The information and statistics set out in this section and other sections of this document were extracted from different official government publications, available sources from public market research and other sources from third parties, and from the independent industry report prepared by Frost & Sullivan. The Company engaged Frost & Sullivan to prepare the F&S Report, an independent industry report, in respect of the **[REDACTED]**. *The information from official government sources has not been independently verified by us, the* **[REDACTED]**, *the Sole Sponsor, the* **[REDACTED]**, *the* **[REDACTED]**, *the* **[REDACTED]**, *any of their respective directors or any other parties involved in the* **[REDACTED]**, *and no representation is given as to its accuracy.*

SOURCE OF INFORMATION

We have commissioned Frost & Sullivan, an independent market research and consulting company, to conduct an analysis of, and to prepare a report on the global back-end semiconductor transport media and MEMS and sensor packaging market. The report prepared by Frost & Sullivan for us is referred to in this document as Industry Report. We agreed to pay Frost & Sullivan a fee of HK$1,450,000 which we believe reflects market rates for reports of this type.

Founded in 1961, Frost & Sullivan has 40 offices with more than 2,000 industry consultants, market research analysts, technology analysts and economists globally. Frost & Sullivan's services include technology research, independent market research, economic research, corporate best practices advising, training, client research, competitive intelligence and corporate strategy.

We have included certain information from the Industry Report in this document because we believe this information facilitates an understanding of the global back-end semiconductor transport media and MEMS and sensor packaging market for the prospective investors. The Industry Report includes information of the global back-end semiconductor transport media and MEMS and sensor packaging market as well as other economic data, which have been quoted in this document. Frost & Sullivan's independent research consists of both primary and secondary research obtained from various sources in respect of the global back-end semiconductor transport media and MEMS and sensor packaging market. Primary research involved in-depth interviews with sizeable industry participants and industry experts. Secondary research involved reviewing company reports, independent research reports and data based on Frost & Sullivan's own research database. Projected data were obtained from historical data analysis plotted against macroeconomic data with reference to specific industry-related factors. Except as otherwise noted, all of the data and forecasts contained in this section are derived from the Industry Report, various official government publications and other publications.

The Frost & Sullivan Report was complied based primarily on the following assumptions: (i) the social, economic and political environment of the globe and China is likely to remain stable in the forecast period, and (ii) related industry key drivers are likely to drive the market in the forecast period.

GLOBAL SEMICONDUCTOR AND INTEGRATED CIRCUIT (IC) INDUSTRY OVERVIEW

Definition and Classification

- A **semiconductor** material has conductivity between conductors and insulators at room temperature. Semiconductor devices are used in integrated circuits, consumer electronics, network communication, automotive electronics and other fields.
- An **integrated circuit** is a set of electronic circuits on one small flat piece (or "**chip**") of semiconductor material, usually silicon.

Value Chain

The value chain of the semiconductor and integrated circuit industry is comprised of industry players in the upstream, midstream and downstream. Different levels of specialization and functional delineation in

the value chain have led to the emergence of two key operating models in the semiconductor industry, namely (i) fabless-foundry; and (ii) Integrated Device Manufacturer (IDM). In the fabless-foundry model, production is split by (i) design; (ii) IC/Wafer Manufacturing; and (iii) IC Assembly, Packaging & Testing. In the IDM model, one company carries out all or most of the stages of production including design, manufacturing, and assembly, testing, and packaging, while some production procedures of IDM may also be subcontracted to other contract manufacturers.

Upstream players are mainly comprised of:

- *Research and Development companies* focuses on draft, advance and streamline technology throughout the supply chain.
- *Design companies (Fabless)* solely focus on IP and IC design and contract out fabrication. Fabless companies can benefit from lower capital costs while concentrating their research and development resources on the end market.
- *IC/Wafer Manufacturing companies (Front-end/ Foundries)* focuses on front-end semiconductor manufacturing, which refers to the fabrication from a blank wafer to a completed wafer. These foundry companies concentrate on contract manufacturing, processing, testing, photo mask and chemical procedure.
- *IC Assembly, Packaging & Testing companies (Back-end)* are subcontractors performing assembly, testing, and packaging tasks, which then supply IC for the production of all sorts of semiconductor products, while raw material suppliers provide lead frames and packaging material to supplement this stage of production.
- *Transport media companies* are specialised manufacturer focuses on the production of carrier for containment of semiconductor components during all stages of the manufacturing process. The back-end semiconductor transport media companies provide back-end functions of the semiconductor and IC industry, (i.e. assembly, packaging and testing).
- *Semiconductor equipment manufacturers* provide semiconductor manufacturing equipment e.g. clean track, diffusion furnace and plasma etcher to IC/Wafer manufacturers, while raw materials suppliers provide raw wafer and chemicals to manufacturers.

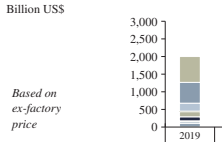
Midstream players distributors and sales channels and downstream players include various electronics production manufacturers in segments such as automotive, consumer electronics, industrial and construction, aerospace and defence and communication and networking.

Global Market Size of Electronics Industry

Semiconductor as an essential elements for various types of electronic products, shall grow along with the continuous development of electronic end-products. The depth of application of semiconductor has been growing, for instance, sensors and actuators are increasingly applied across all segments, the demand for Artificial Intelligence enabled, 5G and IoT related equipment are booming, which in turn further propelled the demand for semiconductor as an essential component.

The global electronics market size is growing continuously from US$1,999.7 billion to US$2,155.9 billion from 2019 to 2023, representing a CAGR of 1.9%. Particularly, the increase of automotive electronics industry with CAGR of 5.2% from 2024 to 2028 will be mainly contributed by increasing integration and implementation of advanced safety systems such as automatic emergency braking, lane departure warning and smart parking assistance systems to decrease road accidents in vehicles. Medical electronics is expected to grow rapidly with CAGR of 4.0% in the next 5 years as a result of factors such as aging population, advanced healthcare devices, and increase demand for customization and precision medical services.

Breakdown of Global Electronics Market Size by Applications, 2019–2028E



	2019	2020	2021	2022	2023	2024E	2025E	2026E	2027E	2028E	CAGR 2019–2023	CAGR 2024E–2028E
Consumer Electronics and Smart Modules/Devices	734.1	722.3	792.9	760	740.2	769.8	796.7	820.6	837.0	849.6	0.2%	2.5%
Telecommunications	592.6	565.9	608.3	631.6	650.5	673.3	695.5	717.1	738.6	760	2.4%	3.1%
Automotive Electronics	226.2	216.3	239.1	250.2	272.0	292.4	309.9	326.9	343.2	358.6	4.7%	5.2%
Marine Electronics	13.6	13.6	13.9	14.15	14.5	14.8	15.1	15.3	15.5	15.7	1.6%	1.5%
Industrial Electronics	148.2	140.7	151.0	155.8	160.2	165.5	170.0	173.7	177.2	180.4	2.0%	2.2%
Medical Electronics	114.5	110.6	119.6	125.2	130.7	136.6	142.5	148.2	154.0	159.5	3.4%	4.0%
Defense and Aerospace	29.7	27.3	29.4	31.3	32.9	34.1	35.1	36.0	36.9	37.7	2.6%	2.5%
PV Modules	37.5	35.6	38.8	42.8	46.7	50.0	52.5	54.5	56.2	57.9	5.6%	3.7%
Others	103.3	102.7	104.3	106.6	108.2	109.6	110.9	112.0	113.0	113.9	1.2%	1.0%

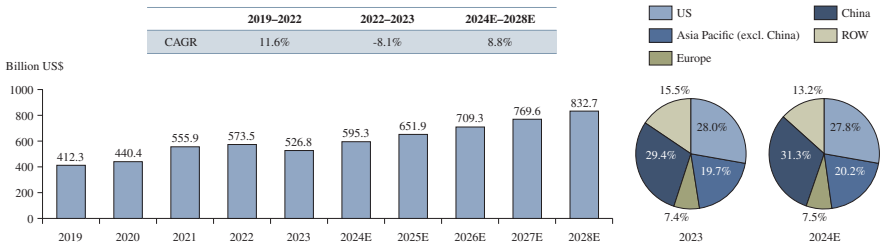
Source: Yearbook of World Electronics Data, Frost & Sullivan

Global Market Size of Semiconductor Industry

Semiconductor is the basis and driving force for the rapid development of information technology industry. It has been highly penetrated and integrated into all fields of economic and social development. Its technical level and development scale have become one of the important symbols to measure a country's industrial competitiveness and comprehensive national strength. The growth of regional economy and leading technological advance has boosted the market size of semiconductor industry from approximately US$412.3 billion in 2019 to approximately US$573.5 billion in 2022, representing a CAGR of 11.6% but showed a decrease of 8.1% in 2023 to US$526.8 million.

The short-term downturn of the global semiconductor market size is primarily the result of a confluence of factors, including but not limited to the industry cyclical nature, increasing inflation, geopolitical tension, lingering effects of COVID-19 and the downturn of the global macro-economy. However, promoted by the rapid technological development as well as recovering demand for semiconductor devices in various downstream sectors, including automotive and consumer electronics, the semiconductor industry is expected to rebound in 2024. The market size of semiconductor industry is forecasted to reach approximately US$832.7 billion by 2028, with a CAGR of 8.8% from 2024 to 2028. Given the potential growth rate, the slowdown of market demand in 2023 is expected to be a short-term adjustment of the semiconductor industry and is not expected to be long-term in nature. The global semiconductor industry is competitive and the industry standards are constantly changing. Among the major countries and regions, China is expected to occupy the largest market share of the global semiconductor industry (31.3%), followed by the United States (27.8%) and Asia Pacific (excluding China) (20.2%) in 2024.

Global Market Size of Semiconductor Industry by Sales Value by Major Countries, 2019–2028E



Source: Frost & Sullivan

The semiconductor industry operates within a complex and dynamic cyclical framework, which usually experiences fluctuations about every 1–2 years. The cycle is determined by changes in industrial supply and demand relations and is driven by transformative advancements in industry technologies and downstream applications. The cycle sets the stage for the industry's direction, relying on the continual upgrade of new terminal technologies and the emergence of new-generation applications.

The semiconductor industry has faced a challenging period characterized by a downward cycle, commencing since 2022, which was attributed to the factors such as global economic conditions, trade tensions, and geopolitical uncertainties, introduces a level of unpredictability that dampened investment and consumer spending. Given these circumstances, the semiconductor industry navigated through a period of contraction and decreased market activity. Companies within the sector experienced challenges such as reduced sales, profit margins, and capital expenditures. This downturn impacted various segments of the semiconductor supply chain, from manufacturers to suppliers, as the industry adjusts to the prevailing economic conditions. However, the outlook suggests a recovery in 2024. The industry could rebound as macroeconomic uncertainties subside, and end demand regains momentum.

Industry participants must strategically navigate the dynamic cycles to remain competitive and resilient, adapting to transformative innovations, managing production capacities effectively,

and responding agilely to the immediate demands of the market. The understanding of the cyclical patterns is fundamental for stakeholders in the semiconductor sector, enabling them to make informed decisions and position themselves strategically in a landscape characterized by constant change and technological evolution.

Key Development Trend and Outlook of IC Industry Globally and Asia

From the prospective of the global IC industry, the demand for differentiated products the development of a new path of IC industry. With the rapid development of 5G, Internet of things, artificial intelligence, etc., the demand of ICs has become more and more diverse. Different application scenarios have differentiated requirements for the elements of IC computing speed, power consumption and cost. Major research institutions and major manufacturers began to explore new technologies and products. In recent years, key markets of the world's integrated circuits have shifted from Europe and the United States to the Asia. After entering the 21st century, the economic level of the Asia has developed rapidly. The demand for integrated circuit products has increased. In Asia, the increasing focus toward IoT platforms is boosting the growth of the market size of IC industry in the world. Countries such as China, India, Japan and South Korea are actively trying to strengthen the IoT platforms. Governments of these countries and regions are focusing on entering various public and private collaborations, on leveraging IoT advancements for smart cities, automation, and other industrial applications, thus reinforcing the development of the IC industry. The IC industry in Southeast Asia has been growing rapidly after entering the 21st century. Singapore and Malaysia began to undertake part of the IC business from Japan and South Korea in the 1990s. After 30 years of development, integrated circuit industry has become one of the pillar industries of these two countries. The Philippines, Thailand, and Vietnam also see great prospects in the local IC industry, hoping to attract more international companies with low labor and land costs. Moreover, Asia has long held the largest market share of the IC industry globally owing to the presence of several established vendors of analog ICs and electronics products. The region has emerged as a major automotive hub, with a maximum market share in terms of vehicle production and sales, as China continues to account for a large and growing portion of vehicle shipments, which drives the analog IC market. Furthermore, the demand for ICs is expected to continue to increase, driven by the development of new technologies such as artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT).

As a result, the number of ICs being produced is likely to achieve accelerated growth. This growth will be supported by advancements in manufacturing technology, which will allow for the creation of smaller and more precise components such as chips. This will enable the creation of more powerful and complex computing devices, which are essential for meeting the demands of these new technologies.

GLOBAL BACK-END SEMICONDUCTOR TRANSPORT MEDIA INDUSTRY OVERVIEW

Definition and Classification

Back-end semiconductor transport media refers to the carrier for containment of semiconductor components during all stages of the manufacturing process, for example, during component-assembly operations, transport and storage from the manufacturing plant to the board-assembly site, and when feeding components to automatic-placement machines for surface mounting on board assemblies.

As semiconductor devices consist of delicate components and structures, the carriers for shipping, handling, or processing of semiconductors are carefully designed and follow specific industry standards. As well as protecting the leads of the components from damage during shipment, handling, and placement, the carriers are required to have a high degree of uniformity and consistency in order to feed parts at high speeds in an automated component placing and delivery system.

In general, the back-end transport media of semiconductor are classified by configurations, which mainly comprise tray and tray related products, and tape and reel.

Major Types of Back-end Semiconductor Transport Media

- *Tray and tray related products:* trays for transporting back-end semiconductors are conform to JEDEC standards. Trays are specified with stackable feature and fixed-size slots for placement of chips. As trays can be stacked and bound together to form standard packaging configurations, they are often used for transport and storage of the semiconductor components. Trays are also commonly used in automated testing, inspection, and assembly processes. Tray related products may include end-caps and tabs which are used to handle a full tray stack and for easy sorting and coding.

- *Tape and reel:* The tape-and-reel configuration consists of a carrier tape with sequential individual cavities that hold individual components, and a cover tape that seals the carrier tape to retain the components in the cavities. The tape is wound onto a rigid plastic reel that provides mechanical protection during handling and storage. The tape-and-reel configuration is commonly used for feeding components to automatic-placement machines for surface mounting on board assemblies.

Features of Back-end Semiconductor Transport Media

Semiconductors such as integrated circuits, modules and other components are extremely sensitive devices and require careful packaging and handling. The typical features of semiconductor transport media are listed below:

- *Strong and rigid:* As a containment of semiconductor, the back-end semiconductor transport media are required to hold and protect the semiconductor from physical damage. The materials used should be strong and the structure of the carrier should be rigid with minimum twist.

- *Uniformity and consistency:* The handling media require high degree of uniformity that allows automated pick-and-place machines to efficiently locate and transport the components from the handling media to applicable places throughout the board assembly process. Further, the shape of the carrier is required to be consistent to allow easy storage and handling, for example, components are nested into pockets in fixed position rows and columns on trays and tapes which can be stacked and bound together. The configurations of the transport media of semiconductors are conformed by industry standards and it is uncommon to mix multiple manufacturers' brands due to the high precision requirement for the handling media.

- *Electrostatic discharge protection:* Semiconductor components are very sensitive to electrostatic charges and any slight static electricity can damage the semiconductor. As such, the design and materials used for the carrier are often static dissipative, specifically to avoid electrostatic charges build up during the peeling off of cover tape prior to automatic pick-and-place or other mechanical movement.

- *High specifications:* Back-end semiconductor transport media are manufactured to high specification with engineered plastics. During the manufacturing process, the baking temperature, as well as humidity are controlled carefully as any slight changes of the environment can alter the dimensions of the product and potentially affect the functionality of the transport media.

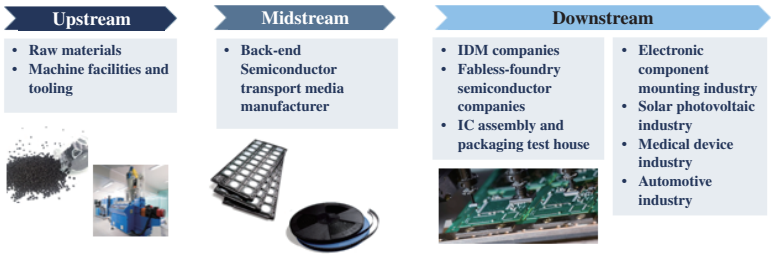
- *Uncommon to reuse:* Back-end semiconductor transport media is designed to act as the carriers of these semiconductor devices for shipping, handling, or processing, as well as protecting the leads of the components for damage during shipment, handling and placement. In light of the high standard of back-end semiconductor transport media that the customers required, the customers are practically unlikely to reuse the transport media, which is primarily attributed by (i) it would not be economical to clean and reuse the transport media considering the risk of damaging the fragile semiconductor devices of which the unit price is significantly higher than the unit price of the back-end semiconductor transport media; and (ii) it is costly and practically impossible for the customers to trace the destination of the transport media

and collect them for reuse as they are not used in-house and are shipped to different locations for production and the production process might be further sub-contracted by the downstream industry players.

Value Chain of Back-end Semiconductor Transport Media

The value chain of back-end semiconductor transport media is fairly straightforward. The upstream supplier of a back-end semiconductor transport media manufacturer consist of raw materials supplier such as pre-dried granular plastic or special engineered moulding compounds and related manufacturing facilities and tooling such as injection moulding machine. Apart from being the media for storage and handling of semiconductor components, the products are used at various stages across the manufacturing process of semiconductors, for instances, trays and carrier tapes are readily used to present semiconductor components to pick-and-place machines for automatic placement onto printed circuit boards. While majority of downstream customers are back-end semiconductor manufacturing companies, there are industries other than traditional

electronics that also demand for backend semiconductor transport media, for example, the solar photovoltaic industry, medical device industry, as well as the automotive industry. Semiconductor corporations generally need to conduct factory audit on their suppliers and qualify such suppliers for relevant back-end semiconductor transport media, before establishing business relationship with them.



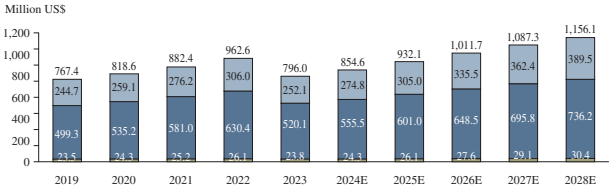
Source: Frost & Sullivan

Global Market Size

Owing to rising digitalization across the world, the surge in demand for semiconductors for commercial use, industrial use, and consumer electronics is driving the back-end semiconductor transport media industry. The total market grew from US$767.4 million in 2019 to US$ 962.6 million in 2022, representing a CAGR of 7.8%, but showed a decrease of 17.3% in 2023 to US$796.0 million. Looking forward, as semiconductor industry continue to benefit from the development of advanced technology such as artificial intelligence and machine learning, the industry of back-end semiconductor transport media is anticipated to reach US$1,156.1 million in 2028, up from US$854.6 million in 2024, with a CAGR of 7.8%.

Global Market Size of Back-end Semiconductor Transport Media Industry Breakdown by Type of Media, 2019–2028E

CAGR	2019–2022	2022–2023	2024E–2028E
Tray and tray related products	7.7%	-17.6%	9.1%
Tape and reel	8.1%	-17.5%	7.3%
Others	3.6%	-8.9%	5.7%
Total	**7.8%**	**-17.3%**	**7.8%**



Note: Others include shipping tubes, customised plastic injected parts and other accessories such as end pins, stoppers and plugs.

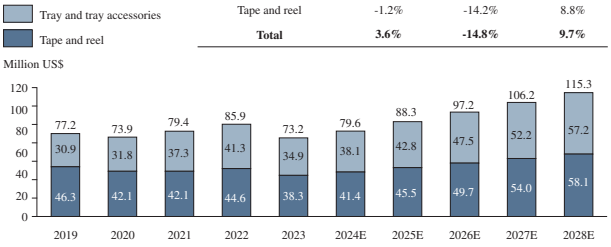
Source: Frost & Sullivan

Market Size of the PRC

The market size of the back-end semiconductor transport media industry in the PRC experienced a significant decrease in 2023, primarily due to the decline in China's semiconductor market. This decline can be attributed to a combination of factors, including but not limited to economic sanctions impacting access to critical technologies and markets, and intense competitive pressure from the United States. The downturn underscores the challenges confronted by Chinese semiconductor companies in preserving market share amid rapid technological progress and global economic tensions. The market size of the back-end semiconductor transport media industry in the PRC increased from US$77.2 million in 2019 to US$85.9 million in 2022, representing a CAGR of 3.6%, but showed a decrease of 14.8% in 2023 to US$73.2 million. To address these challenges, China need to focus on bolstering domestic innovation, diversifying supply chains, and strengthening international collaborations to enhance its competitiveness and resilience in the semiconductor industry amidst evolving geopolitical dynamics and technological landscapes. The market size of the back-end semiconductor transport media industry in the PRC is expected to grow robustly at a CAGR of 9.7% from US$79.5 million in 2024 to US$115.3 million in 2028 with continued development in emerging technologies in the domestic Chinese market.

PRC Market Size of Back-end Semiconductor Transport Media Industry Breakdown by Major Type of Media, 2019–2028E

CAGR	2019–2022	2022–2023	2024E–2028E
Tray and tray related products	10.2%	-15.5%	10.7%
Tape and reel	-1.2%	-14.2%	8.8%
Total	**3.6%**	**-14.8%**	**9.7%**



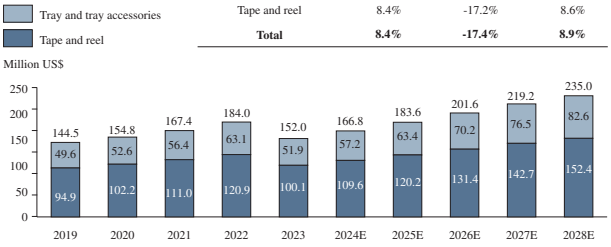
Source: Frost & Sullivan

Market Size of Taiwan

Taiwan has been a semiconductor manufacturing hub due to its well-established supply chain and strong capabilities in wafer manufacturing. The decline in global consumer electronics demand has indeed resulted in reduced global semiconductor orders in 2023, significantly impacting manufacturing output in Taiwan. Given the integral role of semiconductor manufacturing in Taiwan's economy, the downturn in global semiconductor orders directly affects the country's economic performance. As affected by slight stagnation in economy and downstream demand, the market size of back-end semiconductor transport media industry in Taiwan grew from US$144.5 million in 2019 to US$184.0 million in 2022, representing a CAGR of 8.4%, but showed a decrease of 17.4% in 2023 to US$152.0 million. Going forward, in anticipation of the continued development of semiconductor application, the back-end semiconductor transport media industry in Taiwan is expected to grow from US$166.8 million in 2024 to US$235.0 million in 2028, with a CAGR of 8.9%.

Taiwan Market Size of Back-end Semiconductor Transport Media Industry Breakdown by Major Type of Media, 2019–2028E

CAGR	2019–2022	2022–2023	2024E–2028E
Tray and tray related products	8.4%	-17.8%	9.6%
Tape and reel	8.4%	-17.2%	8.6%
Total	**8.4%**	**-17.4%**	**8.9%**



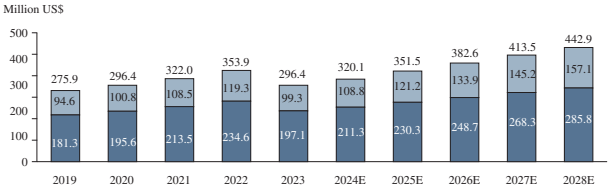
Source: Frost & Sullivan

Market Size of Southeast Asia

Southeast Asia countries such as Philippines, Malaysia, and Thailand are popular sourcing destination for semiconductor manufacturers and IC assembly and packaging test houses manufacturers due to their competitive labor costs. The region had experienced a moderate growth during 2019 to 2022, with a CAGR of 8.6%, but also showed a decrease of 16.3% in 2023 to US$296.4 million. Looking forward, in anticipation of shifting supply chains from China to Southeast Asia due to political conflicts between China and western countries and diversification of global supply chain, the market of back-end semiconductor transport media is expected to reach US$442.9 million in 2028, from US$320.1 million in 2024 with a CAGR of 8.5%.

Southeast Asia Market Size of Back-end Semiconductor Transport Media Industry Breakdown by Major Type of Media, 2019–2028E

CAGR	2019–2022	2022–2023	2024E–2028E
Tray and tray related products	8.0%	-16.8%	9.6%
Tape and reel	9.0%	-16.0%	7.8%
Total	**8.6%**	**-16.3%**	**8.5%**



Market Outlook in Selected Regions

Growth outlook of the back-end semiconductor transport media industry in the PRC – As a result of the continuing decoupling between the PRC and the western countries, there are an increasing number of companies to shift their supply chain and manufacturing facilities away from the PRC. It is expected that PRC-located companies will comparatively reduce their manufacturing capacities and operations and face decrement in international purchase orders. However, China is taking active measures to counter western countries repressive actions against China in the filed of semiconductor. For instance, China is reported to raise more than RMB200 billion through the Integrated Circuit Industry Investment Fund (ICF) to accelerate the development of cutting-edge technologies. In addition, due to the growing political emphasis on the security of supply chain, the market demand for locally made products from PRC enterprises is expected to increase rapidly. As such, the emergence of PRC brands of fabless and IC assembly will create market opportunities for back-end semiconductor transport media industry.

Growth outlook of the back-end semiconductor transport media industry in Taiwan and Southeast Asian countries – As more international companies swift their supply chain away and reduce their reliance on the PRC market, Southeast Asian countries such as Malaysia and Philippines become popular sourcing alternative due to their low labour and operating costs. Such long-term diversification trend in the global supply chain will also sustain the market demand in these regional countries. Major semiconductor manufacturers and IC assembly and packaging test houses are expanding their manufacturing capacity in Southeast Asia, for instances, Amkor Technology announced in late 2021 that it has plan to build a smart packaging assembly factory in Vietnam. Further, Taiwan is anticipated for positive market outlook in the back-end semiconductor transport media industry as it had well-established manufacturing facilities and related technical know-how.

Key Growth Drivers and Market Opportunities

Robust downstream demand for semiconductor product – The demand for back-end semiconductor transport media is highly dependent on the downstream demand from brand owners and end-customers for electronics products, which are embedded with integrated circuits. Affected by fluctuations in downstream demand and macroeconomic uncertainty, the global market size of semiconductor industry experienced a short-term downturn in 2023. Although the semiconductor industry is known for its occasional short-term weakness, its long-term outlook remains highly promising. Chips play a pivotal role in driving major emerging technologies like AI, IoT, and 6G. Also, they are indispensable for advancements in medicine and the development of innovative medical devices. Moreover, electric grid and climate solutions depend heavily on these minuscule silicon components, underlining their critical importance in our lives. This fundamental reality is unlikely to change in either the short or long term. Back-end semiconductor transport media serve as an essential and complementary containment product for semiconductor during transportation, especially when semiconductor end-products and subassemblies are frequently transported regionally and globally along the supply chain given the surging demand for quicker turnaround in recent years. In turn, back-end semiconductor transport media shall be continuously driven by the robust growth of the semiconductor market. Further, driven by the assimilation of technological innovation, especially during the outbreak of the COVID-19, the demand for various electronic products such as mobile phones, notebooks, telecommunication servers, automotive, smart home and smart wearables have been propelled. The continuous increase in penetration of electronic devices and digitalisation in various application circumstances, coupled with strong product replacement cycle in view of uprising technologies such as 5G networking and Internet of Things, has spurred the demand for semiconductor products and thereby the demand for back-end transport media as an indispensable medium. With the development of the semiconductor industry, there is a trend towards miniaturization in chips. Technological advancements, diversified applications and increased sophistication in chip design continue to drive the growth of back-end semiconductor transport media market despite the challenges posed by miniaturization of semiconductors. For example, the trend towards smaller, more compact electronic control units (ECUs) in the automotive industry is a significant result of miniaturization of chips, allowing for higher integration levels on a single semiconductor. While this might imply a reduction in the demand of back-end semiconductor transport media due to the smaller size of semiconductor, the growing adoption of electronic systems in vehicles and the demand for advanced features counteract this potential decline in sales volume of back-end semiconductor transport media.

In addition, the emerging applications of semiconductors are exemplified by their integration into various sectors such as smart home devices, the automotive industry, and healthcare devices. For instance, semiconductors are now fundamental components in smart refrigerators for temperature control, display panels, and intelligent connectivity. In the automotive sector, the increasing global sales of new energy vehicles drive demand for power devices with semiconductors utilized in advanced driver-assistance systems (ADAS), infotainment systems, etc. Additionally, healthcare devices, including medical imaging equipment, patient monitoring devices, wearables, and diagnostic tools, are increasingly incorporating semiconductor technology for enhanced functionality. It is also worth mentioning that not all semiconductors are suitable for miniaturization. In certain cases, larger and more robust semiconductors are required to meet specific application requirements. For instance, in power electronics, which involves the control and conversion of electrical power, miniaturization may not be the primary consideration. Instead, semiconductors capable of handling high power levels, high voltages, and high temperatures are of greater importance. Similarly, in the automotive industry, where semiconductors are used for engine control, safety systems, and other critical applications, robustness, reliability, and durability take precedence over

miniaturization. As a result, the demand for back-end semiconductor transport media is increasing and remains stable.

Increasing production capacity of upstream manufacturer – The production scalability of upstream semiconductor products serve as pivotal factor for the demand for back-end semiconductor transport media industry. Since 2020, several dedicated foundries of semiconductor has allocated extensive effort in ramping up production volume with capacity utilisation reaching almost 100%. Further, companies such as UMC, TSMC and GlobalFoundries have announced plans to devote considerable capital to boost its production capacity, while Samsung is planning to construct a dedicated fab for manufacturing 5G networking and machine learning integrated circuit. Apart from investing in physical factories and assets in raising production volume, alternative and emerging technologies in semiconductor production such as robotics, automated machineries and smart factories contribute to reducing lead time, shortening production cycle and amplifying the production volume. Service providers in the back-end semiconductor transport media industry would in turn be benefitted under the expanding production volume in the upstream with growing turnover of transportation required.

Despite these positive developments, the upstream semiconductor industry has faced challenges since 2022, marked by a downward cycle attributed to global economic conditions, trade tensions, and geopolitical uncertainties. This unpredictability has led to a dampening of investment and consumer spending in the semiconductor sector. However, the industry outlook suggests a recovery in 2024. This anticipation is based on the expectation that macroeconomic uncertainties will subside, leading to a resurgence in end-demand for semiconductor products. The industry including major players, is positioning itself for this recovery through strategic investments in production capacity and technology.

The impact of increased production volume in the upstream sector is expected to benefit service providers in the back-end semiconductor transport media industry. As upstream production expands, there is a corresponding increase in the transportation requirements for semiconductor products. Overall, the industry is navigating challenges with a forward-looking perspective, combining capacity expansion with technological innovation to address the evolving demands of the market.

Advanced specification and value-added services provision – The technological innovation such as upgrade of configuration and structure of integrated circuit and miniaturised MEMS-embedded integrated circuit, has heightened the standards for back-end transport media. The accelerated number of varieties of integrated circuits rolled out in the market has also propelled the research and development in relation to developing compatible and up-to-standard back-end transport media. Semiconductor tray and tape and reel service providers not only ensure fundamental properties including compatibility, electrostatic protection, mechanical integrity, thermal stability to be well performed, to offer other additional scope of services has also been increasingly important, such as (i) the ability to provide stackable trays with other vendor's tray in similar package matrix, in accordance with customer's needs; (ii) handling of the life cycle of used products including the collecting, sorting, cleaning, measuring, testing and

packing process to ensure the recycled tray products is functioning well during next usage; (iii) provide sufficient amount of standardised tooling, as well as off-the-shelf mold designs to accommodate to customised cases, and equipped with extensive design and tooling expertise to quickly address custom requirements; and (iv) integrated services such as logistics handling and arrangement and after-sales customer services. Service providers in the back-end semiconductor transport media industry with core competence on technical know-how and expertise, shall provide value-added and tailor-made service in response to the dynamic technological requirement. Integrated service providers offering one-stop services shall benefit from the growing opportunities on widening service scope and accommodate to more business prospect.

Surging demand for tape-and-reel – The packaging method of semiconductor devices has been evolving into miniaturisation and greater end-product effectiveness. The latest packaging method designs with protocol code namely QFN-style, DFN and WLCSP are fast growing segment leveraging surface mount and wafer level technique which streamlines the manufacturing process and are increasingly applied in different types of electronic products such as electric vehicles, consumer electronics and medical devices. As the tape-and-reel configuration is commonly used for feeding components to automatic-placement machines for surface mounting on board assemblies, the continuous advancement in surface mount packaging method shall propel the demand for tape-and-reel in the long run.

Market Development Trends

Uprising of Manufacturing Origin in the PRC and South East Asia – In past decades, the production and supply chain of semiconductor has been concentrated in few predominant production locations such as South Korea, Taiwan and the U.S. In recent years, in the PRC and in South East Asia countries such as Malaysia and Philippines, there are a growing number of companies undertaking the role of IC/wafer manufacturer i.e. front-end manufacturer and foundries, as well as IC assembly, packaging testing i.e. back-end manufacturer. It is attributable to the endeavours by the local government which collectively underpin the development of semiconductor industry to avoid technological decoupling throughout the local supply chain. For instance, the PRC Government promulgated policies in relation to semiconductor industry in supporting upstream academia research and development, implementing tax relief policies, enforcing law related to securing intellectual properties and accelerating further international cooperation. Back-end semiconductor transport media service providers as one of the integral stakeholders in the industry, have found increasing presence in this area to accommodate and complement with the upstream manufacturers, where the opportunities for cooperation with upstream manufacturers are continuously expanding.

Integration of Automation and Technology in Tray and Tape and Reel Production – Tray and tape and reel service providers are increasingly devoted to accelerate automation and assimilate computer numerical controlled machineries into the production and inspection line. In view of the outbreak of the COVID-19, leading players in the industry leverage incorporation of such technology to implement automation to elevate overall production yield and efficiency under the operational pressure of shortage of labour and growing labour cost. For instance, visual inspection incorporating artificial intelligence technology is adopted which is assisting to recognise defects under complex circumstances and monitor for production anomalies and be able to eliminate faulty trays in real time.

Growing Adoption of Lean Management – Back-end semiconductor transport media service providers in recent years adopted lean management directions. It involves the revamp of operation plan to save cost of inefficiencies, reduce the inventory of material and tools and minimise waste generation with conservation of valuable materials. The incorporation of data-based resources management system has also been conducive in decision making, identifying root causes and propelling continuous improvement in implementing lean management.

Market Challenges and Constraints

Rising Cost of Operation – In the manufacturing industry in the PRC, the rising cost of operation is expected to put additional cost pressure on semiconductor transport media providers. The average monthly salary of production and equipment operator, professional technician and managerial staff in manufacturing industry have increased at CAGR of 7.1%, 10.7% and 6.7% respectively from 2019 to 2023. Particular raw material such as Acrylonitrile Butadiene Styrene (ABS) has also recorded a price rise at CAGR of 5.4% from 2019 to 2023. Accordingly, market participants may need to consider investing considerably on automated production machinery to minimise the impact of rising labour cost as well as transferring the growth in cost of operation to customer to alleviate its impact on profitability.

Dependence on Economic Environment and External Uncertainties – The back-end semiconductor transport media industry is subject to economic volatility and various political events and global crisis. For instance, in recent years, during the outbreak of the COVID-19, the implementation of lockdown policies has caused chip production facilities to shut down, leading to the depletion of inventories. The U.S. China Trade War where the U.S. government imposes hefty tariff to various products imported from China and vice versa, has significantly impacted the output volume of semiconductor from the PRC. Severe weather in the U.S. and fires at facilities in Japan has further delayed the production schedule of various semiconductor products. The back-end semiconductor transport media as a direct complementary goods of semiconductor, shall be directly impacted by with these adverse events.

Shortage of Expertise and Talented Labor – A shortage of expertise and talented labor, coupled with an absence of systematic cultivation and recruitment for human capital, may pose a significant challenge for the development of the industry. According to the PRC Semiconductor Industry Association, there is a workforce shortage of 400,000 labors in the PRC's semiconductor and related products industry under the premise of the production target in the coming few years, which may possibly alter the development progress and production schedule within the PRC.

Disruption in Supply Chain – Global event such as the COVID-19 outbreak since early 2020 and the US China Trade War has temporarily affected the supply of electronics due to the disruption on material supply chain and availability of labour associated with the containment measures undertaken around the globe. Constraints in material sourcing and price fluctuation in raw material poses significant challenge to industry players.

Entry Barriers

1. Business relationship

The back-end transport media industry is characterised with a relatively concentrated market landscape with less than 30 market players participating while top players account for a high market share. Given the long-standing relationship of existing tray and tape and reel manufacturers with various levels of stakeholders such as brand owners and traders, relationship and networking within the industry act as an entry barrier due to the fact that the fabrication of back-end semiconductor transport media require materials and equipment supply, as well as sales network and reputation comprising traders and various downstream customers. Business relationship also enable back-end semiconductor transport media manufacturers to expand their product offerings and achieve provision of one-stop shop solution in order to stand out from other competitors.

2. Capital investment

Manufacture of back-end semiconductor transport media is considered a capital-intensive business with substantial initial investment in purchase of module and tooling, establishment of production facilities with automated and precise production chain and automated inspection tool as well as recruitment of technical staff. The initial set up cost together with the operational cost will pose a barrier for new entrants without sufficient financial resources.

3. Stringent quality requirement

As semiconductor products are considered extremely sensitive devices, downstream clients and brand owners of electronics are therefore generally maintaining stringent requirements towards their contract manufacturers and demonstrate stickiness to qualified back-end transport media service providers. Manufacturers shall continuously monitor the products are of high quality and are highly consistent and stable. Back-end transport media that are able to undergo stringent and comprehensive verification, validation, testing, site audit processes are highly preferred by customers. Further, steady flow of product is one of the key considerations when downstream customers select a back-end semiconductor transport media provider, as a result, suppliers who have their own production facilities can maintain competitive advantages within the industry. Therefore, establishment and existing players excel their competitive advantages in this area while it poses certain barrier to new entrant.

4. Industry know-how

Tray and tape and reel are fundamental components to a wide variety of transporting integrated circuit products in different technical specifications. The evolving requirement of these integrated circuit product such as size and ability to withstand pressure, heat and shock, will further enhance the barrier to new entrants without technical know-how in respect of design, manufacturing and packaging of power discrete semiconductor devices. Apart from the technical know-how, sales channels and business network are considered pre-requisites for back-end semiconductor transport media manufacturers in the market.

Cost Structure Analysis

From 2019 to 2023, the labour cost in the manufacturing industry in the PRC increased steadily. In particular, the average monthly wage of professional technician has increased from

RMB8,424.6 to RMB12,663.3 during 2019 to 2023, representing a CAGR of approximately 10.7%. The increasing labour cost is attributable to increasing demand of skillful labour equipped with skills such as knowledge on computerised management system, modelling analytical skills and proficiency in foreign languages.

Going forward, the average monthly wage of employed persons in manufacturing industry, including production and equipment operator, professional technician and managerial staff are expected to grow at a slower trend at a CAGR of 6.4%, 6.7% and 7.0% respectively for 2024 to 2028, owing to the increasing amount of labour entrants, resulting in a stable growth of wage.

Average Monthly Salary of Employed Persons in Manufacturing Industry (the PRC), 2019–2028E

(Unit: RMB)	2019	2020	2021	2022	2023	2024E	2028E	CAGR (2019–2023)	CAGR (2024E–2028E)
Production and equipment operator	4,863.0	5,110.3	5,668.7	6,099.1	6,408.5	6,863.5	8,796.5	7.1%	6.4%
Professional technician	8,424.6	8,890.1	9,800.9	11,899.0	12,633.3	13,562.4	17,582.1	10.7%	6.7%
Managerial staff	12,118.1	12,749.7	13,924.8	14,621.0	15,692.8	16,806.9	22,040.4	6.7%	7.0%

Source: Frost & Sullivan

Impact of Uncertainty in the Environment

Impact of COVID-19

COVID-19 outbreak since early 2020 has temporarily affected the supply of electronics due to the disruption on material supply chain and availability of labour associated with the containment measures undertaken in different countries. On the other hand, COVID-19 has also prompted a new way of communicating, which is referred as working and learning remotely. The stay-at-home orders and remote communication has spurred a massive spike in computers, tablets and consumer electronics. The demand for electronic products has not been significantly affected by COVID-19, attributable to the acceleration of technologies such as cloud technologies, edge computing, 5G technologies, industry 4.0, robotics and automation, mobility (electrification and ADAS), augmented reality and virtual reality and biometrics, as a result of reduced human contact and technology assimilation. Also, the retail sales channels of electronic products have seen a shift from offline to online channels as reflected by the surge of e-commerce platforms in recent years. It has also been reported that the surge in demand for smart devices has caused the shortage of global chip supply for electronics, reflecting the strong and sustained demand for electronics amid the COVID-19 outbreak. Back-end semiconductor transport media as an indivisible complementary product of semiconductor, is benefitted by the robust downstream demand for semiconductor product as well as expanding production volume of upstream manufacturer.

Impact of the Trade Conflict

The trade conflict between the United States and the PRC has brought about certain negative impact, given that (i) the imposition of tariffs by the U.S. to the PRC has reduced the overall demand of semiconductor products in the PRC from influential brand owners in the US; (ii) the US has invoked action against Chinese manufactured imports including many electronic components to minimise the transfer of intellectual property and technology to the PRC, resulting in a diminishing exchange of professional knowledge in the industry; and (iii) the shift of electronics production from China to other Asian countries has been accelerated by the trade dispute, multinational companies are moving production to these countries due to lower labour costs, favourable trade conditions and openness to foreign investment; (iv) the commencement of the U.S. to the PRC trade war has also led to constraints in material sourcing from suppliers and increase of raw material costs.

In general, the impact of the political conflict between the PRC and the United States on semiconductor industry is primarily short-term implications for the reasons including but not limited to:

Rise of Chinese Brands

The trade conflict between the United States and the PRC has spurred a significant transformation in the local supply chain within the PRC. Chinese enterprises that once heavily relied on foreign suppliers are swiftly diversifying by establishing their own brands and products. This not only helps fill the supply gap resulting from decreased imports but also fortifies their homegrown brand identity. Moreover, with a growing political emphasis on supply chain security, the demand for Chinese-made products is set to surge. Consequently, the emergence of Chinese fabless and IC assembly brands presents market opportunities for the back-end semiconductor transport media industry.

Technological Advancements

Both the PRC and the United States have been making substantial investments in their domestic semiconductor industries, particularly in research and development. Notably, these efforts have led to advancements in manufacturing technology, design capabilities, and research institutions. In the long run, these strides in semiconductor technology can partially offset the impact of external tensions.

Complete Industry Chain Integration

The PRC's market has proactively adjusted its supply chain management to counter the adverse effects of the trade war. Driven by shifts in customer supply chains, global back-end semiconductor transport media companies are increasingly relocating their sourcing from the United States to the PRC. This trend further catalyzes the growth of the domestic back-end semiconductor transport media industry, reducing reliance on external sources for crucial components and providing a shield against supply chain disruptions.

Adaptability of Back-End Semiconductor Transport Media

The adaptability of back-end semiconductor transport media products is a key asset, enabling quick adjustments to accommodate different semiconductor products. This flexibility is pivotal in addressing short-term supply chain disruptions or adapting to changes in product specifications. In the short term, this adaptability can help mitigate immediate impacts of political conflicts on the semiconductor industry.

A Secure and Orderly Development Environment

The PRC-U.S. political conflict has sharpened the PRC's focus on cybersecurity. This heightened attention is likely to lead to increased regulatory oversight, mandating stricter cybersecurity standards and compliance for semiconductor companies. In the short term, this may necessitate operational adjustments and investments, potentially affecting costs. However, in the long run, these efforts can yield substantial benefits, include a more secure and structured development environment, improved competitiveness, and enhanced risk management. This will be advantageous for the entire industry.

Impact of Unstable Downstream Customer Demand

If downstream customers of tray and tray related products manufacturers of back-end semiconductor transport media industry are named by relevant authorities not to purchase their chip products due to changes in local policies or political reasons, it would have a short-term impact on the global back-end semiconductor transport media industry. However, when downstream customers temporarily refrain from having sustainable demand for back-end semiconductor transport media due to changes in local policies or political reasons, semiconductor manufacturers typically would address these concerns swiftly. They usually collaborate closely with relevant authorities to ensure product safety and compliance with regulations. Additionally, the semiconductor industry benefits from a vast ecosystem of suppliers and manufacturers, allowing it to adapt and find alternative solutions quickly. The industry's ability to innovate, diversify its product offerings, and respond to changing market dynamics enables global back-end semiconductor transport media industry to rebound swiftly from any short-term disruptions, ensuring that market demand remains robust in the long run.

COMPETITIVE LANDSCAPE OF GLOBAL BACK-END SEMICONDUCTOR TRANSPORT MEDIA INDUSTRY

The global back-end semiconductor transport media industry is a concentrated market with less than 30 players and the top players accounted for most market shares. The reason behind such market structure was mainly due to the high cost of defects in transport media for printed circuit board assembly house and so they tend to source from reputable market players and will not compromise quality for more competitive pricing products. Top 5 players are headquartered in Korea, Japan, Taiwan and the PRC. The market share of our Group in the global back-end semiconductor transport media market industry was approximately 2.6% in 2023. For the tray and tray related products manufacturers in global back-end semiconductor transport media industry, the top two players have a combined market share of approximately 26–37% in 2023 whereas the market share of our Group was approximately 8.4% in 2023.

Ranking of Tray and Tray Related Products Manufacturers in Global Back-end Semiconductor Transport Media Industry, 2023

Rank	Name of Company	Market share *(%)*	Description
1	Company A	17–22	Company A is one of the first manufacturers specialises in plastic injection moulding for semiconductor packages based in Korea. Company A offers a broad portfolio of products, including trays, wafer carrier products, carrier tape and reels, bare die tapes and shipping tubes.
2	Company B	9–15	Company B is one of the top semiconductor packages manufacturers based in Japan. Company B offers a comprehensive line of semiconductor transport products including but not limited to JEDEC IC matrix trays and moisture barrier bags.
3	The Group	8.4	–
4	Company C	7–8	Company C is one of the top semiconductor packages manufacturers based in Korea. Company C offers a comprehensive line of semiconductor transport products and static-control products.
5	Company D	6–7	Company D is one of the top manufacturers of semiconductor packaging materials in Taiwan. Company D focuses on the design and production of diverse consumer plastic injection moulding products.

Note: The official revenue and market share data is unavailable since all of the above are private companies. Frost & Sullivan derived market share estimates for pertinent players by analyzing publicly available information.

Factors of competition for back-end semiconductor transport media industry lies in the ability to establish long-standing relationship with renowned semiconductor manufacturers due mainly to the provision of high-quality products and good reputation, as well as the ability to address customers' needs with speed.

GLOBAL MEMS AND SENSOR PACKAGING INDUSTRY

Introduction to MEMS and Sensor

Micro-Electro-Mechanical-System ("**MEMS**") is a miniaturized mechanical and electro-mechanical element (i.e., devices and structures) that are made using the techniques of microfabrication and photolithography process. MEMS is a manufacturing technology and a paradigm for designing and creating complex mechanical devices and systems.

Due to technology advancement, MEMS is able to leverage batch fabrication techniques for scalability to attain a low per-device production cost. The physical dimension of a MEMS can range from millimeters to micrometers. MEMS are usually integrated and packaged together on the same substrate with other Integrated Circuits ("**IC**"), while MEMS devices and systems have the ability to sense, control and actuate on the micro scale, and generate effects on the macro scale.

MEMS are assimilated into different applicable components, including radio-frequency device, pressure sensor, microphone, accelerometer, gyroscope, inertial components, inkjet print head, optical devices and other devices. MEMS can be found in systems ranging across industries such as consumer electronics, automotive, healthcare, industrial and other uses. A major application for MEMS is as sensors. Primary MEMS sensors are pressure sensors, chemical sensors, and inertial sensors (accelerometers and gyroscopes), and infrared sensors for temperature measurements.

Compared with Integrated Circuit ("**IC**"), Micro-Electro-Mechanical-System ("**MEMS**") embodies the following advantages (i) the reduced physical size, volume, weight, which minimises the usage of energy and material which can help with the reduction of costs; (ii) core competence of MEMS improves accuracy, reproducibility, reliability, and sensitivity (iii) diversity and integration of applications on various field; and (iv) high level of customisation during production and application.

Definition and Technical Requirements of MEMS and Sensor Packaging Industry

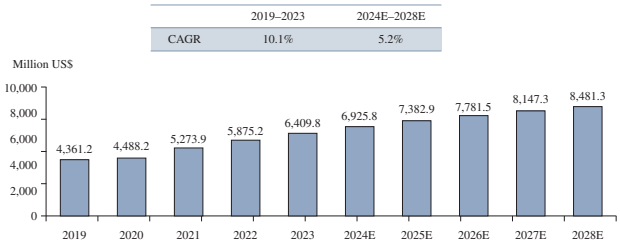
MEMS and sensor packaging serve as an integral operational procedure which principally structure various electronic and mechanical components into a metal, plastic, or ceramic casing, which provides a means for the whole manufactured package to connect to the external environment.

A MEMS and sensor packaging provider offers services ranging from (i) package and substrate design, development and prototyping; (ii) mechanical, thermal and electrical analysis; (iii) handling of packaging materials, IC packaging & product transfers; (iv) air cavity and injection molded packaging; and (v) package qualification and reliability testing. It is pivotal for MEMS packaging services providers to provide packaged MEMS products that are able to withstand harsh environments, intense shock and vibration, extreme temperatures and severe humidity, while delivering high reliability and dimensional stability at significantly reduced costs.

Market Size of MEMS and Sensor Packaging Industry

MEMS sensor integrated circuit are packaged in first-level packaging, which is also named as back-end manufacturing, while second-level packaging adds further electronics, robust housing and connectors to the MEMS sensor structure. Market size here denotes only first-level packaging. The market size by revenue of MEMS and sensor packaging industry has increased from US$4,361.2 million to US$6,409.8 million from 2019 to 2023, representing a CAGR of approximately 10.1%. The proliferation of MEMS designs into electronic products, coupled with the high complexity and various technical challenges and requirements, has precipitated a continuous demand for MEMS and sensor packaging provision. Going forward, the market size by revenue of MEMS and sensor packaging is expected to grow at CAGR of approximately 5.2% from 2024 to 2028.

Global Market Size by Revenue of MEMS and Sensor Packaging Industry, 2019–2028E



Source: Frost & Sullivan

COMPETITIVE LANDSCAPE OF GLOBAL MEMS AND SENSOR PACKAGING INDUSTRY

MEMS and sensor packaging industry is considered highly specialized industry which requires sophisticated and long product development cycle, extensive technical know-how and considerable investment in corresponding machinery. The industry is multidisciplinary involving the domains of electronics, machinery, materials, process manufacturing, physics, and others.

MEMS and sensor packaging plays a vital role in the protection of the wafer and chipset structure from environmental factors along with providing other benefits such as conductivity, connective communication, etc. The global MEMS and sensor packaging market is fragmented and highly competitive. The packaging service for MEMS and sensor packaging market is comprised of approximately 500 players globally and there are approximately 300 players in the MEMS and sensor packaging market in the PRC.

COMPETITIVE STRENGTHS OF OUR GROUP

Please refer to the paragraph headed "Business – Competitive strengths" in this document for a detailed discussion of competitive strengths of our Group.