TAIWAN AND THE GLOBAL SEMICONDUCTOR SUPPLY CHAIN

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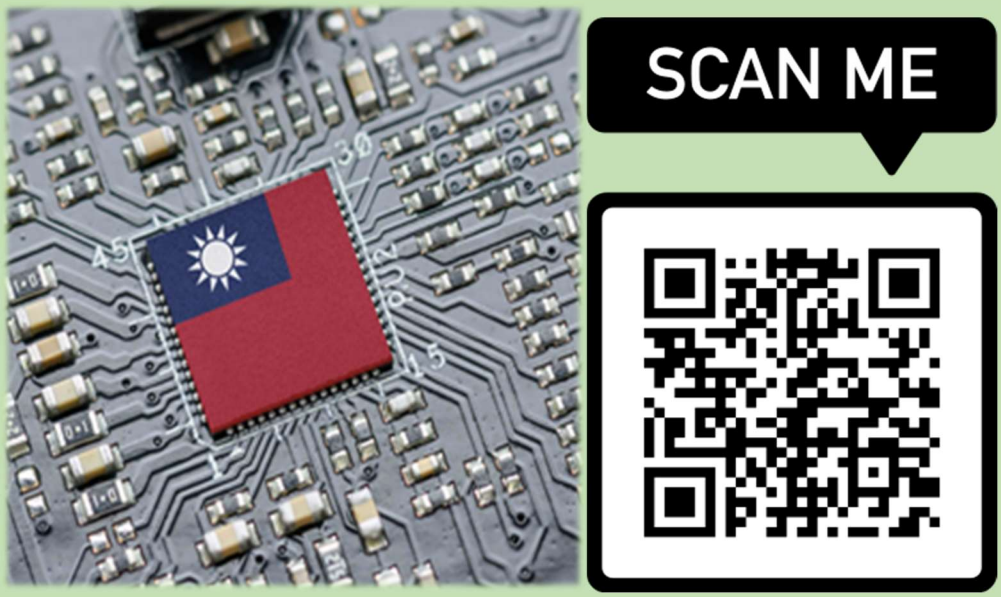
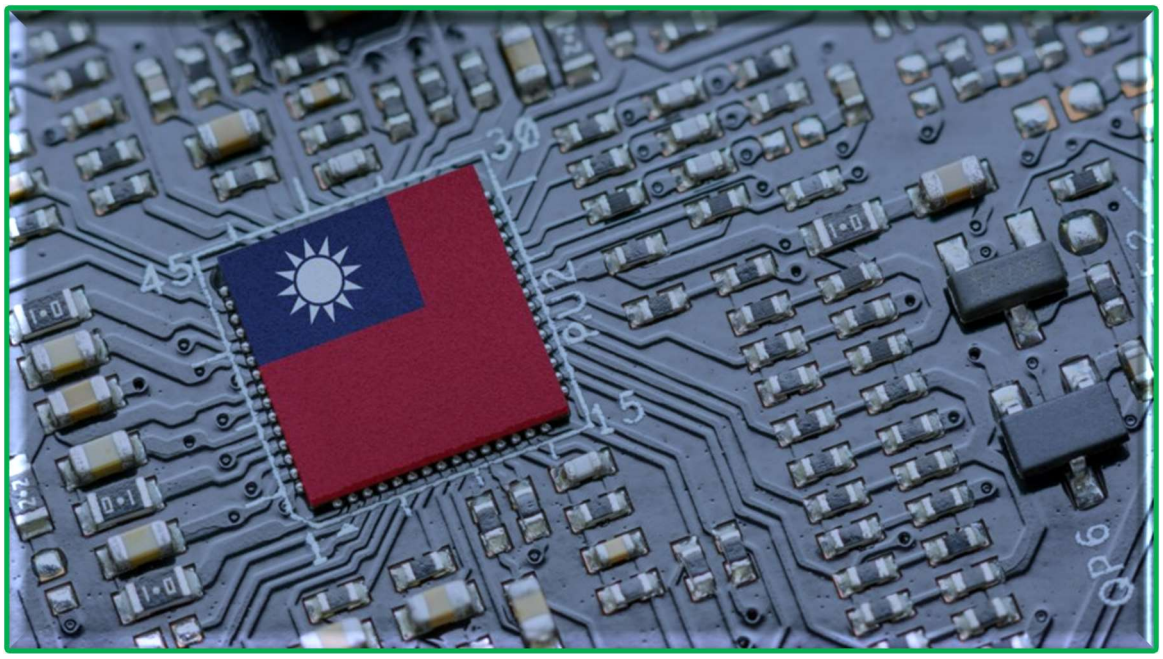


IN THE SPOTLIGHT

Article contributed by the Taiwan Stock Exchange Corporation:

TAIWAN'S SEMICONDUCTOR INDUSTRY

I. Role of Taiwan's Semiconductor Industry in the Global Semiconductor Market
II. Division of Labor and Integration of Taiwan's Semiconductor Industry Chains
III. Role of Taiwan's Capital Market in Advancing the Semiconductor Industry



Source: Shutterstock

I. Role of Taiwan's Semiconductor Industry in the Global Semiconductor Market

Semiconductors are the foundation of modern technology. As critical components of electronic products, semiconductors power the development of high-tech products and services, are a key force driving global economic development and technological innovation, and are integral to applications in our daily lives and various industries, including Artificial intelligence (AI), Internet of Things (IoT), 5G communications, cloud computing, electric vehicles (EV), autonomous vehicles, healthcare, military systems, transportation, and clean energy.

In 2022, Taiwan manufactured 63.8% of the world's semiconductors, and its production of sub-7 nanometer (nm) high-end ICs garnered a global market share of more than 70%. Taiwan's 2 nm process technology is the most advanced in the world, and it remains the global leader in terms of both technology and productivity. Taiwan's IC packaging and testing output value is also ranked first in the global semiconductor market with a market share of 58.6%. Moreover, Taiwan's IC design output value accounted for 20.1% of the global market with a market share second only to that of the United States. Without a doubt, Taiwan plays a critical role for global economic growth and technological innovation.

Table 1: Output Value of Taiwan's IC Industry as a Percentage of the Global Industry Output Value in 2022

Unit: US$ billion

2022	Taiwan Output Value	Global Output Value	Taiwan Percentage	Taiwan's Rank	Major Taiwanese Firms	Major Foreign Firms
IC Industry Total	162.4	707.6	22.0%	2	TSMC, MediaTek (MTK)	Intel (US), Samsung (Korea)
IC Design	40.6	201.6	20.1%	2	MediaTek (MTK), Novatek	Qualcomm (US), NVIDIA (US)
Foundry	90.47	142.1	63.8%	1	TSMC, UMC	Global Foundries (US), SMIC (China)
IDM (including Memory)	7.6	323.8	2.3%	5	Nanya (NTC), Winbond	Samsung (Korea), Micron (US)
IC Packaging and Testing	23.5	40.1	58.6%	1	ASE (ASEH), Powertech (PTI)	Amkor (US), JCET (China)

Source: Industrial Development Administration of the Ministry of Economic Affairs, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

- Taiwan's total IC output value ranks second in the world and trails only the United States.
- Taiwan's IC design output value ranks second in the world and trails only the United States.

- Taiwan's foundry output value ranks first in the world. Taiwan accounts for 70% of the global advanced manufacturing capacity and is a leader in developing the 2nm and below process technologies.
- Taiwan's IDM output value ranks fifth in the world, trailing only the United States, South Korea, Europe, and Japan (its memory output value ranks fourth in the world, trailing only South Korea, the United States, and Japan).
- Taiwan's IC packaging and testing output value ranks first in the world.

The onset of the trade war and technology war between the United States and China in 2018 and the outbreak of the COVID-19 pandemic in 2020 have exposed the vulnerabilities of a highly geographically concentrated global semiconductor supply chain. This has prompted the governments of major economies to make plans to relocate their semiconductor supply chains outside of China or in their home countries in order to mitigate the geopolitical risks and improve their supply chain resiliency and security. The resulting shift in the global semiconductor landscape, from one that is highly interconnected and interdependent towards one that is more regionally integrated, has accentuated Taiwan's importance to the global semiconductor industry.

Taiwan's industrial development policies implemented since the 1970s have played a crucial role in positioning Taiwan as an important player in the global semiconductor supply chain. Its policy of establishing science and technology parks has fostered the growth of comprehensive and mature semiconductor industry clusters encompassing all key stages of the value chain – from IC design to manufacturing, packaging, and testing – and offers the advantage of one-day supply cycle time. This rapid cycle time provides an efficient and seamless support system for the semiconductor industry, from research and development to production and manufacturing. Additionally, Taiwan's high-end talent pool, advanced technology, low cost, high production capacity, flexibility in customization, and the support by the science and research capabilities of the United States, Europe, Japan as well as its own research and development, have worked together to create a robust and resilient semiconductor ecosystem that can effectively and efficiently manage issues from semiconductor development to trial production and mass production, thereby accelerating the development of semiconductor process technologies.

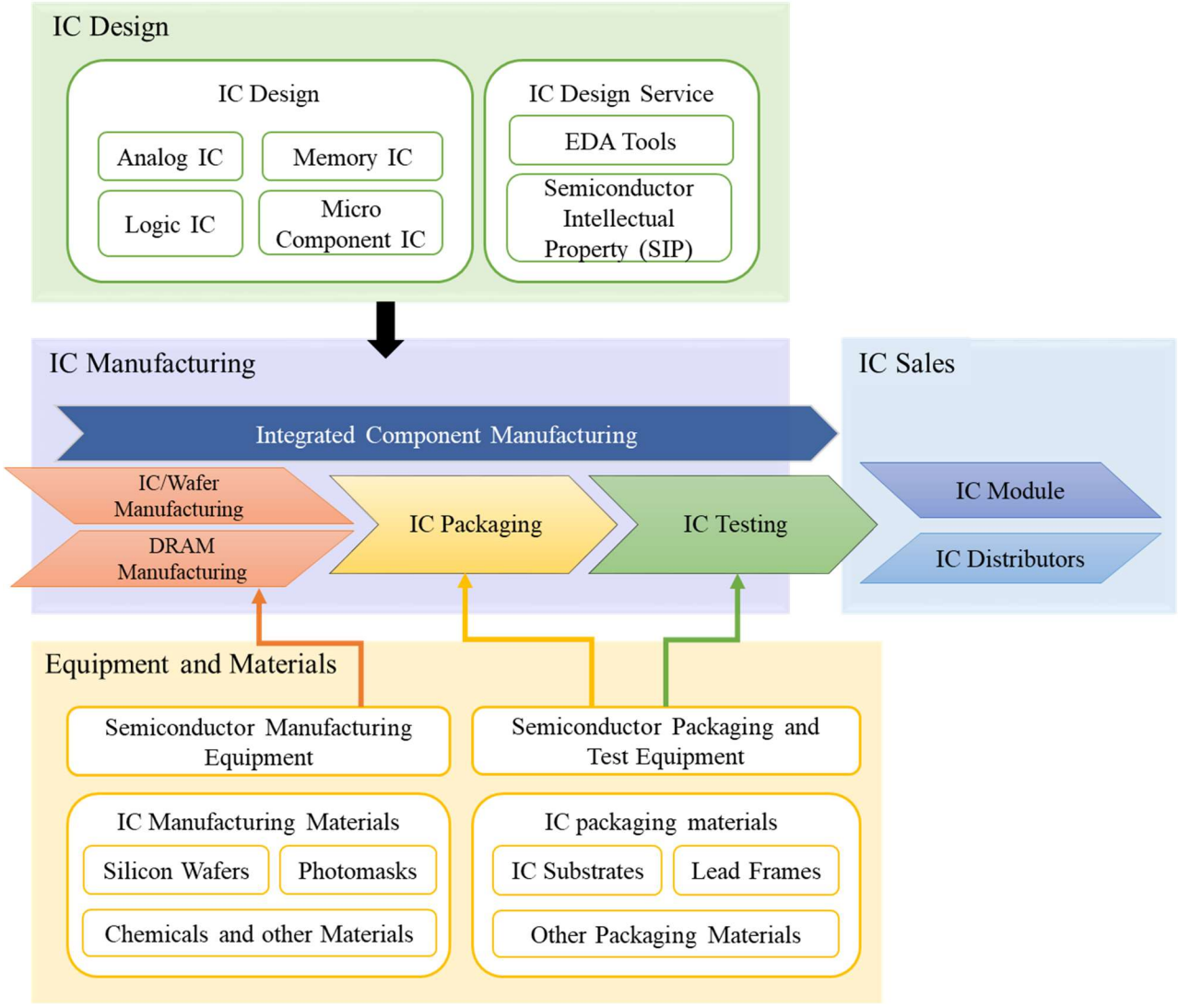
Currently, Taiwan's semiconductor manufacturing companies mainly manufacture products in Taiwan and sell them across the globe. More than 90% of the main production sites as well as high-end technologies, advanced processes, and forward-looking research and development remain in Taiwan. In addition, major international companies such as ASML, Lam Research, and Entegris continue to expand their investments in Taiwan, including by establishing production sites or investing directly in semiconductor companies in Taiwan. Applied Materials and Tokyo Electron have also set up training centers for advanced process equipment in Taiwan. Leading international information and communication technology (ICT) and integrated circuit (IC) companies such as Apple, Broadcom, and Qualcomm have selected Taiwanese companies to provide contract wafer manufacturing and IC packaging and testing services. Taiwan's collaboration with many international partners is testament to its role as a reliable and secure partner in the semiconductor supply chain.

Although the United States, Japan, and Europe have invited Taiwan Semiconductor Manufacturing Company Limited (TSMC), the top Taiwanese semiconductor company, to set up operations in their countries, the new plants in these countries will not change Taiwan's position in the global semiconductor industry. It is also difficult for other countries to take over Taiwan's production capacity or its pivotal role in the global semiconductor industry in the near and foreseeable future.

II. Division of Labor and Integration of Taiwan's Semiconductor Industry Chains

The semiconductor industry chain can be divided into three major sectors, namely, (1) upstream: integrated circuit (IC) or chip design and intellectual property (IP) design, (2) midstream: IC manufacturing, wafer fabrication, related production process testing equipment, masks, and chemicals, and (3) downstream: IC packaging and testing, related production process testing equipment, components (e.g., substrates and lead frames), IC modules, and IC channels (see Figure 1).

Figure 1: Upstream, Midstream, and Downstream Industry Chains in Taiwan's Semiconductor Industry



Source: Industry Value Chain Information Platform, compiled by Taiwan Stock Exchange Corporation, December 2023

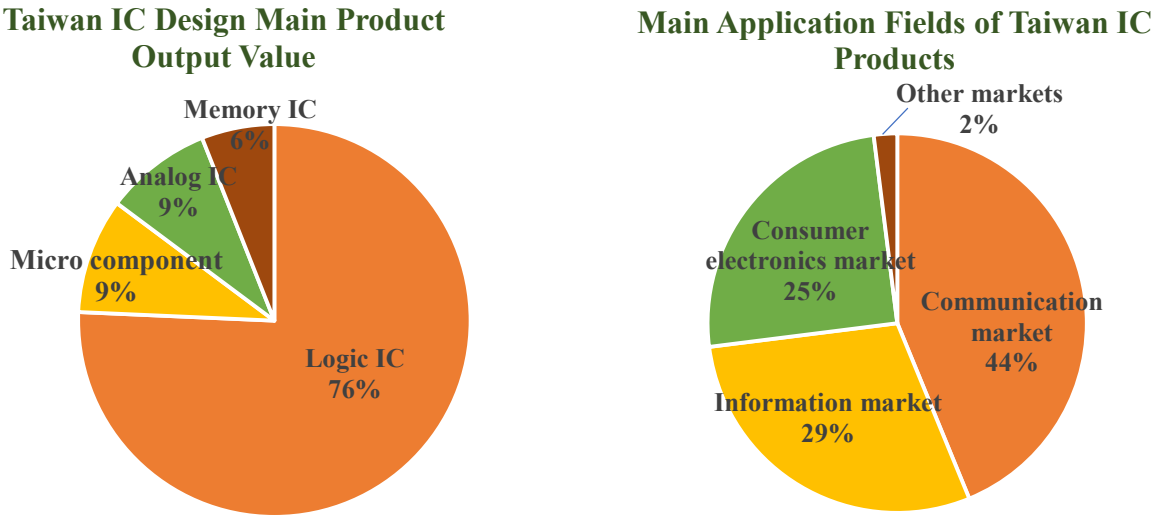
After IC design companies complete the product design, they appoint a foundry or IDM (an integrated device manufacturer that provides all services from IC design to manufacturing, packaging, testing, and sales) to produce semi-finished wafer products. Following preliminary tests, the products are sent to a packaging manufacturer for cutting and packaging. The IC testing manufacturer then conducts final tests, and the finished products that pass the tests are sold to system manufacturers through sales channels for assembly and production of system products. The communication market, with a 44% share, is the largest market for system products, followed by the information market at 29% and then the consumer electronics market at 25% share (see Figure 2).

Taiwan's semiconductor industry leverages the professional division of labor between upstream, midstream, and downstream suppliers in the supply chain to mitigate competition and create partnerships with other businesses. Moreover, its complete semiconductor industrial chain has created a robust and efficient system that continues to grow, work closely with the global supply chain, and deepen collaborations with its partners. This resilience and adaptability allow Taiwan's semiconductor industry to provide swift and close support to the global industry and have made Taiwan a significant player in the global market.

I. Upstream: IC design:

It includes IC design, IC design services (IP supply, electronic design automation or EDA, and design services), and other sub-industries. IC design serves as the foundation for all IC products. IC design companies use computer-aided design (CAD) and other IC design assistance tools developed by EDA companies to design the layout of transistors on the chip and the circuits that connect the transistors to create certain specifications and functions for chips. IC designs are broadly categorized into memory IC, micro component IC, analog IC, and logic IC based on chip function and signal transmission methods. Logic ICs account for 76% of the market, followed by micro component ICs and analog ICs, both accounting for 9% of the market, and lastly memory ICs which accounts for 6% of the IC design market (see Figures 1 and 2).

Figure 2: Output Value of Taiwan's IC Design Main Products and the Main Fields of Application of Taiwan's IC Products



Source: Taiwan Industry Economics (TIE) Database, Taiwan Institute of Economic Research

Silicon Intellectual Property (SIP) is the intellectual property of the IC design, and its development process includes IP design and IP verification. As reusing the IP core can effectively shorten the product development cycle and reduce costs, especially in contemporary IC design for increasing the functionality of the chip, chip design has become increasingly complex. In addition, existing IP components that have been verified are used to satisfy the need for shortening the time-to-market of ICs. Due to the differences in customer requirements for IC product functionality and production processes, IC design companies must develop a wide range of IPs in order to achieve economies of scale. IC design service companies specializing in IP design have emerged as a result.

In 2022, Taiwan's IC design industry was the second largest in the world in terms of output value, trailing only the United States. Three of the top ten global IC design companies in 2022 were Taiwanese companies. In descending order in terms of their ranking and annual revenue, they included MediaTek in fifth place with US$ 18.2 billion, Realtek in seventh place with US$ 3.8 billion, and Novatek in eighth place with US$ 3.5 billion (see Table 2).

Table 2: 2022 Ranking of Main Global IC Design Companies by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Country/Market	2022 Revenue	2022 Market Share
1	Qualcomm	US	36.8	17%
2	Broadcom	US	26.9	13%
3	Nvidia	US	26.5	12%
4	AMD	US	23.5	11%
5	**MediaTek (MTK)**	**TW**	**18.2**	**8%**
6	Marvell	US	5.9	3%
7	**Realtek (RT)**	**TW**	**3.8**	**2%**
8	**Novatek**	**TW**	**3.5**	**2%**
9	Willsemi	CN	2.6	1%
10	CirrusLogic	US	2.0	1%
Market share of the world's top ten companies				69%
Total market share of Taiwanese companies				**12%**

Source: Companies, TechInsights, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

IC design service companies that work closely with foundries tend to generate higher revenue. Taiwan's two largest foundries, Taiwan Semiconductor Manufacturing Corporation (TSMC) and United Microelectronics Corporation (UMC), have established their own design service alliances. The main IC design service companies in Taiwan today are Global Unichip Corporation (GUC) and Alchip Technologies, which are part of the TSMC alliance, and Faraday Technology Corporation, which is part of the UMC alliance. These companies allied with TSMC and UMC occupy a larger share of the IC design service market in Taiwan.

Table 3 shows the ranking of the main listed Taiwanese IC design companies in 2022 in terms of revenue. Benefiting from an increase in 5G penetration, MediaTek, a leading company focusing on mobile phone System-on-Chip (SoC), topped the ranking with a revenue of US$ 18.2 billion. Realtek, which saw strong demand for its communications network ICs, computer peripheral ICs and connected media ICs, came in second with a revenue of US$ 3.8 billion. This was followed closely by Novatek, whose two major

product lines of SoC and display driver IC had grown significantly, with a revenue of US$ 3.5 billion. Other chip design companies specializing in display driver ICs including Himax Technologies Inc., Raydium Semiconductor Corporation, Fitipower Integrated Technology Inc. and Sitronix Technology Corp. were ranked fifth, seventh, eighth and ninth, respectively. Sixth-ranked Phison Electronics Corporation and seventh-ranked Silicon Motion Technology Corporation, both specializing in memory card control ICs had a revenue of US$ 2.0 billion and US$ 0.9 billion, respectively. Meanwhile, Elite Semiconductor Microelectronics Technology Inc. (ESMT), which specializes in memory ICs and analog ICs, ranked tenth with a revenue of US$0.5 billion.

Table 3: 2022 Ranking of Main Taiwanese IC Design Companies

Unit: US$ billion

2022 Ranking	Company Name	Securities Market	2022 Revenue	Main Products
1	MediaTek (MTK)	TWSE	18.2	Mobile phones, digital TV IC, IoT IC
2	Realtek (RT)	TWSE	3.8	Communication IC, audio processor IC, monitor controller IC
3	Novatek	TWSE	3.5	Display driver IC
4	Phison	TPEx	2.0	Memory card control IC
5	Himax	NASDAQ	1.2	Display driver IC
6	SiliconMotion	NASDAQ	0.9	Memory card control IC
7	Raydium	TWSE	0.8	Display driver IC
8	FITIPOWER	TWSE	0.7	Display driver IC
9	Sitronix	TWSE	0.6	Display driver IC
10	ESMT	TWSE	0.5	Memory, analog IC

Source: Companies, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

II. Midstream: IC manufacturing:

After the IC design company designs the IC circuit layout, it is transferred to the foundry for IC manufacturing. The manufacturing process requires the transfer of the circuit and circuit components onto the wafer with a photomask, and the wafer is manufactured through oxidization, diffusion, chemical vapor deposition (CVD), etching, and ion implantation. As the IC circuit design has several layers, the process requires complex procedures,

including the use of several photomasks and pattern creations to form circuits and components before a complete integrated circuit is produced. Consequently, both the technical and capital requirements of IC manufacturing are high.

IC manufacturing can be divided into two broad categories, namely foundries that specialize in producing data processing and computing IC, and memory manufacturers that produce memory IC (see Figure 1). Taiwan's IC manufacturing industry focuses mainly on semiconductor foundries, which account for more than 90% of the output value of Taiwan's IC manufacturing industry.

Taiwan adopted a business model of specialized division of labor in both the upstream and downstream sections of the industry chain, and has developed a unique foundry contract manufacturing business. By focusing on specific areas of the semiconductor manufacturing process, Taiwanese semiconductor companies can achieve a high level of expertise and efficiency. In addition to mitigating the competition with other businesses, these companies have achieved both superior yield performance with mature manufacturing processes due to their technological lead and cost savings in production processes. They also offer diverse manufacturing processes and capacity options to satisfy market demand. Being at the forefront of technology and having built a reputation for reliability and quality, most of the semiconductor companies in Taiwan have formed strategic partnerships with major tech companies, allowing them to sign long-term contracts with customers in order to generate stable profits.

Taiwan's foundries also focus on the development of advanced processes. Companies such as TSMC have contributed to the technological innovation and capital investment in Taiwan's overall IC manufacturing industry, and in the process, extended Taiwan's lead in advanced processes. In 2023, Taiwan maintained its lead across the board from 0.18 micrometers (μm) to 20 nm and sub-10 nm processes in the global IC manufacturing industry (see Table 4). TSMC announced in 2023 that mass production will begin for the 2 nm process by 2025 (see Table 5). The market expects that tech giants, such as Advanced Micro Devices (AMD), NVIDIA, Qualcomm, MediaTek, Broadcom,

and Intel, will begin using TSMC's 3 nm processes in the second half of 2023 to 2024.

Table 4: Overview of Global Capacity of Process Technologies in 2023

	Over 0.18µm	0.18µm to 40nm	40nm to 20nm	20nm to 10nm	Under 10nm	Total
Taiwan	16.8%	29.4%	29.5%	9.9%	62.6%	21.4%
South Korea	6.8%	9.6%	27.3%	29.3%	36.7%	20.4%
Japan	17.1%	13.5%	-	23.6%	-	15.8%
China	20.5%	15.6%	15.4%	14.8%	-	15.3%
North America	16.0%	12.5%	17.0%	11.6%	0.7%	12.6%
Europe	12.1%	7.2%	6.8%	1.7%	-	5.7%

Source: Taiwan Industry Economics (TIE) Database, Taiwan Institute of Economic Research, June 2023

Table 5: Global Foundry Advanced Process Mass Production Timeline

	2021	2022	2023	2024 (F)	2025 (F)
2nm					TSMC, Samsung
3nm+			TSMC		
3nm, 3nmGAA		TSMC, Samsung			
4nm	TSMC, Samsung				
5nm+, Intel 18A				Intel	
5nm, Intel 20A				Intel	
7nm+, Intel3			Intel		
7nm, Intel4			Intel		
10nm, Intel7		Intel			

Source: Taiwan Industry Economics (TIE) Database, Taiwan Institute of Economic Research, October 2023

According to estimates, Taiwan's mature process capacity will account for 43% of the global capacity by 2025, and advanced process capacity will account for 69% of the global capacity. Through its continuous innovation, investment and strategic planning, Taiwan's foundry industry is expected to maintain its lead in the medium to long-term development.

Table 6 shows the ranking of the top ten foundries in the world in 2022 in terms of revenue. Of the top ten foundries, TSMC garnered a market share of 55% with a revenue of US$ 75.9 billion. United Microelectronics Corporation (UMC), Taiwan's other semiconductor giant, accounted for 7% of the top ten

foundries' global market share with a revenue of US$ 9.2 billion. Two other Taiwanese foundries, Powerchip Semiconductor Manufacturing Corporation (PSMC) and Vanguard International Semiconductor Corporation (VIS) with revenues of US$ 2.6 billion and US$1.7 billion respectively, are the seventh and eighth top foundries in the world by revenue. In total, of the top ten foundries in the ranking, Taiwanese companies garnered a market share of 97% in 2022.

Table 6: 2022 Ranking of Main Global Foundry by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Country/ Market	2022 Revenue	2022 Market Share
1	**TSMC**	**TW**	**75.9**	**55%**
2	Samsung Electronics	KR	22.1	16%
3	**UMC**	**TW**	**9.2**	**7%**
4	Global Foundries	US	8.1	6%
5	SMIC	CN	7.3	5%
6	Hua Hong	CN	3.7	3%
7	**PSMC**	**TW**	**2.6**	**2%**
8	**VIS**	**TW**	**1.7**	**1%**
9	Tower Semiconductor	IL	1.7	1%
10	DB HiTek	KR	1.3	1%
Market share of the world's top ten companies				97%
Total market share of Taiwanese companies				**65%**

Note: Only revenue from the foundry business is included for Samsung Electronics.
Source: Companies, TechInsights, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

Table 7: 2002 Ranking of Main Global Memory Product Manufacturers by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Country/Market	2022 Revenue
1	Samsung Electronics	KR	53.5
2	SK Hynix	KR	33.3
3	Micron Technology	US	25.2
4	Kioxia	JP	10.6
5	Western Digital	US	6.8
6	**Nanya (NTC)**	**TW**	**1.9**
7	**Winbond (WEC)**	**TW**	**1.8**
8	**Macronix**	**TW**	**1.5**
9	YMTC	CN	0.8
10	CXMT	CN	0.7

Note: Only revenue from the memory business is included for Winbond; the revenue of CXMT is an estimate.
Source: Companies, TechInsights, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

Taiwan is home to a number of leading manufacturers that specialize in memory products. Table 7 shows the ranking of the top ten memory product manufactures in the world in 2022 by revenue. Nanya Technology Corporation (NTC), Winbond Electronics Corporation and Macronix International are three memory chip makers in Taiwan that are among the top ten in the world, with revenues of US$ 1.9 billion (sixth place), US$ 1.8 billion (seventh place) and US$ 1.5 billion (eighth place) respectively in 2022.

Table 8: 2022 Ranking of Main Taiwanese Foundry by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Securities Market	2022 Revenue	Main Products
1	TSMC	TWSE	75.9	Foundry
2	UMC	TWSE	9.2	Foundry
3	PSMC	TWSE	2.6	Foundry, DRAM
4	Nanya (NTC)	TWSE	1.9	DRAM
5	Winbond (WEC)	TWSE	1.8	DRAM, FLASH
6	VIS	TPEx	1.7	Foundry
7	Macronix	TWSE	1.5	Flash, ROM, Foundry
8	Nuvoton (NTC)	TWSE	1.4	IDM, Foundry
9	WIN	TPEx	0.6	Foundry
10	EPISIL	TPEx	0.1	Foundry

Note: Only revenue from the memory business is included for Winbond; only revenue from foundry is included for EPISIL.

Source: Companies, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

Table 8 shows the ranking of listed Taiwanese foundries by revenue in 2022. Topping the list are the three largest and most prominent contract chipmakers in Taiwan – TSMC, UMC and PSMC. TSMC's revenue totaled US$ 75.9 billion, second-ranked UMC's revenue totaled US$ 9.2 billion, while third-ranked PSMC's revenue amounted to US$ 2.6 billion. Nanya, Winbond, VIS, Macronix and Nuvoton, which were ranked from fourth to eighth place, respectively, crossed the US$ 1 billion mark for revenue in 2022. Ninth-ranked WIN Semiconductors Corporation and tenth-ranked EPISIL Technologies Inc. had a revenue of US$ 600 million and US$ 100 million, respectively.

III. Downstream: IC packaging and testing:

IC packaging refers to the covering of a processed wafer with plastic, ceramic, or metal coating after the die is cut in order to protect the die from contamination, increase the ease of assembly, enhance the electrical connection between the chip and the electronic system and to allow for heat dissipation. IC testing can be divided into two stages. The first is the wafer test before packaging to test the chip's electrical properties. The second is the IC finished product test, which is mainly implemented to test whether the IC

functions as intended, including its testing of its electrical properties and heat dissipation capacity so as to ensure quality.

Taiwan's IC packaging and testing industry ranks first in the world. With the rise of Internet of Things (IoT applications), Taiwan's IC packaging and testing companies have continued to develop high-end packaging and heterogeneous integration technologies, significantly increasing their lead over their competitors.

In 2022, six Taiwanese companies were ranked among the top ten global IC packaging and testing companies, including the world's largest packaging and testing company, Advanced Semiconductor Engineering Technology Holdings (ASE or ASEH), which boasted a market share of nearly 30%. The top ten IC packaging and testing companies accounted for 85% of the global market share. Of the companies in the ranking, Taiwanese companies accounted for 45% of the market share (see Table 9).

Table 9: 2022 Ranking of Main Global IC Packaging and Testing Companies by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Country/Market	2022 Revenue	2022 Market Share
1	**ASE (ASEH)**	**TW**	**12.2**	**29%**
2	Amkor	US	7.0	17%
3	JCET	CN	5.0	12%
4	TFMC	CN	3.1	7%
5	**Powertech (PTI)**	**TW**	**3.0**	**7%**
6	HUATIAN	CN	1.8	4%
7	**KYEC**	**TW**	**1.2**	**3%**
9	**Chipmos**	**TW**	**1.0**	**2%**
8	**Chipbond**	**TW**	**0.9**	**2%**
10	**Sigurd**	**TW**	**0.6**	**2%**
Market share of the world's top ten companies				85%
Total market share of Taiwanese companies				**45%**

Note: Only revenue from packaging and testing is included for ASE (ASEH).
Source: Companies, TechInsights, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

Table 10: 2022 Ranking of Main Taiwanese IC Packaging and Testing Companies by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Securities Market	2022 Revenue	Main Products
1	ASE (ASEH)	TWSE	12.2	Logic IC packaging and testing, mixed-signal IC packaging and testing
2	Powertech (PTI)	TWSE	3.0	Memory packaging and testing, logic IC packaging and testing
3	KYEC	TWSE	1.2	Wafer probing, IC product testing
4	Chipmos	TWSE	1.0	Driver IC packaging and testing, memory packaging and testing
5	Chipbond	TPEx	0.9	Driver IC packaging and testing, gold bumping
6	Sigurd	TWSE	0.6	Mixed-signal IC, RF, power semiconductor packaging and testing
7	OSE	TWSE	0.5	Memory packaging and testing
8	Ardentec	TPEx	0.5	Memory wafer testing, digital and mixed-signal IC testing
9	FATC	TWSE	0.3	Memory packaging and testing
10	WALTON	TWSE	0.3	Memory packaging and testing

Note: Only revenue from packaging and testing is included for ASE (ASEH).
Source: Companies, Market Intelligence & Consulting Institute (MIC) of the Institute for Information Industry

Table 10 shows ranking of the top ten Taiwanese IC packaging and testing companies in 2022 by revenue. For the Taiwanese IC packaging and testing companies included in the ranking, the main products include computing IC and memory IC testing, demonstrating the diversity and comprehensiveness of Taiwan's IC packaging and testing industry (see Table 10).

IV. IC equipment and other supply chains

According to the SEMI's report, Taiwan will continue to maintain its lead in expenditures on global foundry equipment in 2024, with a total of US$ 24.9 billion. However, nearly 80% of the expenditures consist of purchases of foreign equipment, which shows that there is significant room for growth for domestic equipment manufacturers.

Taiwan's government has actively implemented a policy for domestic production of semiconductor equipment in recent years. It integrated national and industry resources, and encouraged companies to invest in semiconductor equipment development with the aim of attaining "local production of foreign company equipment, and domestic production of advanced packaging and testing equipment" to increase the use of domestic equipment by Taiwan's semiconductor companies. The government also seeks to connect the entire industry to jointly support the upgrade of Taiwan's semiconductor equipment industry and enhance the international competitiveness of Taiwan's semiconductor equipment industry. Its goal is to make Taiwan a "high-end manufacturing center in Asia" and "center of advanced semiconductor processes."

Table 11 shows the main listed companies in Taiwan's IC manufacturing, packaging and testing supply chains. Some of the supply chain companies in the midstream of the semiconductor supply chain include United Integrated Services (UIS), which helps clients build manufacturing facilities and install clean rooms; Marketech International Corporation, which produces wafer manufacturing equipment; Taiwan Mask Shop (TMC) which produces photomasks; and companies such as Eternal, Topco and Wahlee that produce chemicals and photoresist.

Downstream in the semiconductor supply chain, companies such as Chroma and Scientech produce packaging and testing equipment while Chang Wah Technology Co., Ltd., SDI Corporation, and Jih Lin Technology Co., Ltd. produce lead frames among other products for the semiconductor industry. Additionally, Unimicron, Nan Ya PCB (N.P.C), and Kinsus are all involved in the production of substrates for the semiconductor industry.

Both the companies in the upstream and downstream of the semiconductor supply chain play a crucial role in the semiconductor industry by providing the necessary components for various electronic devices and to meet the evolving needs of the industry.

Table 11: Main Listed Companies in Taiwan's IC Manufacturing, Packaging, and Testing Supply Chains

Supply Chain		Supply Chain Companies
Midstream	Wafer plant construction and system integration	UIS, L&K
	Wafer manufacturing equipment	MIC, Fiti
	Silicon wafer manufacturing	FST
	Photomasks	TMC
	Chemicals, photoresist	Eternal, Topco, Wahlee
Downstream	Packaging and testing equipment	Chroma, Scientech
	Substrates	Unimicron, NanYaPCB (N.P.C), Kinsus
	Lead frames	ChangWah, SDI, JihLin

Source: Compiled by the Taiwan Stock Exchange Corporation

V. IC distributors

IC distributors are only responsible for IC trading and sales, and are not involved in the production. Their business model mainly consists of procurement from upstream semiconductor design companies or manufacturers, and the supply of key components or materials to downstream electronics industry manufacturers. They play the role of an intermediary in the entire semiconductor industry.

Distributors are indispensable for the success of Taiwan's semiconductor industry as they provide marketing channels and networks for upstream component suppliers. Due to the reach of distributors and high market sensitivity, they can quickly obtain market information and recommend new technologies to downstream manufacturers. They also leverage their integration and price negotiation capability for procurement from upstream suppliers to provide favorable prices for manufacturers. The most significant difference between semiconductor distributors and other distributors is that the former help original manufacturers with sales, technology, and

warehousing management, resolve customer issues in design and mass production, and help customers shorten the time-to-market for new products.

In 2022, four Taiwanese companies, namely, WPG Holdings (WPG), WT Microelectronics (WT), Supreme Electronics and Edom Technology, were ranked among the top ten global IC distributors (see Table 12). The IC distributor industry favors large companies, which tend to retain their lead. As 30% to 40% of IC industry products are sold through distributors, there is limited room for market growth and the intermediary service providers have margins of only 3% to 5%. Moreover, distributors generally rely on economies of scale, so mergers and acquisitions become an important means for distributors to expand their range of suppliers and customers.

Table 12: 2022 Ranking of Main Global IC Distributors by Revenue

Unit: US$ billion

2022 Ranking	Company Name	Country/Market	2022 Revenue	2022 Market Share
1	Arrow	US	24.6	11%
2	**WPG**	**TW**	**24.5**	**11%**
3	Avnet	US	20.6	9%
4	**WT**	**TW**	**19.0**	**9%**
5	Macnica	JP	6.7	3%
6	Toyota Tsusho	JP	5.5	3%
7	Future Electronics	CA	5.5	3%
9	**Supreme**	**TW**	**5.5**	**3%**
8	CECport	CN	5.4	3%
10	**Edom**	**TW**	**4.0**	**2%**
Market share of the world's top ten companies				57%
Total market share of Taiwanese companies				**25%**

Source: Gartner

In recent years, Taiwanese IC distributors such as WPG and WT have continuously expanded their businesses through mergers and acquisitions. They have also used horizontal partnerships to increase synergy in operations. WT announced in 2023 the US$ 3.8 billion acquisition of 100% of the shares Future Electronics, a Canadian IC distributor ranked seventh in the world. The settlement and consolidation will be completed in 2024, and the acquisition is expected to make WT one of the top three IC distributors in the world and

increase its competitiveness in future development. Among the four Taiwanese IC distributors, WPG ranked first in terms of revenue, followed by WT, Supreme and Edom (see Table 13).

Table 13: 2022 Ranking of Main Taiwanese IC Distributors by Revenue and Products Distributed

Unit: US$ billion

2022 Ranking	Company Name	Securities Market	2022 Revenue	Main Products
1	WPG	TWSE	24.5	Core components, memory components, discrete and logic components, analog and mixed-signal components, optical and sensor components; brands distributed include: AMD, Broadcom, Infineon, Intel, Kioxia, MediaTek, Micron, Nanya, Novatek, Nuvoton, NXP, Phison, Qualcomm, Realtek, Samsung, ST Micro, Willsemi, and Winbond
2	WT	TWSE	19.0	Analog IC, microcontrollers, memory IC, microprocessors, application specific IC; brands distributed include: Broadcom, ESMT, Intel, Marvell, MediaTek, Micron, Nanya, NXP, Nuvoton, Qualcomm, Realtek, and ST Micro
3	Supreme	TWSE	5.5	Memory components; brands distributed include: Samsung, MediaTek, Novatek, and CIRRUS LOGIC
4	Edom	TWSE	4.0	Integrated circuits, electronic components, memory

Source: Companies' annual reports for 2023 shareholders' meetings

III. Significant Role of Taiwan's Capital Market in Advancing the Semiconductor Industry

The Semiconductor Industry Association (SIA) of the United States stated in 2021 that if Taiwan was unable to produce chips for an entire year, the revenue of the global electronics industry would fall by nearly US$ 500 billion. Besides its pivotal role in the global semiconductor industry, the robust international competitiveness of Taiwan's semiconductor companies is also an important engine of growth for Taiwan's capital market.

As of December 2023, the total market value of semiconductor companies listed on the Taiwan Stock Exchange Corporation (TWSE) accounted for approximately 40% of the market value of all listed companies in Taiwan. The semiconductor industry plus other ICT-related industry accounted for 60% of the total market value. Their operations include IC design, foundry, and packaging and testing. The upstream, midstream, and downstream sections of the industry form comprehensive semiconductor industry clusters which play a crucial role in Taiwan's economic growth and technological advancement.

Taiwan's stock market offers advantages in terms of low price-earnings ratio and high yields. Its transaction value and turnover rate are some of the highest among Asian markets, which demonstrate that Taiwanese stock prices are relatively reasonable and highly liquid, and that investors can obtain stable cash dividends. In addition, more than 50% of foreign capital investments in Taiwan's capital market are invested in semiconductor stocks, which demonstrates the indispensable role of Taiwan's semiconductor industry in the global capital market (see Appendix).

Going forward, the TWSE will continue to help Taiwan's semiconductor companies leverage the power of the capital market and national industry policies and resources to consolidate the key role of Taiwan's semiconductor industry in the global semiconductor industry chain while expanding its lead over its competitors.

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Appendix：Basic Information of Main Listed Companies of Taiwan's IC Industry

Unit: Capital, revenue, market value: US$ billion

Industry Chain	Stock Code	Short Name of the Company in English	Short Name of the Company in Chinese	Listing Date	Capital	2022 Revenue	Revenue in the First Three Quarters of 2023	Market Value	PB Ratio	PE Ratio	Dividend Yield	Company Website
IC design	2454	MTK	聯發科	2001/07/23	0.51	18.39	9.82	48.37	3.83	21.55	8.04%	www.mediatek.com
	2379	RT	瑞昱	1998/10/26	0.16	3.75	2.35	7.38	5.43	25.31	6.01%	www.realtek.com
	3034	NOVATEK	聯詠	2002/08/26	0.19	3.68	2.69	9.95	5.04	14.11	7.24%	www.novatek.com.tw
	3592	Raydium	瑞鼎	2022/01/07	0.02	0.76	0.43	0.98	2.83	21.43	10.19%	www.rad-ic.com
	4961	FITIPOWER	天鈺	2018/10/17	0.04	0.66	0.40	1.10	2.03	17.42	3.01%	www.fitipower.com
	8016	Sitronix	矽創	2003/12/25	0.04	0.60	0.39	1.11	3.33	19.23	7.61%	www.sitronix.com.tw
	3006	ESMT	晶豪科	2002/03/04	0.09	0.54	0.28	0.87	2.48	-	1.90%	www.esmt.com.tw
IC design service	3661	Alchip	世芯-KY	2014/10/28	0.02	0.46	0.69	7.39	13.14	84.72	0.42%	www.alchip.com
	3443	GUC	創意	2006/11/03	0.04	0.81	0.64	7.07	24.6	53.38	0.85%	www.guc-asic.com
	3035	Faraday	智原	2002/08/26	0.08	0.44	0.30	3.07	10.66	53.39	1.30%	www.faraday-tech.com
Foundry	2330	TSMC	台積電	1994/09/05	8.30	75.84	49.63	478.73	4.47	16.71	1.91%	www.tsmc.com
	2303	UMC	聯電	1985/07/16	4.00	9.34	5.41	19.56	1.75	9.14	7.36%	www.umc.com
	6770	PSMC	力積電	2021/12/06	1.30	2.55	1.06	3.92	1.28	51.02	3.42%	www.powerchip.com
	4919	NTC	新唐	2010/09/27	0.13	1.40	0.87	1.99	3.88	25.69	4.71%	www.nuvoton.com
Memory	2408	NTC	南亞科	2000/08/17	0.99	1.91	0.68	7.43	1.35	-	2.84%	www.nanya.com
	2344	WEC	華邦電	1995/10/18	1.34	3.17	1.80	3.79	1.3	-	3.53%	www.winbond.com
	2337	Macronix	旺宏	1995/03/15	0.59	1.46	0.70	1.71	1.09	-	6.25%	www.macronix.com
IC packaging and testing	3711	ASEH	日月光投控	2018/04/30	1.40	22.48	13.61	17.94	1.87	14.48	6.87%	www.aseglobal.com
	6239	PTI	力成	2004/11/08	0.24	2.81	1.66	2.72	1.64	15.51	6.25%	www.pti.com.tw
	2449	KYEC	京元電子	2001/05/09	0.39	1.23	0.79	3.24	2.72	17.54	4.23%	www.kyec.com.tw

Industry Chain	Stock Code	Short Name of the Company in English	Short Name of the Company in Chinese	Listing Date	Capital	2022 Revenue	Revenue in the First Three Quarters of 2023	Market Value	PB Ratio	PE Ratio	Dividend Yield	Company Website
	8150	ChipMOS	南茂	2014/04/11	0.23	0.79	0.50	0.95	1.21	18.98	5.64%	www.chipmos.com
	6257	SIGURD	矽格	2003/08/25	0.15	0.63	0.37	0.93	1.77	16.97	6.58%	www.sigurd.com.tw
	2329	OSE	華泰	1994/04/20	0.26	0.52	0.39	1.05	4.09	28.93	1.43%	www.ose.com.tw
	8131	FATC	福懋科	2007/11/29	0.14	0.35	0.18	0.55	1.48	21.99	8.43%	www.fatc.com.tw
	8110	WALTON	華東	2007/10/31	0.17	0.32	0.17	0.25	0.76	-	0.98%	www.walton.com.tw
Wafer plant construction and system integration	2404	UIS	漢唐	2000/03/14	0.06	1.61	1.64	1.49	4	9.81	6.13%	www.uisco.com.tw
	6139	L & K	亞翔	2003/08/25	0.07	1.20	1.06	1.05	3.33	15.82	2.40%	www.lkeng.com.tw
Wafer manufacturing equipment	6196	MIC	帆宣	2004/05/24	0.06	1.69	1.33	0.86	2.5	11.26	4.19%	www.micb2b.com
	3413	Fiti	京鼎	2015/07/28	0.03	0.50	0.31	0.61	1.73	10.09	6.98%	www.foxsemicon.com.tw
Wafers	3532	FST	台勝科	2007/12/10	0.12	0.55	0.36	2.04	2.56	16.67	4.45%	www.fstech.com.tw
Photomasks	2338	TMC	光罩	1995/04/17	0.08	0.26	0.17	0.63	3.38	18.14	3.25%	www.tmcnet.com.tw
Chemicals, photoresist	1717	ETERNAL	長興	1994/03/31	0.38	1.64	1.02	1.12	1.39	24.07	4.05%	www.eternal-group.com
	5434	TOPCO	崇越	2003/08/25	0.06	1.77	1.20	1.10	2.4	12.48	5.46%	www.topco-global.com
	3010	WAH LEE	華立	2002/07/22	0.08	2.46	1.60	0.76	1.31	11.78	6.07%	www.wahlee.com
Packaging and testing equipment	2360	CHROMA	致茂	1996/12/21	0.14	0.74	0.44	2.93	4.24	22.54	3.72%	www.chromaate.com
	3583	Scientech	辛耘	2013/03/12	0.03	0.19	0.16	0.57	4.61	29.04	1.63%	www.scientech.com.tw
Substrates	3037	UNIMICRON	欣興	2002/08/26	0.49	4.71	2.53	8.64	3.03	16.42	4.51%	www.unimicron.com
	8046	N.P.C	南電	2006/04/07	0.21	2.17	1.06	5.13	3.38	15.83	7.26%	www.nanyapcb.com.tw
	3189	KINSUS	景碩	2004/11/01	0.15	1.39	0.62	1.44	1.43	51.24	6.55%	www.kinsus.com.tw

Industry Chain	Stock Code	Short Name of the Company in English	Short Name of the Company in Chinese	Listing Date	Capital	2022 Revenue	Revenue in the First Three Quarters of 2023	Market Value	PB Ratio	PE Ratio	Dividend Yield	Company Website
Lead frames	8070	CHANGWAH	長華*	2007/12/31	0.02	0.73	0.40	0.76	1.64	14.5	7.33%	www.cwei.com.tw
	2351	SDI	順德	1996/04/25	0.06	0.39	0.27	0.69	3.2	27.38	2.71%	www.sdi.com.tw
	5285	JihLin	界霖	2014/02/25	0.03	0.21	0.12	0.25	2.67	42.23	4.63%	www.jihlin.com.tw
IC distributors	3702	WPG	大聯大	2005/11/09	0.60	25.97	15.79	4.17	1.72	24.25	4.96%	www.WPGholdings.com
	3036	WT	文曄	2002/08/26	0.33	19.14	13.08	3.88	1.98	29.4	3.63%	www.wtmec.com
	8112	Supreme	至上	2007/12/31	0.17	5.83	3.33	0.89	1.78	18.95	7.87%	www.supreme.com.tw
	3048	EDOM	益登	2002/10/01	0.09	3.98	2.43	0.21	1.26	174.64	8.18%	www.edomtech.com

Note 1: The market value, PB ratio, PE ratio, and dividend yield are based on the closing prices of the companies on November 30, 2023, and the financial reports for Q3 2023.

Note 2: TWD to US$ exchange rate: 2022 revenue: 29.849; revenue in the first three quarters of 2023: 30.955; capital, market value: 31.255

Source: Financial reports of companies on the Market Observation Post System(https://mops.twse.com.tw/mops/web/index) compiled by the Taiwan Stock Exchange Corporation, December 2023

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