "Review of Global Semiconductor Manufacturing Industry Development in 2022 and Outlook for 2023," IEK, ITRI, June 17, 2023, p.4.

The Big Three – TSMC, Samsung and Intel – are the highest spending semiconductor companies in the world. In 2023, with a capital expenditure (capex) estimated at US$ 32 billion each, TSMC and Samsung are the biggest spenders. They are followed by Intel, which has a capex of US$ 22 billion. The combined expenditures of TSMC and Samsung represent 46% of the entire semiconductor industry capital spending, underscoring the substantial role these two companies play in the global semiconductor industry.

[24] Jenny Leonard, Ian King, and Alberto Nardelli, "US, Europe Growing Alarmed by China's Rush Into Legacy Chips," Bloomberg, July 31, 2023.

In the same year, China's SMIC's capex is estimated at US$ 5 billion, accounting for 4% of the total capex of global semiconductor manufacturers while HHGrace Semiconductor (a wholly owned subsidiary of Huahong Group)'s capex, at US$ 0.9 billion, accounts for 1%. Together, China's two largest chip foundries account for just 5% of total worldwide semiconductor industry capital spending this year (see Figure 2).

Figure 2: Capital Expenditure of Global Semiconductor Companies:2023 (estimate)



Source: Chia-Chen Lee, "Taiwan IC Industry Development in 2023Q2," IEK, ITRI, September 7, 2023, pp. 4-5.

Figure 3 shows China's IC market size from 2021 to 2025. The size of China's IC market reached a high of US$ 192.5 billion in 2021. In 2022, as the global economy experienced a sharp decline in consumer market demand due to the Russia-Ukraine conflict, global inflation, and COVID-19 lockdowns in China, its market size contracted 6.2% to US$ 180.5 billion. The semiconductor supply chain inventory corrections that followed meant that the capacity utilization, revenue, and gross margin of the semiconductor foundry industry during this period were adversely affected. Moreover, as uncertainties persist amidst an unstable global economy, weak end-market demand, and suppliers continuing to adjust inventories, China's IC market size is estimated to decline further by 9.8% to US$ 162.8 billion in 2023.

The global semiconductor industry is expected to begin to recover in 2024.[25] Recovery in China is also expected with its IC market forecasted to grow in 2024 and 2025. For 2024, the market size is forecasted to grow 6.1% and reach a market size of US$ 172.7 billion. In 2025, the IC market in China is estimated to grow 4.3% and reach a value of US$ 180.2 billion.

Figure 3: China's IC Market Size: 2021-2025

Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 4-7.

China's IC Packaging and Testing Industry

China's IC packaging and testing industry, an early pioneer in the semiconductor sub-industries, is an important player in the more labor-intensive processes of the IC industry. According to the China Semiconductor Industry Association, the sales revenue of China's IC packaging and testing industry in 2022 amounted to RMB 300 billion yuan (US$45.1 billion) (see Table 1).

Table 6 shows the top ten global semiconductor packaging and testing companies by revenue in 2022. The total revenue of the global ten largest semiconductor packaging and testing companies was US$ 34.4 billion in 2022.

[25] SEMI and Tech Insights, Semiconductor Manufacturing Monitor, November 1, 2023

Additionally, the total revenue of China's three companies, namely, JCET, Tongfu and HT-Tech, place them among the top ten largest semiconductor packaging and testing companies in the world in 2022. With a combined revenue of close to US$ 9.4 billion in 2022, the three Chinese companies accounted for a 27.3% share of the total revenue of the ten companies.

Meanwhile, Taiwan is the global leader in the IC packaging and testing industry, with five of its companies (ASE+SPIL, Powertech, King Yuan Electronics Corp., Chipbond and Sigurd) among the list of top ten global semiconductor packaging and testing companies in 2022. While China's IC packaging and testing industry has shown remarkable progress, it is still catching up to the more fully developed and technologically advanced industry in Taiwan (see Table 6).[26]

Table 6: Global Semiconductor Packaging and Testing Companies in 2022

Unit: US$ million

Ranking in 2022	Ranking in 2021	Companies	Revenue in 2021	Revenue in 2022	Growth Rate
1	1	ASE+SPIL (TW)	11,634	12,239	5.2%
2	2	Amkor (US)	6,138	7,092	15.5%
3	3	JCET (CN)	4,661	4,977	6.8%
4	4	Tongfu (CN)	2,452	3,093	26.2%
5	6	Powertech (TW)	2,297	2,286	-0.5%
6	5	HT-Tech (CN)	1,426	1,318	-7.6%
7	7	KYEC (TW)	1,205	1,237	2.7%
8	8	Chipbond (TW)	976	811	-16.9%
9	9	UTAC Holding (SG)	681	732	7.5%
10	12	Sigurd (TW)	596	629	5.5%
China's total revenue			8,539	9,388	9.9%
Total revenue of above companies			32,066	34,414	7.3%
China's share of above companies			26.6%	27.3%	

Source: 2023 Semiconductor Industry Yearbook, IEK, ITRI, July 2023, p. 4-41.

[26] Daxue Consulting, "China's semiconductor industry: Seeking for self-sufficiency amid tensions with Taiwan and the US chip export ban," September 28, 2022.

CHINA'S POLICIES

Source: Chinese government website.

China started its journey to self-sufficiency in 2014 after its State Council released the "National Guidelines for Development and Promotion of the Integrated Circuit (IC) Industry", where the IC industry was identified as a strategic industry "supporting national economic and social development and maintaining national security"; and where China's dependence on imported ICs is deemed a risk to the competitiveness of the industry and the country's information security.[27] Accordingly, the Chinese government has launched a state-backed investment fund called 'National Integrated Circuit Industry Investment Fund' in 2014 and rolled out its 'Made in China 2025' plan a year later (see Figure 4).

Figure 4: Chinese Semiconductor Industrial Policy

POLICY	DETAILS
National Integrated Circuit Industry Investment Fund (also known as	To bring China's semiconductor industry on par with leading international competitors, the Big Fund supports local semiconductor start-ups and research and development, and help to accelerate technology transfer through foreign direct investment and joint venture. This involves: • investing in indigenous semiconductor companies and research and development • using the Big Fund for outbound foreign direct investment (FDI) to acquire foreign companies • providing funds to facilitate inbound FDI such as greenfield investment and joint ventures with non-Chinese companies.[28]

[27] State Council of the People's Republic of China, "Guideline for the Promotion of the Development of the National Integrated Circuit Industry," World Trade Organization, 2014, https://members.wto.org/CRNAttachments/2014/SCMQ2/law47.pdf.

[28] John VerWey, "Chinese Semiconductor Industrial Policy: Past and Present," United States International Trade Commission, Journal of International Commerce and Economics, July 2019, p. 13.; James Andrew Lewis,

POLICY	DETAILS
the China Integrated Circuit Investment Fund or the Big Fund)	The Big Fund is managed by Sino IC Capital, a company established by China Development Bank in 2014. The fund's shareholders include the Ministry of Finance, China Tobacco, China Telecom, and several local governments and investment funds. It operates as a corporate entity under the Ministry of Industry and Information Technology and the Ministry of Finance. The fund has three phases, each with different fundraising targets and investment focuses: • **Phase I (2014-2019)**: The fund raised US$ 21.8 billion in 2014 and invested in 23 domestic semiconductor companies, mainly in chip manufacturing, design, and packaging. The fund also facilitated several mergers, acquisitions, and IPOs in the industry.[29] • **Phase II (2019-2024):** The fund raised US$ 29.08 billion in 2019 and increased its focus on etching machines, film, test, and cleaning equipment, as well as new applications enabled by 5G and AI. The fund aimed to build an independent and controllable industrial chain for the Chinese IC industry.[30] • **Phase III (2023-2028):** The fund is reportedly raising US$ 41 billion in 2023 and is expected to invest in advanced nodes (7 nm or less), memory, and logic chips, as well as emerging technologies such as quantum computing and neuromorphic computing. The fund hopes to achieve global leadership in innovation and quality in the semiconductor industry.[31]
Made in China 2025 (MIC 2025)	Formulated in 2015, the policy seeks to transform China's manufacturing sector by decreasing China's reliance on foreign technology imports and cementing its position in the global supply chains of critical technologies.[32] MIC 2025 focuses on intelligent manufacturing in 10 strategic sectors: 1) advanced information technology; 2) automated machine tools and robotics; 3) aerospace and aeronautical equipment; 4) ocean engineering equipment and high-tech shipping; 5) modern rail transport equipment; 6) energy saving and new energy vehicles; 7) power equipment; 8) new materials;

"Rethinking Technology Transfer Policy toward China," Center for Strategic and International Studies, November 17, 2023.

[29] Luffy Liu, "China's 'Big Fund' Phase II Aims at IC Self-Sufficiency," EE Times, October 30, 2019; Julie Zhu, Kevin Huang, Yelin Mo and Roxanne Liu, "Exclusive: China to launch $40 billion state fund to boost chip industry," Reuters, September 5, 2023.

[30] Luffy Liu, "China's 'Big Fund' Phase II Aims at IC Self-Sufficiency," EE Times, October 30, 2019.

[31] Ibid; Ma Si and Hu Dongmei, "China's largest quantum computing cloud platform unveiled," China Daily, August 20, 2023.

[32] Daxue Consulting, "China's semiconductor industry: Seeking for self-sufficiency amid tensions with Taiwan and the US chip export ban", September 28, 2022.

POLICY	DETAILS
	9) medicine and medical devices; and 10) agricultural equipment. MIC 2025 entails a 3-step strategy: • **Step 1 (2015-2025):** basic industrialization, progress made in smart and green manufacturing; • **Step 2 (2025-2035):** complete industrialization, tier-2 manufacturing leader with solid indigenous R&D, breakthrough in key sectors; and • **Step 3 (2035-2050):** Tier-1 manufacturing leader with advanced technology and industrial system.[33] With reference to semiconductors, the goals are: 1) To develop the IC design industry, speed up the development of the IC manufacturing industry, upgrade the assembly, testing and packaging (ATP), and facilitate breakthroughs in the key equipment and materials of integrated circuits.[34] 2) By 2020, China's semiconductor design and manufacturing should be one to two generations behind industry leaders and supported by a robust domestic supply chain of equipment, material and ATP service suppliers. 3) By 2030 the main segments of the IC industry should reach advanced international levels.[35] The goal of raising local content of semiconductor chips to 40% by 2020 and 70% by 2025 was revised in 2019, with a new goal of reaching US$ 305 billion in output by 2030, and meeting 80% of domestic demand.[36]

The National IC Plan and MIC 2025 represent China's major semiconductor industrial plans. Various measures, including tax incentives, subsidies, and new powers for selected leading semiconductor companies are implemented to accelerate the development of the entire semiconductor supply chain in China. Additionally, the Central Science and Technology Commission (CSTC) was established in March 2023 to beef up the Chinese Communist Party Central Committee's "centralized and unified leadership over science and technology-related work" (see Figure 5).[37]

[33] The State Council, People's Republic of China, "Made in China 2025", March 30, 2017; Michael Settelen, "'Made in China 2025' And China's Evolving Industrial Policy," Switzerland Global Enterprise, January 3, 2023.
[34] State Council of the People's Republic of China, "Made in China 2025 Technical Roadmap," October 29, 2015.
[35] U.S. Chamber of Commerce, Made in China 2025, March 16, 2017, p. 65.
[36] Congressional Research Service, "China's New Semiconductor Policies: Issues for Congress," April 20, 2021.
[37] State Council of the People's Republic of China, "China to restructure ministry in sci-tech self-reliance drive," March 7, 2023.

Figure 5: Implementation of Made in China 2025

MEASURE	DETAILS
Tax Incentives	**Corporate Tax Breaks** Preferential tax treatment from the first profitable year for domestic semiconductor players in 2020: • Qualifying integrated circuit (IC) projects and enterprises that have operated for more than 15 years will be exempt from corporate income tax for up to 10 years if they employ the 28 nm process or more advanced nodes. • Those producing 65 nm to 28 nm chips will get 5 years of tax exemption and a 50% discount on the corporate tax rate for the subsequent five years.[38]
	Exemption of Import Duties in Chip Equipment and Inputs until 2030 Exemption of taxes from July 27, 2020 to December 31, 2030 on imports of some semiconductor companies that are critical to the country's IC development, including IC production equipment parts, raw materials and other consumables.[39]
	Tax Credit for Investments in Semiconductor Research and Development Tax credit for investments in semiconductor R&D was upgraded by 20%. For the entire calendar years from 2023 to 2027, the pre-tax deduction rate for R&D related expenses will increase from the current 100% to 120%.[40] **"Super-input" value added tax (VAT) credit** From 1 January 2023 to 31 December 2027, general VAT taxpayers engaging in IC design, manufacturing, equipment, materials, packaging and testing would be eligible for an extra 15% "super-input VAT credit." This allows qualified IC enterprises to credit their eligible input VAT at a rate of 115%.[41]
Special Economic Zone Subsidies	**Lin-gang Special Area** Established in 2019, Lin-gang New Area is part of the Shanghai Pilot Free Trade Zone to build a comprehensive industrial base for integrated circuits. It provides guidance on its entire supply chain layout, innovation, openness and cooperation. Besides promoting the development of key areas such as core chips, specialty processes, key equipment, and basic materials, it also supports multinational companies in setting up offshore R&D and manufacturing centers. According to its action plans, it aims to achieve: 1) IC industry output value of RMB 100 billion yuan (US$ 15.27 billion) by 2025, compared to RMB 10 billion yuan (US$ 1.5 billion) in 2021.

[38] State Taxation Administration of the People's Republic of China, "Tax breaks to lend IT sector helping hand," December 25, 2020; Jane Zhang and Che Pan, "China unveils major tax incentive policy to encourage innovation in domestic semiconductor industry", August 5, 2020.
[39] Global Times, "Import duties in chip equipment, inputs exempted until 2030", March 29, 2021.
[40] Arrian Ebrahimi, "China Boosts Semiconductor Subsidies as US Tightens Restrictions", The Diplomat, September 28, 2023.
[41] Carolyn Wright, Tax News Update (Global Edition): "China introduces 'super-input VAT credit' policy for integrated circuit enterprises", Ernst & Young LLP, June 6, 2023.

MEASURE	DETAILS
	2) Build a high-level industrial ecosystem with global influence - the "Oriental Chip Port" by 2035. Corporate income tax rates for companies specializing in IC, artificial intelligence, biomedicine and civil aviation have been set at 15% in Lin-gang for five years from the date of establishment, compared to the usual 25% in the rest of China.[42]
	China-Korea Integrated Circuit Industrial Park The municipal government of Wuxi and memory chip giant SK Hynix started construction of the industrial park in October 2021.[43] The project involves a total investment of about RMB 2 billion yuan (US$ 310 million) and aims to strengthen the high-quality development of the IC industry in Wuxi by attracting more upstream and downstream projects in its industrial chain. The city is expected to become home to 19 new semiconductor-related projects with a combined investment of US$ 4.7 billion.[44]
	Special Economic Zone in Hengqin Established in July 2022 as a major new outpost for China's semiconductor industry, the Hengxin Special Economic Zone offers: 1) Up to RMB 30 million yuan (US$ 4.4 million) each for semiconductor firms to set up new offices or conduct R&D activities in Hengqin; 2) RMB 5 million yuan (US$ 686,502) and 50% of tapeout cost to firms that establish R&D programs in Hengqin; 3) Up to RMB 25 million yuan (US$ 3.43 million) to firms involved in 14 nm or lower chip processing design; 4) More than RMB 100,000 yuan (US$ 13,930) each to researchers and senior managers who signed contracts with Chinese semiconductor firms and were assigned to work in Hengqin for a three-year period; and 5) RMB 1 million yuan (US$ 139,300) to companies that can nurture semiconductor talent in Hengqin.[45]

[42] State Council of the People's Republic of China, "Notice on the overall plan of Lingang New Area," August 6, 2019, https://www.gov.cn/zhengce/content/2019-08/06/content_5419154.htm; Invest in China, "Lin-gang outlines ambitious 2025 IC development goals," August 15, 2022. China Daily, "Shanghai zone to be home of 1,000 high-tech firms by 2025," August 23, 2022.

[43] Justin Feng, "How are Washington and Beijing Utilizing Industrial Policy to Bolster Domestic Semiconductor Manufacturing?" Center for Strategic and International Studies, March 29, 2022.

[44] Tracy Qu, "New China-Korea semiconductor industrial complex starts construction amid Beijing's push for tech self-reliance," South China Morning Post, October 8, 2021; The Information Office of Wuxi Municipal People's Government, "S Korean semiconductor giant to expand development in Wuxi," January 30, 2021.

[45] Jiaxing Li, "China ramps up subsidies to lure chip firms to Hengqin, an island near Macau, turning it into a major semiconductor outpost," South China Morning Post, July 28, 2022; Gary Clyde Hufbauer and Megan Hogan, Policy Brief 22-13 CHIPS Act Will Spur US Production but Not Foreclose China, Peterson Institute for International Economics, October, 2022, p. 10.

MEASURE	DETAILS
Whole Nation System	The new "Whole Nation System" is embedded in China's 14th five-year plan, as well as its local and sector-specific versions, which collectively map key strategies for advancing the country's development from 2021 to 2025. Specifically, the new "Whole Nation System" for R&D consists of key elements including integrating and diverting resources to priority cutting-edge technologies such as artificial intelligence and quantum science, strengthening basic research, and establishing national labs and industry clusters.[46]
Central Science and Technology Commission	Established in March 2023, the commission, which sits directly under the Communist Party of China's Politburo, is higher ranking than all government ministries.[47] It is likely to focus on the semiconductor industry, given its importance to China's goal of technological self-sufficiency. It has authority over the Ministry of Science and Technology, and is intended to accelerate progress towards China's goal of scientific self-reliance and to ease China's technological chokepoints.[48] To date, few details on the commission have been made public. Analysts attributed China's secrecy to worries about policy pressure from Washington, fears about espionage and potential links between the commission and the People's Liberation Army.[49] Many, however, see the establishment of the commission as a direct response to the tough measures adopted by the U.S.A. designed to dent China's ambitions of technology supremacy.[50]
New Powers to Select Group of Companies	China is nurturing closer co-operation with a select group of companies, namely, chipmakers SMIC, Hua Hong Semiconductor and Huawei, as well as equipment suppliers Naura and Advanced Micro-Fabrication Equipment Inc China. These chosen few will have access to additional government funding without having to achieve performance goals that were previously necessary. They will also be able to play a bigger role in state-backed research projects, reducing the influence of state-owned companies and academic institutes.[51]

ASSESSMENT OF CHINA'S POLICIES

China's "Made in China 2025" policy and National Integrated Circuit Industry Investment Fund, also known as the Big Fund, aim to (1) help the country catch up with and ultimately surpass Western technological prowess in

[46] Xiao Tan and Yao Song, "China's 'Whole Nation' Effort to Advance the Tech Industry," April 21, 2022.
[47] Eduardo Baptista, "China to restructure sci-tech ministry to achieve self-reliance faster', Reuters, March 7, 2023.
[48] Charles Mok, "The Party Rules: China's New Central Science and Technology Commission, The Diplomat, August 23, 2023.
[49] Jane Cai, William Zheng and Echo Xie, "Mystery around China's new science and tech body a sign of secrecy to come, analysts say," South China Morning Post, September 4, 2023.
[50] Dr. Yu Jie, "The emerging leaders behind Beijing's drive for technological self-reliance", Chatham House, July 24, 2023.
[51] Qianer Liu, "China gives chipmakers new powers to guide industry recovery," Financial Times, March 21, 2023.

advanced industries, and (2) reach its national goal of achieving semiconductor self-sufficiency by investing in its domestic semiconductor companies.

Table 7 compiles information on China's share of the global semiconductor market and its production capacity in 2022. China's market size was worth about US$ 180.4 billion, or about 31.4% of the global semiconductor market, which in 2022 stood at US$ 574.1 billion.

Table 7: China's Share of Global Semiconductor Market and Production Capacity in 2022

Unit: US$ billion

Item	Value/Revenue	Global Share
Market size[1]	180.4	31.4%
Production capacity[2]	Not Available	18%
IC corporations[3]	7.3	1.3%
IC design[4]	4.2	2.4%
IC foundry[5]	11.3	7.9%
IC packaging and testing[6]	9.4	27.3%
Capital expenditure[7]	5.9	5.0%

Note:

1. Market size includes demand of domestic and foreign-invested companies in China. Global semiconductor market in 2022 was US$ 574.1 billion, China's share was 31.4% = US$180.5 billion/ US$ 574.1 billion.
2. Production capacity includes capacity of domestic and foreign-invested companies in China, with IC Insights reporting that foreign companies are expected continue to comprise more than 50% of IC production in China through 2026.[52]
3. IC corporation: China's share of global 25 largest IC companies was 1.3%.
4. IC design: China's share of global 15 largest IC design companies was 2.4%.
5. IC foundry: China's share of global ten largest foundry corporations was 7.9%.
6. IC packaging and testing: China's share of global ten largest semiconductor packaging and testing companies was 27.3%.
7. Capital expenditure: China's share of global 15 largest IC companies is estimated 5% in 2023.

Source: Compiled from earlier tables and figures from IEK, ITRI.

Performance of China's semiconductor industry

The Chinese government has been making serious efforts to close the gap, investing well over US$ 150 billion from 2014 through 2030 in semiconductors.[53]

[52] IC Insights, "Research Bulletin: China-Based IC Production to Represent 21.2% of China IC Market in 2026," May 18, 2022.

[53] Semiconductor Industry Association, "SIA White Paper: Taking Stock of China's Semiconductor Industry," July 2021.

- Increased Production Capacity

China's share of global production capacity increased from 10.8% in 2016 to 15.3% in 2020, 16% in 2021, and 18% in 2022.[54] But about half of China's production capacity were produced by foreign-invested enterprises in China.

- Few Successes, Large-Scale Bankruptcy, and Corruption

Industry experts said that the Big Fund has played an indispensable role in building up China's domestic chipmaking industry by providing stable funding and state endorsements to fledgling businesses that struggled to access capital elsewhere.[55] The number of Chinese chip developers increased from 736 in 2015 to 1,780 in 2017. According to a survey by China's state media, over the period of January 1 to October 27, 2020, no fewer than 58,000 microchip companies were established in China, equivalent to about 200 new companies every day, some even without any microchip experience or technology.[56] In 2020–2021 as many as 70,000 chip companies were registered.[57]

The top recipients of Big Fund Phase I (2014-2019) money include Yangtze Memory Technologies Co Ltd (YMTC; US$ 1.89 billion to US$ 2.66 billion), SMIC North (US$ 1.46 billion), SMIC South (US$ 882 million), and JCET (US$ 644 million). YMTC, SMIC and JCET have become success stories in China's semiconductor industry: YMTC is beginning to become a respectable competitor to Micron, SK Hynix, and Samsung; SMIC, despite limitations thrust upon it, is experimenting with multi-patterning techniques to create simple 7nm chips in limited quantity; while JCET remains as China's leading ATP firm.

Nevertheless, China's Big Fund has faced criticisms for its poor targeting of recipient companies. According to TMTpost, a Chinese media, 461 Chinese chip-related companies were revoked or deregistered in 2017, increasing rapidly to 715 such companies in 2018 and 1,294 such companies in 2019. In 2020, the state of Chinese chip-related companies worsened with 1,397 companies going

[54] CTIMES, "Taiwan Maintains Largest Share of Global IC Wafer Fab Capacity, IC Insights Reports," February 24, 2017; Design and Reuse, "Taiwan Maintains Edge as Largest Base for IC Wafer Capacity," July 13, 2021; Knometa Research, "Global Wafer Capacity at Dec 2021 by Fab Location," https://tiesalesm.live/product_details/41676173.html

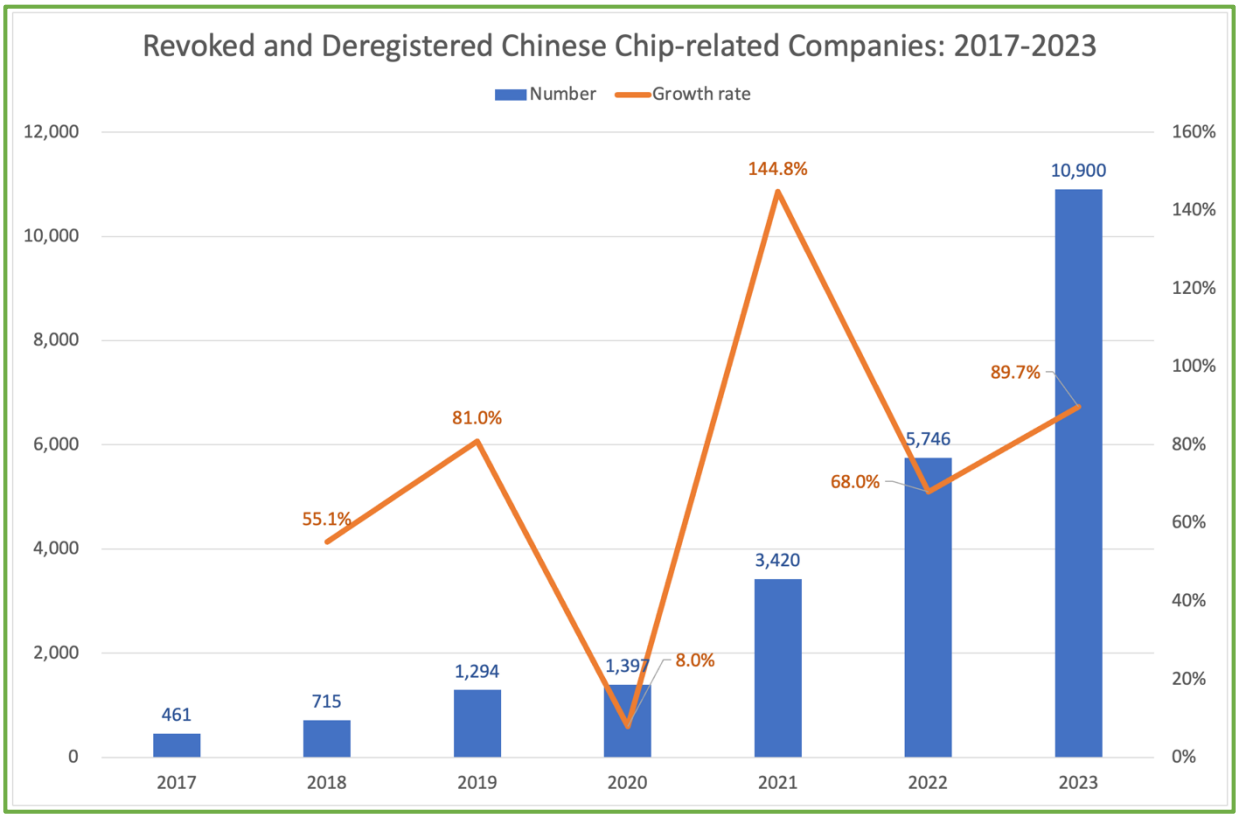
[55] Zhang Erchi, Qu Yunxu, Yu Ning, Qin Min, Zhai Shaohui and Han Wei from Caixin Global, "Five things to know about China's scandal-struck chip industry 'Big Fund'," ThinkChina, August 12, 2022.

[56] 连书华, "运作资金数千亿 晶片大基金管理公司原总裁落马," Epoch Times, July 24, 2022.

[57] Anton Shilov, "10,000 Chinese Chip Developers Closed Shop in 2021–2022," Tom's Hardware, May 10, 2023.

defunct, before dramatically deteriorating by 144.8% to 3,420 such companies in 2021. As many as 5,746 Chinese chip-related companies were deregistered in 2022, a 68% increase from the previous year, and further worsened to 10,900 such companies in 2023, an 89.7% increase from the previous year. This translates to about 31 chip companies revoked or deregistered every day, on average, in 2023. In all, more than 22,757 Chinese chip-related companies went out business during 2019-2023 (See Figure 6).[58]

Figure 6: Revoked and Deregistered Chinese Semiconductor Companies



Source: 林志佳, "2023 年有 1.09 万家中国芯片公司消失，比去年增长近 90%," 钛媒体, Dec. 12, 2023, https://www.tmtpost.com/6830524.html.
Note: 2023 figure only covers January 1 to December 11, 2023.

One example is the failed Wuhan Hongxin Semiconductor Manufacturing Co. Ltd. (HSMC) project. Envisioned as a major project aimed at creating a Chinese-owned 7nm foundry, the Dongxihu district government put up the

[58] Ann Cao, "Tech war: record number of Chinese chip firms going out of business in sign of Beijing's sputtering self-sufficiency drive," South China Morning Post, 15 Sep, 2022. Alex Wu, "Thousands of Chinese Chip Companies Go Bankrupt in 2022 Following US Sanctions," The Epoch Times, February 20, 2023. 连书华, "运作资金数千亿 晶片大基金管理公司原总裁落马," Epoch Times, July 24, 2022. 林志佳, "2023 年有 1.09 万家中国芯片公司消失，比去年增长近 90%," 钛媒体, 2023.12.12, https://www.tmtpost.com/6830524.html.

initial RMB 200 million yuan (US$ 28 million) investment in HSMC despite its founding members having no semiconductor experience.[59]

Other than HSMC, more than 10 high-profile, government-sponsored semiconductor projects were reported to have gone bust between 2020 and 2021.[60] In 2020, a US$ 100 million plant set up by US chip foundry GlobalFoundries and the Chengdu city government ceased operations after remaining idle for almost two years. A US$ 3 billion government-backed chip project owned by Tacoma Nanjing Semiconductor Technology went bankrupt in July 2021 after failing to attract investors.[61]

Corruption also played a role in the challenges faced by China's semiconductor industry. For instance, several top executives associated with a state-owned semiconductor fund were arrested on corruption charges. This included Ding Wenwu, the chief executive of the China Integrated Circuit Industry Investment Fund.[62]

Another example is Zhao Weiguo, the former chairman of computer chipmaker Tsinghua Unigroup, who was accused of corruption by China's anti-fraud watchdog.[63] The regulator alleged that Zhao treated the state-owned company as his private fiefdom, handing profitable businesses to his relatives and friends, and purchasing goods and services from companies managed by his associates at prices significantly higher than the market.[64]

Self-Sufficiency Rate

China has set ambitious goals for increasing its self-sufficiency in semiconductor manufacturing. The "Made in China 2025" initiative aimed to achieve a 40% self-sufficiency rate by 2020, 70% by 2025, and 80% by 2030. These goals reflect China's strategic focus on reducing its dependence on foreign semiconductor technology and enhancing its capabilities in this critical sector.

[59] Jane Zhang, "China's semiconductors: How Wuhan's challenger to Chinese chip champion SMIC turned from dream to nightmare," South China Morning Post, March 20, 2021.
[60] Ibid.
[61] Ibid.
[62] Zeyi Yang, "Corruption is sending shock waves through China's chipmaking industry," MIT Technology Review, August 5, 2022.
[63] Brenda Goh, "China charges Tsinghua Unigroup's former chairman with corruption," Reuters, March 20, 2023.
[64] Ibid.

According to IC Insights, a U.S. research firm, China's semiconductor self-sufficiency rate (= production ÷ market demand) was between 10-15% from 2009 to 2014, and hovered around 15% between 2014 and 2019. The rate increased slightly to 16.6% in 2020 and 16.7% in 2021. Furthermore, China-based IC production is forecasted to represent 21.2% of China IC market demand in 2026. (See Table 8).

Table 8: China's Self-sufficiency Rate on Semiconductor

Unit: US$ billion

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2026
Production	4.2	5.8	7.9	8.8	10.3	11.7	13.4	13	19.3	23.9	19.3	24.2	31.2	58.2
Market	41	57	62	63	69	77	83	94	118	150	131	146	187	274
Ratio (%)	10.2	10.2	12.7	14.0	14.9	15.2	16.1	13.8	16.4	15.9	14.7	16.6	16.7	21.2

Source: IC Insights Research Bulletin, "China-Based IC Production to Represent 21.2% of China IC Market in 2026," May 18, 2022, https://www.icinsights.com/data/articles/documents/1452.pdf.

As a matter of fact, only 6.6% of Chinese market demand was contributed by China-headquartered semiconductor companies in 2021. In that year, the size of China's semiconductor market was about US$ 186.5 billion, of which only US$ 31.2 billion worth of chips were manufactured in China, both by domestic and foreign-invested companies – a self-sufficiency rate of 16.7%. Nevertheless, only US$ 12.3 billion worth of chips were manufactured by China-headquartered companies, accounting for merely 6.6% of domestic consumption. The figures of China's self-sufficiency rate by China's headquartered companies were 6.1% in 2019 and 5.8% in 2020, respectively (See Table 9).

Table 9: China's Self-sufficiency Rate by China's Headquartered Companies

Unit: US$ billion

	2019	2020	2021
China's IC Market	124.6	143.4	186.5
China-based IC Production	19.5	22.7	31.2
China-HQ IC Production	7.6	8.3	12.3
Self-Sufficiency Rate	15.7%	15.8%	16.7%
HQ Self-Sufficiency Rate	6.1%	5.8%	6.6%

Source: IC Insights Research Bulletin, "China-Based IC Production to Represent 21.2% of China IC Market in 2026," May 18, 2022, https://www.icinsights.com/data/articles/documents/1452.pdf. "IC Insights 预计中国芯片 2025 年 70%的自给率难以达成,"https://finance.sina.cn/tech/2021-01-08/detail-iiznctkf0880704.d.html?fromtech=1&from=wap . "IC Insights: there will be no significant progress in chip localization in China in the next 10 years," May 28, 2020, https://www.censtry.hk/article/10086.html.

Increasingly, China's efforts to catch up face major obstacles following the Biden administration's tightening of export controls to curb China's access to advanced chips, chip-making equipment and US talent. In fact, IC Insights

predicts that by 2026, China-made integrated circuit manufacturing is far from meeting the 70% self-sufficiency target set by the Chinese government, reaching only 21.2% of self-sufficiency rate. However, this rate is supplemented by foreign companies (e.g., Samsung, SK Hynix, TSMC, etc.), which contribute to more than 50% of IC production in China. In a nutshell, China's self-sufficiency rate by China's headquartered companies might be around 10% in 2026.

Global Standing

Whilst China accounts for 31.4% of the global semiconductor market, and 18% of global production capacity, these figures include the demand and production of semiconductors by foreign-invested enterprises in China. With the ongoing trade tensions and technology restrictions imposed by the U.S.A. and its allies, there have been discussions about foreign-invested enterprises in the semiconductor industry considering relocating their investments and production from China to other countries.[65] Should this happen, both China's chip market and production capacity will significantly fall.

Thanks to China's large pool of skilled and low-cost labor, the country has grown to become a substantial global player in IC packaging and testing (27.3%) industry. Globally, however, it remains relatively weak in terms of its global market share among major leaders of IC corporations (1.3%), IC design (2.4%) and IC foundries (7.9%) (see Table 7). It will, therefore, take a lot of time, effort and resources for China to catch up with other global leaders in the semiconductor industry.

However, China's global capital expenditure of US$ 5.9 billion this year accounts for just 5% of the total worldwide semiconductor industry capital spending this year (see Figure 2 and Table 7). In contrast, TSMC and Samsung are spending US$ 32 billion each while Intel is expected to spend US$ 22 billion this year. Even with enormous financial support of the Chinese government, there is still a very big gap of financial resources for Chinese local companies to compete with foreign big semiconductor companies in producing advanced chips.

Moreover, although China's Big Fund of US$ 50.88 billion (= US$ 21.8 billion + US$ 29.08 billion of two phases from 2014 to 2024) primarily invests in the semiconductor industry, a total 64.2% of the investments and loans went to

[65] Vietnam Investment Review, "Vietnam's semiconductor potential is being bolstered by the development of manufacturing complexes and related capabilities," August 30, 2023.

fabless startups focused on designing integrated circuits between 2014 and May 2022.[66] This bias means that the Big Fund investments did not significantly contribute to an increase in China's self-sufficiency of semiconductor production.

Advanced Technology Competition

According to TrendForce, there are altogether 44 fabs (12-inch, 8-inch and 6-inch wafer fabs and production lines), including multinational companies TSMC, UMC, Samsung, SK Hynix, and Texas Instruments, operating in China. By the end of 2024, China is looking at establishing 32 large fabs, with all of them are focusing on relatively mature processes.[67]

In China, the Huawei Mate 60 Pro smartphone was hailed as a significant development in its semiconductor industry. Despite U.S. sanctions, the Mate 60 Pro which features the 7nm Kirin 9000s was produced by SMIC. However, experts have said that given China's lack of access to more advanced equipment, it is costly to produce the 7 nm with limited quantity and that SMIC also faces the ceiling of 5 nm process node.[68] Although SMIC can theoretically produce advanced 7nm chips using its existing DUV lithography systems, it is a considerable distance from reaching mass production. In the capital- and technology-intensive chipmaking industry, achieving mass production at a high yield rate is critical, as it can effectively lower the cost per chip.

Transitioning to mass production and reaching a high yield rate requires significant time, manpower, and capital investment, provided the necessary equipment and tools are accessible. However, China is facing sanctions imposed by the global semiconductor alliance led by the United States. Besides working with South Korea, Japan, the Netherlands, and Taiwan to boost production, the United States has also taken steps to tighten export controls on semiconductor chips used for artificial intelligence and the equipment used to manufacture them, in an effort to prevent China from acquiring or producing advanced chips.

As China is increasingly barred from accessing exports of American, Dutch, and Japanese machinery used to make the advanced microchips essential to

[66] Shuhei Yamada, "China's chip self-sufficiency drive in need of factory investment," Nikkei Asia, January 25, 2023.
[67] Dennis Dahlgren, "China is beefing up its wafer capacity," Evertiq, November 16, 2023.
[68] Refer to the November issue of "Taiwan and the Global Semiconductor Supply Chain" published by the Taipei Representative Office in Singapore.

high-tech industry, Chinese companies, universities, and government institutions are racing to develop a homegrown extreme ultraviolet (EUV) lithography that can help etch electronic pathways on the most-advanced silicon microchips. Currently China's Shanghai Microelectronics can manufacture lithography machines that only support mass production of chips using a 90nm or larger processing mode.[69] Even as China works to develop EUV technologies, it still relies heavily on foreign IP, equipment, and materials. It, therefore, does not appear that China will be able to create their own EUV machines in the near future.[70]

CHINA'S RESPONSE TO US-LED SANCTIONS

While China has made it a top priority to develop and strengthen its capabilities across the semiconductor value chain —design, manufacturing, packaging, material inputs, and finished products— so that it can be less reliant on foreign producers, it has also been taking several steps to counter the U.S. CHIPS and Science Act.

China's Contestation

The China Semiconductor Industry Association (CSIA), which represents 744 member-firms in China's semiconductor sector, has denounced the United States' CHIPS and Science Act (CHIPS Act) as a violation of fair trade, and warned that the law could lead to chaos in global supply chains.[71]

China says that U.S. sanctions threaten its access to advanced technology needed by its semiconductor sector, disrupts the global semiconductor industry chain and harms the interests of multinational corporations in the industry.[72] In 2021, Chinese state media notes, Intel's revenue was US$ 74.7 billion, of which 30% was from China.

Additionally, the Chinese argue that subsidies from the CHIPS Act will be insufficient to lure companies away from Chinese markets and that many U.S. chip companies depend on China's industrial base to maintain their global

[69] Marina Yue Zhang, "Can China Achieve Semiconductor Self-Sufficiency?," The National Interest, June 26, 2023, https://nationalinterest.org/blog/can-china-achieve-semiconductor-self-sufficiency-206584.
[70] Eve Register, "Can China Leapfrog ASML in Its Quest for Semiconductor Self-Reliance?" The Diplomat, October 12, 2023.
[71] Che Pan, "Tech war: China semiconductor group slams US Chips and Science Act as violation of fair trade, warns of supply chain chaos", South China Morning Post, August 17, 2022.
[72] Ma Si and Wang Keju, "China slams fresh US curbs on chip exports", China Daily, October 19, 2023.

competitiveness. As illustration, China's Ministry of Commerce asserts that the cost of building and operating in China is 37% lower than in the United States, and that a self-sufficient local supply chain in the U.S. will require at least US$1 trillion in up-front investment and at least US$ 45 billion in annual operating costs.[73]

WTO Dispute Complaint

On December 15, 2022, China issued a lawsuit within the World Trade Organization against the U.S.A.'s semiconductor export controls against them that were levied on October 7, 2022. China claims that measures at issue are inconsistent with multiple provisions of the WTO's General Agreement on Tariffs and Trade, the Agreement on Trade-Related Investment Measures, the Agreement on Trade-Related Intellectual Property Rights, and the General Agreement on Trade in Services.[74]

Micron Chip Ban

On May 21, 2023, China banned the use of American Micron's chips in critical infrastructure projects, which Beijing said posed network security risks that could affect "national security". China began an investigation into Micron in late March, five months after the US unveiled sweeping curbs aimed at cutting off Beijing's access to high-end chips, chipmaking equipment and software used to design semiconductors.[75]

Restrictions on Exports of Gallium and Germanium

In the aftermath of an announcement by the Netherlands that it would support the United States' chip controls with its own equipment curbs, China imposed restrictions on exports of gallium and germanium, two rare metals used in semiconductor manufacturing, citing national security in August 2023. Germanium is used in critical applications such as thermal imaging cameras, solar panels, and fiber optics for telecommunications while gallium is crucial for manufacturing the gallium arsenide chemical compound, which can make radio frequency chips for mobile phones and satellite communication. Exporters of gallium and germanium will need to get a license to ship the metals out of

[73] Ibid.
[74] World Trade Organization, "China initiates WTO dispute complaint targeting US semiconductor chip measures", December 15, 2022.
[75] David Lawder, "US 'won't tolerate' China's ban on Micron chips, commerce secretary says," Reuters, May 28, 2023.

China. China produces about 98% of the world's gallium, and controls 68% of global refined germanium production in various countries, mainly in southeast Asia, according to the U.S. Geological Survey. So far, China's controls appear to have had little impact. Even if Chinese gallium and germanium supplies suffer a bottleneck, analysts suggest that other sources of the metals may be able to ramp up production to compensate.[76]

Graphite Restrictions

On October 20, 2023, China's Ministry of Commerce and the General Administration of Customs jointly announced that as of December 1, 2023, Chinese exporters will be required to apply for permits to ship two types of the material, namely, "artificial graphite materials and related products with high purity (purity>99.9%), high strength (flexural strength>30Mpa) and high density (density>1.73g/cubic centimeter)", as well as "natural flake graphite and its products, including spheroidized graphite and expanded graphite".[77]

China is the world's top graphite producer and exporter while the U.S.A. heavily relies on imports. Besides the U.S.A., Korea, Japan, and India are also major importers of Chinese graphite. As the Chinese government's export control of graphite follows at the heels of the U.S. government's decision to widen its restrictions on Chinese companies' access to semiconductors, many see the Chinese graphite restrictions as a retaliatory action, albeit aimed at the electric vehicle (EV) battery manufacturing this time.

Although China is the current top graphite producer, it is not the sole option for obtaining a sufficient supply. According to the United States Geological Survey, Turkey (27.3%) and Brazil (22.4%) account for half of the world's natural graphite resources, while China is third, with 16%. Moreover, the new Chinese restrictions are set to incentivize anode manufacturers outside of China to seek alternative sources for raw materials. In the case of the U.S.A., Canada and Mexico are set to continue ramping up their own domestic capacity to satisfy its demand.[78] South Korea, another major importer of Chinese graphite, also said that it is prepared to look for alternative sources of graphite if

[76] Rahul Rao, "No Signs Yet of Gallium or Germanium Shortage", IEEE Spectrum, October 10, 2023.
[77] The State Council Information Office, The People's Republic of China, "China announces export control on certain graphite materials, products", October 20, 2023.
[78] Emily Benson and Thibault Denamiel, "China's New Graphite Restrictions", Center for Strategic and International Studies, October 23, 2023.

China's newly strengthened export controls on the key material used in electric-vehicle batteries cause a severe shortage.[79]

CONCLUSION

The semiconductor industry is a strategic priority for China. Described as the world's biggest semiconductor market, its demand for semiconductors comes from both domestic and foreign-invested enterprises in China. Likewise, its semiconductor production figure, which increases from 10.8% in 2016 to 18% of global production capacity in 2022, includes about half produced by foreign-invested enterprises in China. As a result, China's self-sufficiency rate by China's headquartered companies hovered from 6.1% in 2019 to 6.6% in 2021 and is predicted to around 10% in 2026.

In addition, Chinese fabs are focusing on relatively mature processes of wafer foundry and have become a substantial global player in IC packaging and testing industry, while it remains relatively weak in terms of its global market share among major leaders of IC corporations, IC design companies and IC foundries. Moreover, it does not appear that China will be able to create their own advanced EUV machines to produce advanced chips in the near future. China's semiconductor industry, therefore, is still relatively nascent compared to global leaders.

With continued investment and policy support, it is likely that China will continue to make progress in its quest to be self-sufficient and a global leader in the semiconductor industry. However, even with enormous financial support of the Chinese government, there is still a very big gap of financial resources for Chinese local companies to compete with foreign big semiconductor companies in producing advanced chips.

To conclude, the Chinese semiconductor industry faces tremendous challenges, including export restrictions on advanced equipment and chips by the U.S.A and its allies, limited domestic capabilities, enormous failures of Chinese chip-related companies, technological chokepoints, and constraints on financial resources compared to global big chipmaking companies. China's path to achieving the twin goals of reducing its dependence on foreign imports and achieving technological advance is, therefore, fraught with uncertainties.

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[79] Sam Kim, "Korea to Seek Alternative Graphite Source if Shortage Hits", Bloomberg, October 20, 2023.

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