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Industry Report on the Precision Engineering Industry

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CIC introduction, methodologies, and assumptions

China Insights Consultancy was commissioned to conduct an analysis of, and to report on the global and Singapore's precision engineering industry and optical metalens industry, at a fee of approximately USD118,000. This commissioned report was prepared by China Insights Consultancy independent from the influence of the Company and other interested parties.

China Insights Consultancy's primary services include, among others, industry consulting, commercial due diligence, and strategic consulting. Its consulting team has been tracking the latest market trends in multiple business sectors, including the internet, environment, industry, energy, chemicals, healthcare, manufacturing, consumer goods, transportation, agriculture, and finance, and has the relevant and insightful market intelligence in the above industries.

China Insights Consultancy conducted both primary and secondary research using a variety of resources. Primary research involved interviewing key industry experts and leading industry participants. Secondary research involved analyzing data from various publicly available data sources, such as the Singapore Department of Statistics, Department of Statistics Malaysia, Semiconductor Equipment and Materials International (SEMI), etc. The information and data collected by CIC have been analysed, assessed, and validated using CIC's in-house analysis models and techniques.

The market projections in the commissioned report are based on the following key assumptions: (i) the overall social, economic, and political environment in Singapore is expected to remain stable during the forecast period; (ii) Singapore's economy economy is likely to maintain a steady growth trajectory during the forecast period; (iii) the relevant key industry factors are likely to continue to drive the precision engineering market across the world and in Singapore, e.g. growing end-use industries including semiconductor, aerospace, and oil & gas, and advancement of high-precision machine tools provides a higher level of accuracy, repeatability, and efficiency; and (iv) there is no extreme force majeure or unforeseen industry regulations under which the market may be affected in either a dramatic or fundamental way; and (v) global economy will gradually recover from the negative effects of the COVID-19 pandemic.

All statistics are reliable and based on information available as of the date of this report. Other sources of information, including those from the government, industry associations, or market participants, may have provided some of the information on which the analysis or its data is based.

All the information regarding the Company has been sourced from the Company's audited report or management interviews. The information concerning and provided by the Company has not been independently verified by China Insights Consultancy.

Terms and abbreviations (1/3)

ASME: The American Society of Mechanical Engineers

AWS: American Welding Society

AR/VR: Augmented reality and virtual reality

AR/MR: Augmented reality and mixed reality

Build-to-print: Build to print is a type of contract manufacturing that refers to the process of building products to client work instructions. This is commonly used to manufacture components or pieces of equipment.

CAD: Computer-Aided Design

CAGR: Compound Annual Growth Rate

CAICT: China Academy of Information and Communications Technology

CAM: Computer-Aided Manufacturing

CMs: Contract Manufacturers, which manufacture products, in whole or in parts, based on the specification provided by its customers. The products produced by the contract manufacturers are usually sold under the brand name of their customers

CMM: Coordinate Measuring Machines

CNC: Computer Numerical Controls

CNC machines: automated machines operated by computers executing pre-programmed sequences of controlled commands with high precision automated vertical and horizontal machining centres that motion to be commanded through built-in programmes interpreting mathematical or numerical data inputs to conduct automatic, precise and consistent motion control in the manufacturing process.

CPCA: China Passenger Car Association

DLW: Direct laser writing, a high-resolution 3D photolithography technique which relies on the local solidification of a photoresist at the focus of a laser beam to draw structures

EPHA: Environmental Public Health Act

EPMA: Environmental Protection and Management Act

EBL: Electron beam lithography

etc.: Et cetera

EU: The European Union

FOI: Field of illumination

HUD: Head-up display

IDC: International Data Corporation

IP: Intellectual Property

Source: China Insights Consultancy

Terms and abbreviations (2/3)

ISO: International Organization for Standardization

ISO 9001:2015: an internationally recognized standard for Quality Management Systems

IoT: Internet of Things

Large format vacuum chamber: a large size rigid enclosure from which air and other gases are removed by a vacuum pump. The chamber body is formed by welding several pieces together rather than forging the body from a single piece of metal

LED: Light emitting diode

IMF: International Monetary Fund

Multi-axis CNC machines: A CNC machine has typically three axes, while multi-axis CNC machines employ advanced machining equipment and tooling that accommodates motion in four or more directions to facilitate the manufacture of precision parts with complex geometries. They are categorised into 4-axis, 5-axis and even 12-axis CNC machines in accordance with the number of directions the tool within the machine can move. Among multi-axis CNC machines, 4-axis and 5-axis CNC machines are the most common.

mm: millimeter

NIL: Nanoimprint lithography, a novel method of fabricating micro/nanometer scale patterns with low cost, high throughput and high resolution

nm: nanometer

OEMs: Original Equipment Manufacturers

Precision engineering service provider: companies which receive orders from contract manufacturers or directly from OEMs and perform one or several of services including precision machining, precision welding, precision surface treatment, precision metal fabrication, heat treatment, subassembly, etc.

Precision components: The products of precision engineering, which refers to metal components manufacturing primarily through precision machining and precision welding, the main value-added process, with tight tolerance.

QC: Quality Control

R&D: Research and development

RMB: Renminbi, the official currency of China

SEMI: Semiconductor Equipment and Materials International

Semiconductor: a substance that has specific electrical properties that enable it to serve as a foundation for computers and other electronic devices

Silicon wafer: a thin slice of silicon used to fabricate semiconductor devices such as integrated circuits

SKU: Stock Keeping Unit

Source: China Insights Consultancy

Terms and abbreviations (3/3)

SL: Structured light

SSQA: Standardized Supplier Quality Assurance

System integration: full system and subsystems that are assembled together with components and/or subsystems

SNR: Signal-to-noise ratio

Subassembly: a simple assembly of cable, wire, and other small parts. Subassemblies can be joined to other subassemblies and components to form complete product

The Company: Metasurface Technologies Holdings Limited

TIG: Tungsten Inert Gas

TIG welding machines: arc welding machines that use a non-consumable tungsten electrode to produce high-quality welds

ToF: Time of Flight

UV: Ultraviolet

U.S.: the United States

Weld: a joint where two or more parent materials are welded together

WFE: Wafer Fab Equipment

Source: China Insights Consultancy

1. Macroeconomic Analysis of Singapore

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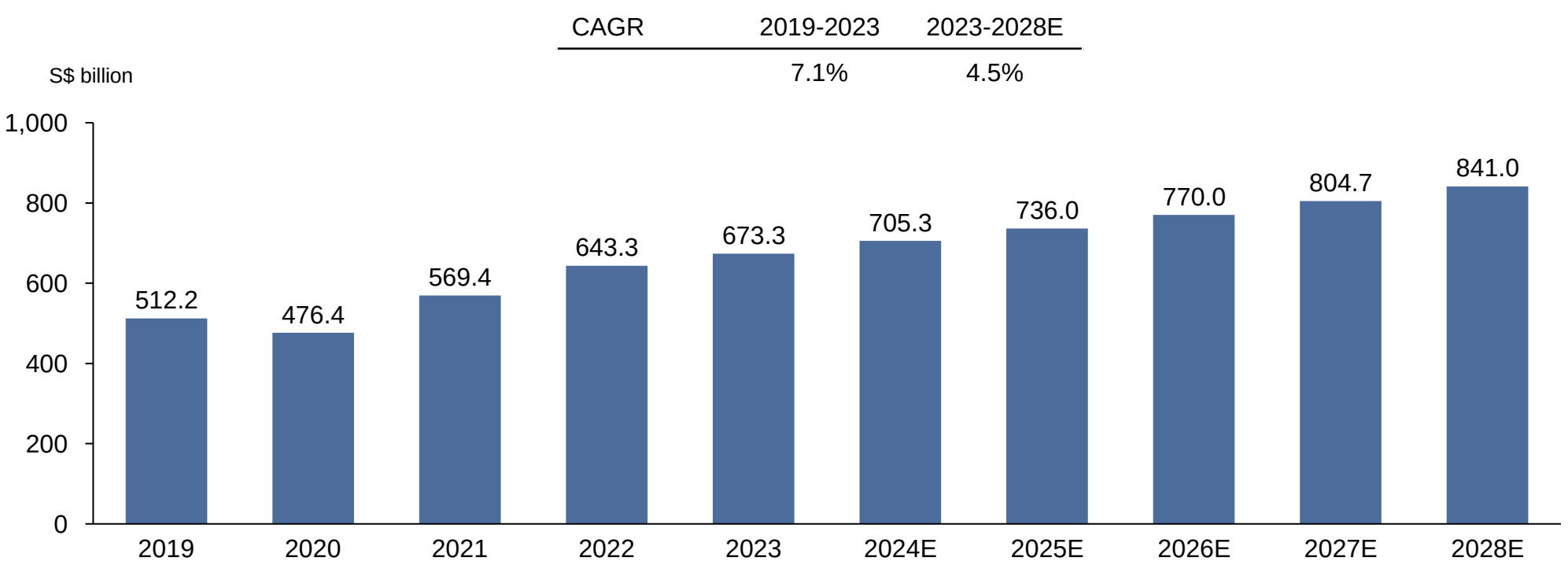
Singapore’s GDP and growth

- Singapore’s GDP has grown steadily in recent years. Manufacturing represents a significant component of Singapore’s GDP and is highly valued and supported by Singapore’s government. The manufacturing sector will continue to be a key driver of Singapore's economic growth in the future.

Gross domestic product, Singapore, 2019-2028E



Key analysis

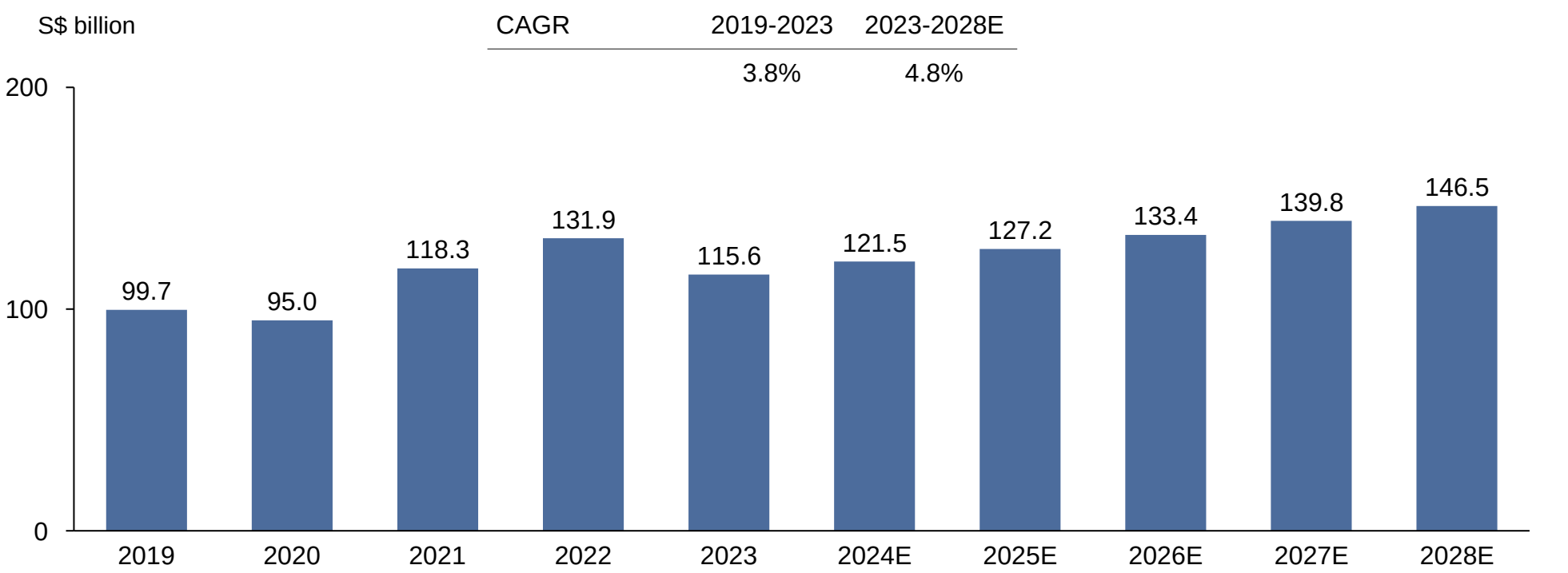
- Singapore’s GDP was reported S$512.2 billion in 2019, followed by a decrease to approximately S$476.4 billion in 2020 due to the COVID-19 pandemic. Benefitting from the effective control of the pandemic by the Singaporean government, together with the recovery of global demand in areas such as electronic devices, travel, etc., Singapore‘s GDP bounced back to S$673.3 billion in 2023 and is projected to reach S$841.0 billion by 2028, representing a CAGR of 4.5% over the period from 2023 to 2028. Manufacturing represents a significant component of Singapore’s GDP and is highly valued and supported by Singapore’s government. In 2021, Trade and Industry Minister Chan Chun Sing announced a new 10-year plan to grow Singapore’s manufacturing sector by 50%, which is expected to increase to more than S$160.0 billion in the next ten years. Therefore, the manufacturing sector will continue to be a key driver of Singapore's economic growth in the future.

Source: IMF, Singapore Department of Statistics, China Insights Consultancy

Singapore's value added by the manufacturing sector

- The Singapore government values the importance of the precision engineering industry and has gone quite far to help the industry to prosper, including tax incentives for companies choosing to be headquartered in Singapore. The value added by the manufacturing sector in Singapore is expected to continue with the growing trend in the next five years.

Value added by the manufacturing sector, Singapore, 2019-2028E



Key analysis

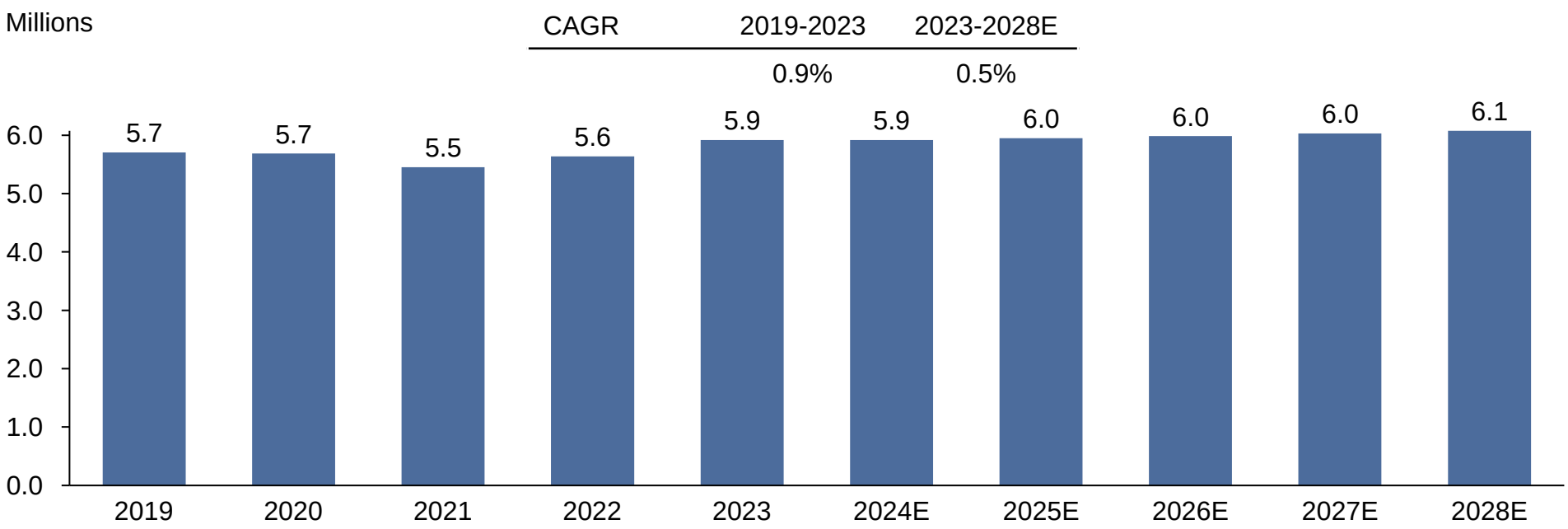
- The value added by the manufacturing sector in Singapore reached S$99.7 billion in 2019, but decreased to S$95.0 billion in 2020 mainly due to the trade war between the United States and China, where the US imposed a series of sanctions or restrictions like high tariffs on chips and parts imported from China to hobble China's chip industry, and a cyclical downturn in the electronics sector in 2019 as well as the COVID-19 pandemic in 2020. The value added by the manufacturing sector increased to S$131.9 billion in 2022, driven in part by the robust performance of the semiconductor industry throughout 2021 and into most of 2022. However, with a soft global demand exerting pressure on Singapore's manufacturing industries, the value added by the manufacturing sector decreased to S$115.6 billion in 2023. However, driven by the recovery of demand in the electronics sector and continuous upgrading of Singapore's manufacturing technology, the value added by the manufacturing sector is estimated to reach S$146.5 billion by 2028 with a CAGR of 4.8% between 2023 and 2028. The continuing growth of the manufacturing sector in Singapore is expected to further promote the development of the precision engineering industry. The Singapore government values the importance of the precision engineering industry and has gone quite far to help the industry to prosper, including tax incentives for companies choosing to be headquartered in Singapore.

Source: Singapore Department of Statistics, China Insights Consultancy

Singapore's population and urbanization rate

- Singapore has a highly qualified human capital pool and technicians for advanced manufacturing are under intense competition.

Total population[1], Singapore, 2019-2028E



Key analysis

- Singapore's population has slightly declined to 5.5 million in 2021 due to (i) more citizens remained overseas continuously for 12 months or more due to the COVID-19 travel restrictions; and (ii) decrease in foreign employment in Singapore due to travel restrictions and uncertain economic conditions. With the recovery of Singapore's economy and the relaxation of the border restriction, citizens and foreign employees are gradually returning to Singapore. In 2023, Singapore's population increased to 5.9 million. Singapore has a highly qualified human capital pool and recruitment for technicians for precision component engineering is under intense competition, especially since COVID-19, due to the travel restrictions and the number of foreign workers a manufacturer can employ is limited by the quota or the dependency ratio ceiling in Singapore.

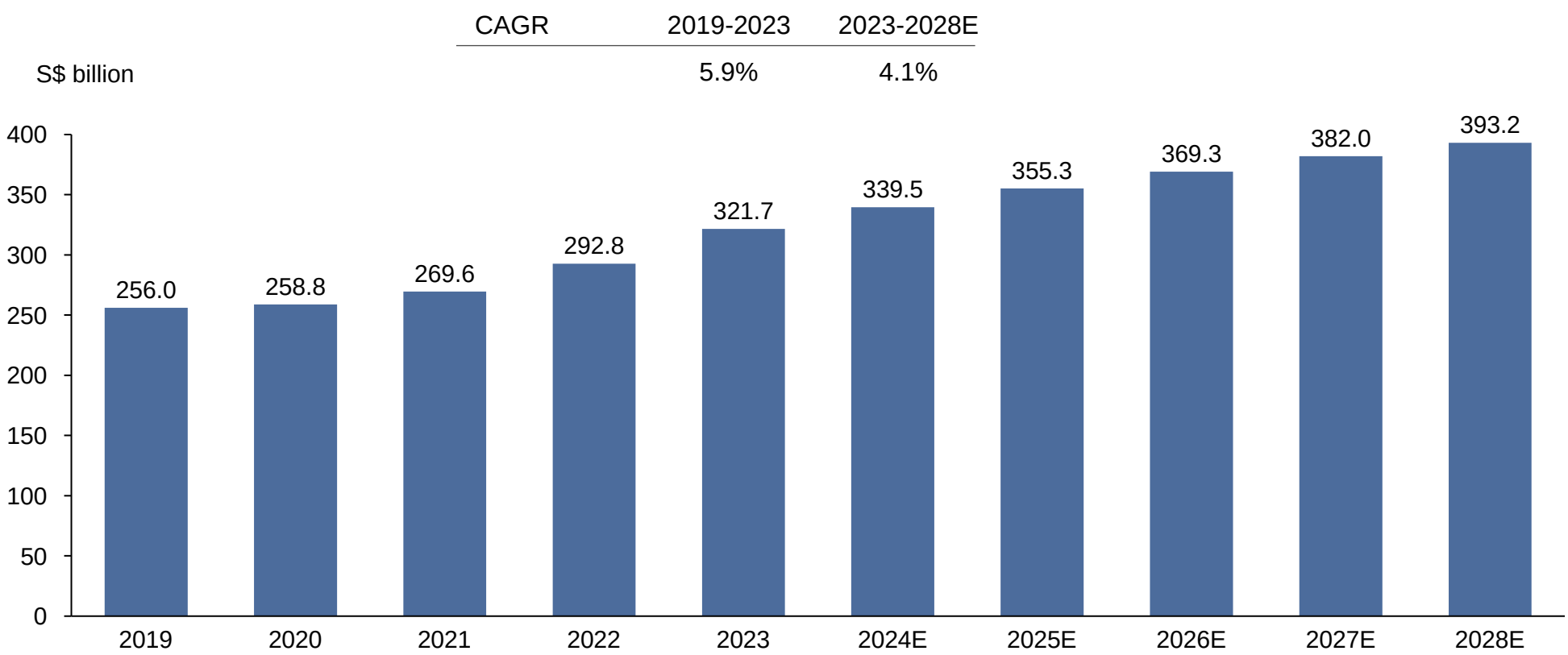
Note: 1. Total population comprises Singapore's residents & non-residents. Resident population comprises Singapore citizens & permanent residents. Data excludes residents who are overseas for a continuous period of 12 months or longer as at the reference period. Non-resident population comprises foreigners who are working, studying or living in Singapore who are not granted permanent residence.

Source: IMF, World Bank, Singapore Department of Statistics, China Insights Consultancy

Singapore’s personal disposable income

- Singapore’s personal disposable income has been rising steadily from 2019 to 2023 and it is projected to grow continuously over the next five years.

Personal disposable income, Singapore, 2019-2028E



Key analysis

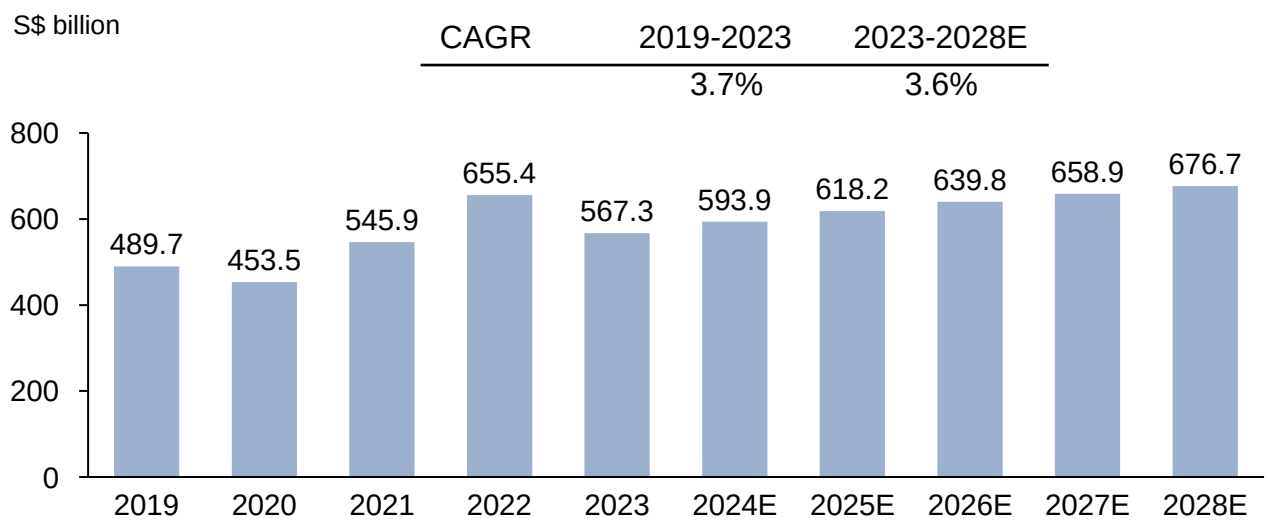
- Singapore’s personal disposable income has been growing at a steady pace, increasing from S$256.0 billion in 2019 to S$321.7 billion in 2023, indicating a CAGR of 5.9%. With Singapore’s economy expected to recover from COVID-19 in the years ahead, Singapore’s personal disposable income is expected to continue rising to reach S$393.2 billion by 2028, representing a CAGR of 4.1% during the period from 2023 to 2028.

Source: Singapore Department of Statistics, China Insights Consultancy

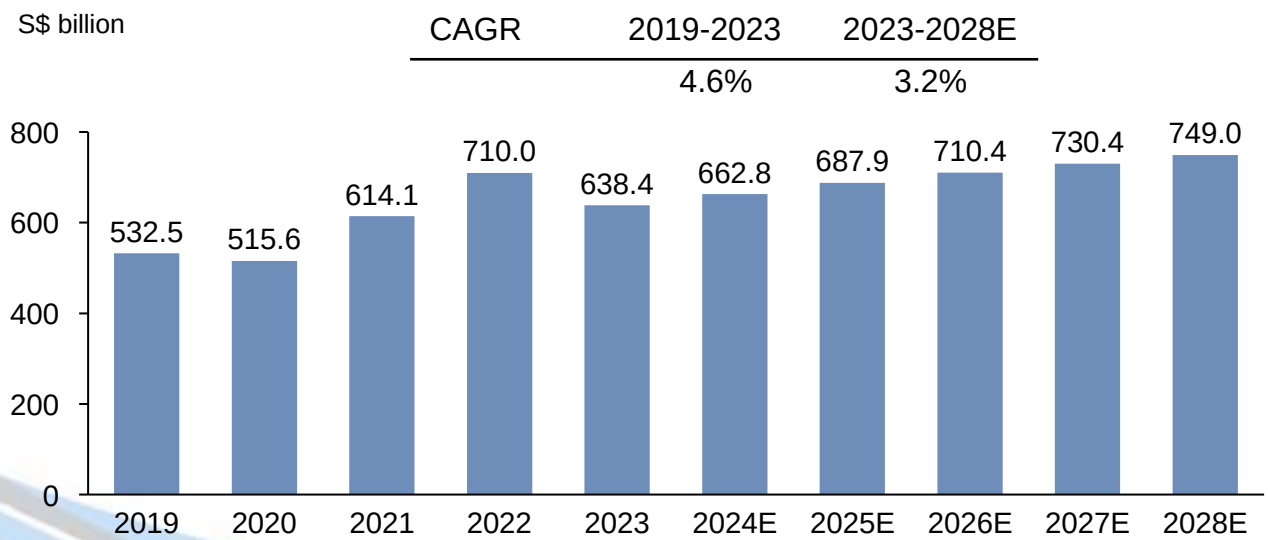
Singapore’s merchandise imports and exports

- Singapore is one of the core distribution and logistics hubs in Asian production and trade. The merchandise imports and exports in Singapore are expected to resume a growth trend in the near future with recovering global electronics demand.

Merchandise imports, Singapore, 2019-2028E



Merchandise exports, Singapore, 2019-2028E



Key analysis

- Singapore’s merchandise imports rose from S$489.7 billion in 2019 to approximately S$655.4 billion in 2022, but then declined to S$567.3 billion in 2023. Similarly, Singapore’s merchandise exports increased from S$532.5 billion in 2019 to approximately S$710.0 billion in 2022, followed by a decrease to S$638.4 billion in 2023. These decreases in imports and exports were primarily attributed to weak global demand, resulting in CAGRs of 3.7% and 4.6% from 2019 to 2023 for imports and exports, respectively. But with gradual recovery of global electronics demand, the merchandise imports and exports in Singapore are expected to resume a growth trend from 2023 onwards to reach S$676.7 billion and S$749.0 billion by 2028, respectively, representing CAGRs of 3.6% for imports and 3.2% for exports from 2023 to 2028.

Source: Singapore Department of Statistics, China Insights Consultancy

2. Overview of the Precision Engineering Industry

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Definition and classification of the precision engineering industry

- In this industry report, the precision engineering industry compromises precision component engineering and system integration

Definition

- **In this industry report, the precision engineering industry comprises precision component engineering and system integration. Precision component engineering refers to metal components manufacturing primarily through precision machining and precision welding, the main value-added process, with tight tolerance.** Other procedures, such as precision surface treatment, precision metal fabrication, heat treatment, subassembly, etc., will be applied depending on the need. The production of precision components may involve one or several of the services mentioned above. System integration refers to full systems and subsystems that are assembled together with components and/or other subsystems. The precision component engineering industry and system integration industry have different requirements to the market players including technical knowhow, manufacturing technology and capital requirement. **The precision engineering industry serves a wide range of end-use industries,** such as the semiconductor, aerospace, and oil & gas industries. In particular, the industry also serves various segments such as display, consumer electronics, and data storage. As such, the growth of the industry is highly related to the growth and broad trend of the end-use industries.
- Customers in certain end-use industries often require their suppliers to obtain industry-specific certifications. The lengthy certification process may take from six months to two or three years. For instance, Standardized Supplier Quality Assessment (SSQA), a certification for quality management system used in the semiconductor industry as a critical pre-requisite for industry leading semiconductors original equipment manufacturers when selecting suppliers. The assessment consists of a self-assessment by the supplier followed by a customer (such as American Materials) validation of the findings. The SSQA score from the assessment of Customer A is recognised by many of other customers in the semiconductor industry. AS9100 and NADCAP, each a widely adopted and standardized quality management system for aerospace manufacturing, are key pre-requisite for leading aerospace companies such as Boeing and Airbus when selecting their suppliers. For the oil & gas industry, ISO 29001 is widely adopted as the quality management system requirement. ISO 29001 defines the quality management system requirements for the design, development, production, installation and service of products for the petroleum, petrochemical, and natural gas industries.

Major classification of precision engineering

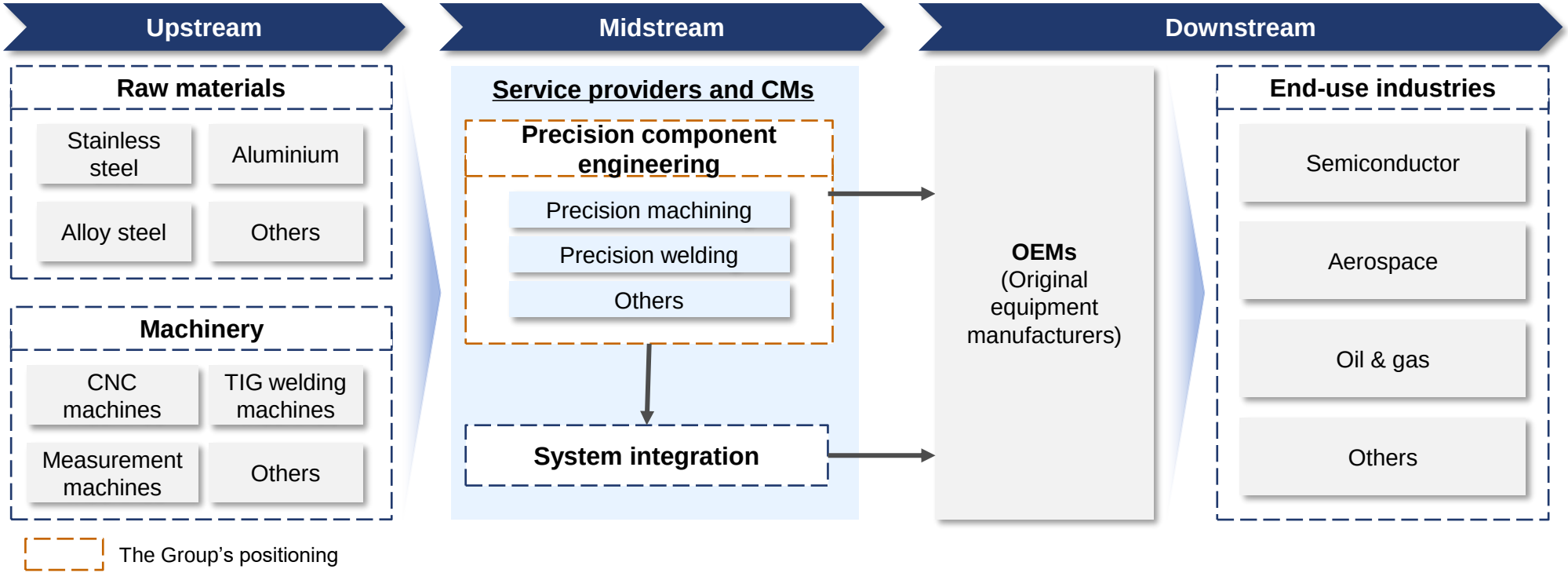
Classification	Definition
Precision machining	• Precision machining is a process which removes excess materials from a workpiece with extreme accuracy to create components with tight tolerance. The precision machine has many types, including turning, milling, grinding, drilling, etc. • Precision machining involves using CNC machines and other advanced machine tools to cut and shape materials and to produce parts that meet extremely strict specifications in terms of size, shape, surface finish and other geometric attributes with micrometer-level of accuracy. The precision machine today is generally controlled using Computer Numerical Controls (CNC) system and supported by CAD & CAM software such as Solidworks, Mastercam, Hypermill.
Precision welding	• Precision welding describes the process by which welds are applied to a workpiece in a very precise and controlled fashion. For example, pipes of various diameters can be welded into various shapes. Dimensional tolerances are tight for both the position of the weld line as well as the depth of the weld. Precision welding is typically used for small parts, parts with tight dimensional tolerances, or parts requiring a barely visible line weld. Some commonly used welding methods include TIG welding, Plasma arc welding, MIG welding, etc. • Precision welding involves using advanced welding methods and specialised processes such as laser and electron beam to join materials together according to strict specifications and tolerance.
Others	• Others include precision surface treatment, precision metal fabrication, heat treatment, system integration, etc. • Surface treatment is an additional process applied to the surface of a material for the purpose of adding functions such as rust and wear resistance or improving the decorative properties to enhance its appearance. Heat treatment is the process of heating metal without letting it reach its molten, or melting, stage, and then colling the metal in a controlled way to select desired mechanical properties.

Source: China Insights Consultancy

Value chain of the precision engineering industry

- The value chain of the precision engineering industry can be divided into upstream, midstream, and downstream; midstream activities create substantial value through precision component engineering and system integration

Value chain of the precision engineering industry



- The upstream of the precision engineering industry consists of raw materials and machinery suppliers. Stainless steel, aluminium, and alloy steel are commonly used raw materials in the industry. There are many types of machinery used including Computer Numerical Control (CNC) machines and Tungsten Inert Gas (TIG) welding machines, etc. Currently, CNC machines are the dominant tools for machining materials.
- It is a common practice for CMs and service providers in the precision engineering industry to have overlapping customers and suppliers as raw material suppliers may also require precision engineering services for their own manufacturing equipment and/or products. This interdependence stems from the maturity and transparency in the precision engineering industry, close and complementary relationships between the business partners and the need for specialised expertise for each process along the supply chain.

- The midstream of the precision engineering industry involves service providers and contract manufacturers (CMs). Service providers receive orders from both CMs and OEMs mainly for the precision component engineering whereas CMs directly receive orders from OEMs and may subcontract part of the production process to service providers. Tthe main responsibility of the service providers is provision of precision component engineering and related services. The main responsibility of CMs is to manufacture and assemble precision engineering components in accordance with the specification of OEMs. It is common for service providers and CMs to outsource part of the process to other service providers along the value chain.

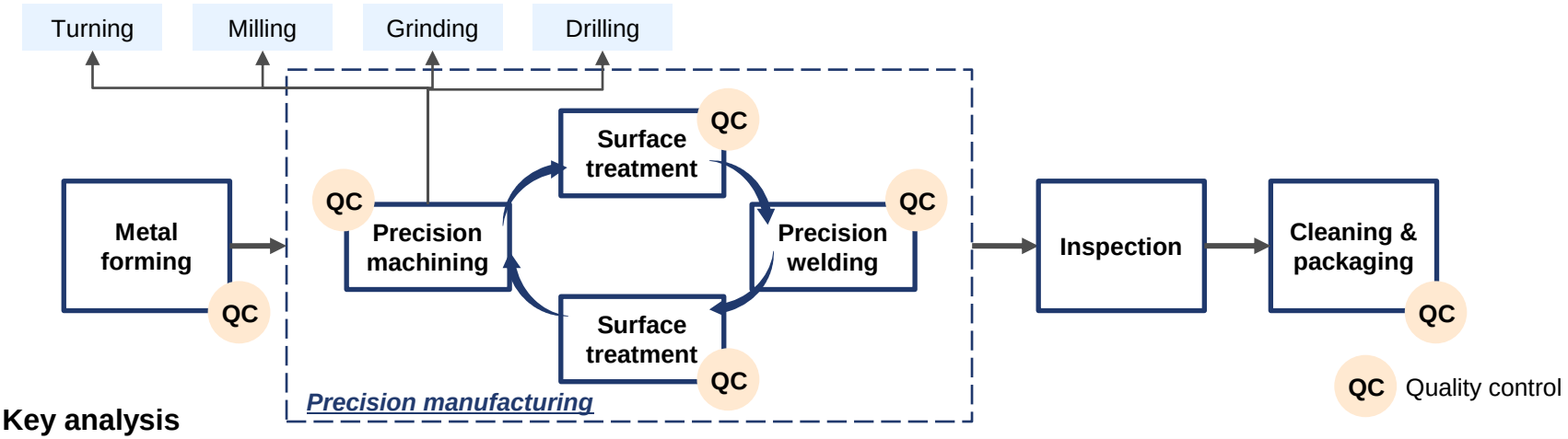
- The downstream of the precision engineering industry consists of OEMs and diverse end-use industries of their products, mainly including semiconductors, aerospace, oil & gas, and others.
- OEMs outsource all or a portion of the engineering and manufacturing of the final products to the specialised suppliers, including CMs and service providers. OEMs may require CMs to source components from certain certified service providers to ensure the quality of products.

Source: China Insights Consultancy

Precision engineering process

- Precision engineering consists of precision manufacturing and precision assembly. The manufacturing process varies a lot depending on the product and the end-use industry. A typical process in manufacturing semiconductor-related components usually consists of metal forming, precision machining, precision welding, surface treatment, inspection, and cleaning & packaging

An example of the whole process to produce a semiconductor related precision component



Key analysis

- **Precision engineering consists of precision manufacturing and precision assembly.** The manufacturing process varies a lot depending on the end-use industry and the product. **A typical process in manufacturing semiconductor-related components usually consists of metal forming, precision machining, precision welding, surface treatment, inspection, and cleaning & packaging.** Among all, precision machining and precision welding are typical core and precision manufacturing procedures. **Quality control** is an important procedure and usually involves each step of the precision manufacturing process.
- **Precision machining** is a value-added part of the process while it is also an intricate process that encompasses turning, milling, grinding, drilling, etc. It is a process where aluminium and other metals are processed to meet the product specifications using CNC machines, advanced and computerized machine tools that are commonly used in the precision engineering industry. **Precision welding** describes the process by which welds are applied to a workpiece in a very precise and controlled way. There are many types of welding including TIG welding, Plasma arc welding, MIG welding, etc. **TIG welding usually produces the highest quality welds** of all because the operator has more manual control over the welding process, meaning that the weld can be strong without burning through the parent material and requires precision and skill to complete. Orbital welding machines can be attached to TIG welding machines to convert manual welding to automated one and achieve higher safety and more efficiency. To produce high-purity precision welds, which involves processes such as tack welding and orbital welding, the use of a cleanroom ranging from Class 1 to Class10,000 is required. The possession of high-level cleanroom, e.g. Class 100 and above, is considered to be an advanced capability in the industry. Mechanical polishing is a process of smoothing surfaces with mechanical force to remove scratches and discoloration on tubes and pipes. It is only required for products which are not produced in a clean room. **Surface treatment** is a process applied to the surface of a material for the purpose of adding functions such as rust and wear resistance. After producing the product, as part of the quality control process, a final **inspection** will be carried out, which includes visual checking, helium leak testing, etc. Helium leak testing involves the use of machines which are of ultra-high vacuum to locate and measure the size of leaks into or out of the parts produced using high purity helium gas. **Cleaning & packaging** requires the use of a cleanroom that filters out contaminants and particulates like dust, and airborne microbes to create the cleanest space possible. This process is usually used to produce gas pipes, pharmaceutical equipment, semiconductor equipment components, etc. Products that are required to be produced and cleaned in a cleanroom, high frequency and high intensity sound waves (usually 50khz) in high purity water and chemicals are used to filter out contaminants and to remove stains. For parts which do not need to be cleaned in a clean room, electroplating is generally used to produce a metal coating on parts using direct electric current to protect the parts from oxidation.
- In the semiconductor sector, possessing both precision machining and precision welding capabilities is vital for manufacturing intricate components. Precision machining ensures accurate fabrication of delicate semiconductor parts, while precision welding enables the assembly of these components with meticulous accuracy, ensuring optimal functionality and reliability in the final semiconductor products.
- Electropolishing is an electrochemcial finishing process that improves surface finish by removing a thin layer from stainless steel or other metals. This process does not need to be conducted inside a cleanroom and is outsourced to third party service providers due to licensing requirements and requirement of specific equipment. Chemical cleaning is to remove contaminants and weld scale using chemical such as nitric acid and hydrochloric acid.
- For chemical cleaning, electropolishing and surface treatment, depending on the specific processes and chemicals used, the companies may be subject to specific ISO standards such as ISO 16232, ISO 8501, ISO 10683, ISO 11408 and ISO 15730, Hazardous Substances Permit Control issued by National Environment Agency (NEA) for handling the hazardous chemicals, and trade-specific certifications such as nickel electroplating certification from the American Electroplaters and Surface Finishers Society (AESF) to demonstrate their competency in nickel electroplating.
- Products produced using precision welding include: (i) water lines: used for supplying water or for cooling purposes; (ii) vacuum lines: used for opening and closing certain hardware as a shutter; (iii) gas lines: used for running different types of gas and have to be produced in clean room
- Mechanical assembly is used to assemble large and complex products. Assembly testing is conducted after the mechanical assembly to check that the positioning of parts meet the required specifications

Source: China Insights Consultancy

Primary precision machining and welding methods

- Primary precision machining methods include turning, milling, grinding, and drilling; primary precision welding methods include TIG welding, Plasma arc welding, and MIG welding

Primary precision machining and welding methods

Precision machining methods	Description
Cutting	Cutting involves the use of CNC machines (automatically) or cold saw (manually) to cut tubes and pipes into the required length
Turning	Turning rotates the workpiece against a cutting tool. It uses primarily round bar stock for machining components. CNC turning machines (horizontal or vertical) are commonly used
Milling	Milling spins the cutting tool against a stationary workpiece. It uses primarily square or rectangular bar stock to produce components. CNC milling machines (horizontal or vertical) are commonly used
Grinding	Grinding uses abrasive surfaces to remove material from metal workpieces
Drilling	Drilling is a cutting process in which a drill bit is used to cut or enlarge a hole in a solid material
Bending	Bending involves bending tubes and pipes into a required shape manually or using CNC bending machines
Facing	Facing is performed to remove the sharp edges at the cutting point of the stainless steel tube and pipe after cutting and bending
Ball pulling	Ball pulling is used to form an extension to the holes on tubes
Polishing	Polishing is performed in order to remove cutter marks on top surfaces, sides, inner diameters and channels of the parts and components. Deburring tools and polishing brushes are used as part of the polishing process to remove such marks

Types of welding method	Description
TIG welding	Tungsten Inert Gas (TIG) welding is technically called gas tungsten arc welding (GTAW). It produces the weld and weld metals with a non-consumable tungsten electrode. In the TIG welding process the arc is formed between a pointed tungsten electrode and the workpiece in an inert atmosphere of argon or helium. The process can be manual or semiautomatic
Orbital welding	Orbital welding refers to automated welding of secured tubes or pipes. It has almost always exclusively been carried out by the TIG technique. Welders need to put the tubes or pipes on a weld pit and an orbital weld head with an electrode rotating (or orbiting) around weld joint of the tube. This process is fully programmable.
Plasma arc welding	Plasma arc welding (PAW) is very similar to TIG welding as the arc is formed between a pointed tungsten electrode and the workpiece. However, by positioning the electrode within the body of the torch, the plasma arc can be separated from the shielding gas envelope.
MIG welding	Metal Inert Gas (MIG) welding employs a consumable wire that acts as both the electrode and the filler material. It is generally used for large and thick materials
Tack welding	Tack welding is a temporary welding process used to hold parts together in preparation for final welding and to maintain the desired alignment and gap between the pieces being welded together

Source: China Insights Consultancy

Major equipment and software used in the precision engineering industry

- Major equipment used include turning & milling machines, multi-axis CNC machines, bending machines, TIG welding machines, helium leak detectors, etc. Major equipment used usually has a useful life of between 5 to 15 years and is generally controlled using a CNC software

- Most precision engineering operations use computer-controlled equipment to remove substrate material from workpieces. It allows for the creation of complex geometries and intricate details. CNC machines normally need to be able to achieve a tolerance of at least ±10μm for machined components and achieve a tolerance of at least ±100μm for large-sized vacuum chambers. Many of these CNC machines are imported from Japan, Germany, and Taiwan. CNC machines from these two countries are featured with higher precision and longer usage life. The equipment used in the precision engineering industry usually has a useful life of between 5 to 15 years. Apart from equipment, the software is also used and plays an important role in assisting the workflow are required. These kinds of professional personnel are under intense competition and are competitive advantage to the industry plamanufacturing of precision components. Professional personnel with the knowledge and experience to operate these machines and design manufacturing yers.

Major equipment

Turning & milling machines
- Useful life: ~10-15 years
- Function: remove unwanted material from the stock material using stationery and rotates.

Multi-axis CNC machines
- Useful life: ~10-15 years
- Function: allow the cutting tool to work on five axes to deliver a final part.

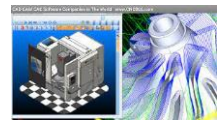
Bending machines
- Useful life: ~10-15 years
- Function: bend metal tubes and sheet metal at an angle and shape.

TIG welding machines
- Useful life: ~15 years
- Function: produce the weld with a non-consumable tungsten electrode.

Helium leak detectors
- Useful life: ~10 years
- Function: locate and measure the size of leaks into or out of a system or containing device. A professional leak detector is needed to locate leaks with speed, accuracy, reliability, high accuracy and sensitivity

Major software

CNC control software
- CNC control software reads program codes and creates signals to control the physical movements of manufacturing equipment. **CNC control software can be used to control a range of equipment**, including grinders, lathes, mills, and routers. By doing so, it eliminates the limitations of traditional manual machining, in terms of accuracy, production rate, and speed. Indeed, CNC control software facilitates the production of complex metal components, which would be difficult to create manually.



"CAD-CAM“ software
- CAD is software for computer-aided design, while CAM is software for computer-aided manufacturing. In practice, the software is used to translate computer-aided design to manufacturing workpieces with computer-aided manufacturing on CNC machines.

Note: according to secondary research, annual reports and prospectus of CNC machines manufacturing companies, the accounting estimate of useful life for CNC machine is usually 10 years. However, it is normal for CNC machines to have a service life of over 10 years with regular maintenance procedures.

Source: China Insights Consultancy

Machines	Description
Coordinate measurement machines	A coordinate measuring machine is a measuring device that measures the geometry of objects by establishing discrete points on a physical surface using a contact probe.
CNC lathe machines	A CNC lathe machine is a machine tool where the material or part is held in place and rotated by the main spindle as the cutting tool that works on the material is mounted and moved on various axes.
CNC milling machines	A CNC milling machine is a machine operated cutting tool programmed and managed by Computer Numerical Control (CNC) systems to to progressively remove material from the workpiece and produce a custom-designed part or product
wire cut machines	Wire cutting machines are used to cut various types of wire and flexible tubing to specific lengths.
Metal cutting machines	Metal cutting machines are machine tools used to fabricate parts by the removal of material, typically metal.
Electrical discharge machines	Electrical discharge machines are used to remove material from a workpiece by using electrical discharges.

Difference between CNC machines with different axis:

A CNC machine is a computer-controlled device that moves along linear or rotary axes to perform various tasks, such as cutting or drilling. A CNC machine has typically three axes: the X-axis, the Y-axis, and the Z-axis. These axes correspond to the movement of the machine's tool in the corresponding direction. The 4th axis denotes the inclusion of an A axis (rotation around the X axis), and the 5th axis denotes the B axis (rotation around the Y axis). The difference comes in the additional capability to rotate about different planes. Both 4-axis and 5-axis CNC milling allow rotation about different coordinates and this quality results in the creation of more complex shapes with relative ease.

Insurance:
The insurance policies maintained by the Group, including business insurance (which covers property, business interruption, public and production broad form liability), work injury compensation insurance, group health insurance, hospital and surgical (for foreign workers) policy, industrial all risk insurance, public liability insurance and combined general liability insurance, are in line with the industry practice.

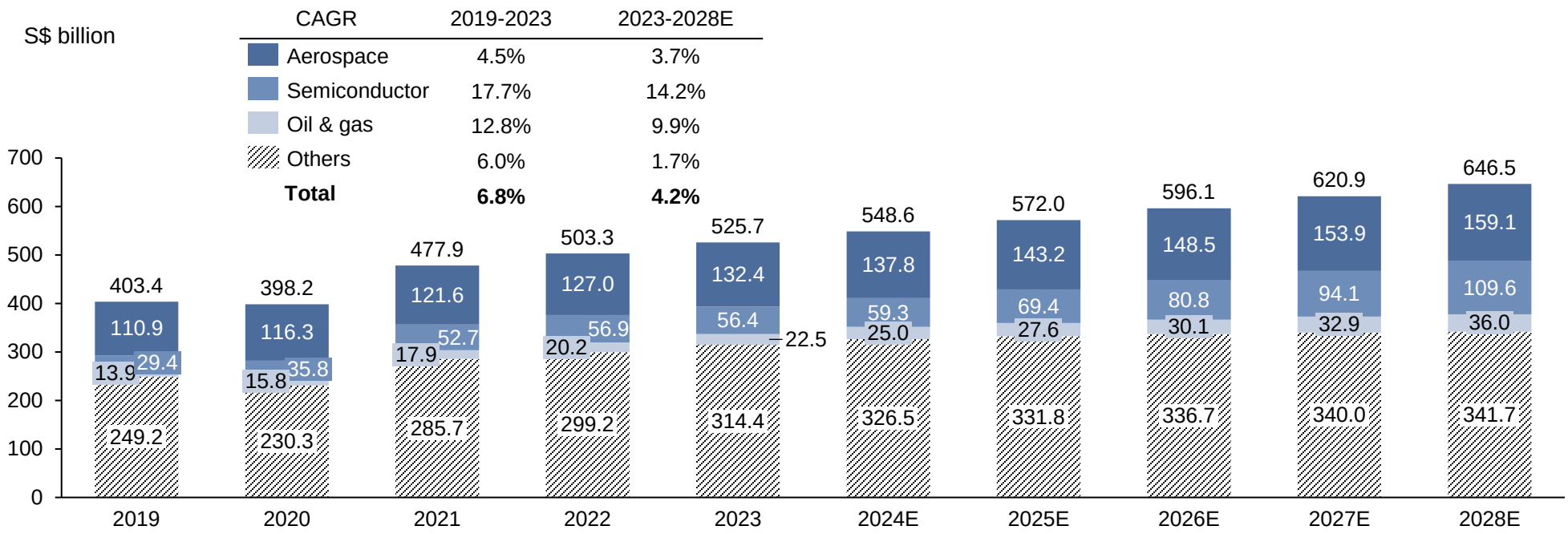
Consignment arrangement :
Consignment arrangement is a relatively common practice in the precision engineering industry.

Long-term contracts:
It is not uncommon in the precision engineering industry that companies do not enter into any long-term contract or framework sales agreement with their customers due to (i) precision engineering companies may prefer to maintain flexibility in their pricing strategies to respond to changes in market conditions or to adjust their pricing in response to changes in production costs; and (ii) precision engineering companies may operate in industries where demand for their products can be unpredictable, hence long-term contracts may not be feasible as they could lead to overproduction or underutilization of resources.

Market size and growth rate analysis of the global precision engineering industry by industry sector

- The global output value of the precision engineering industry increased from S$403.4 billion in 2019 to S$525.7 billion in 2023 at a CAGR of 6.8%, and is expected to increase to S$646.5 billion in 2028, indicating a CAGR of 4.2% between 2023 and 2028

Total output value of the precision engineering industry, by industry sector, Global, 2019-2028E



Note: Others include medical devices and automotive, etc.

Analysis

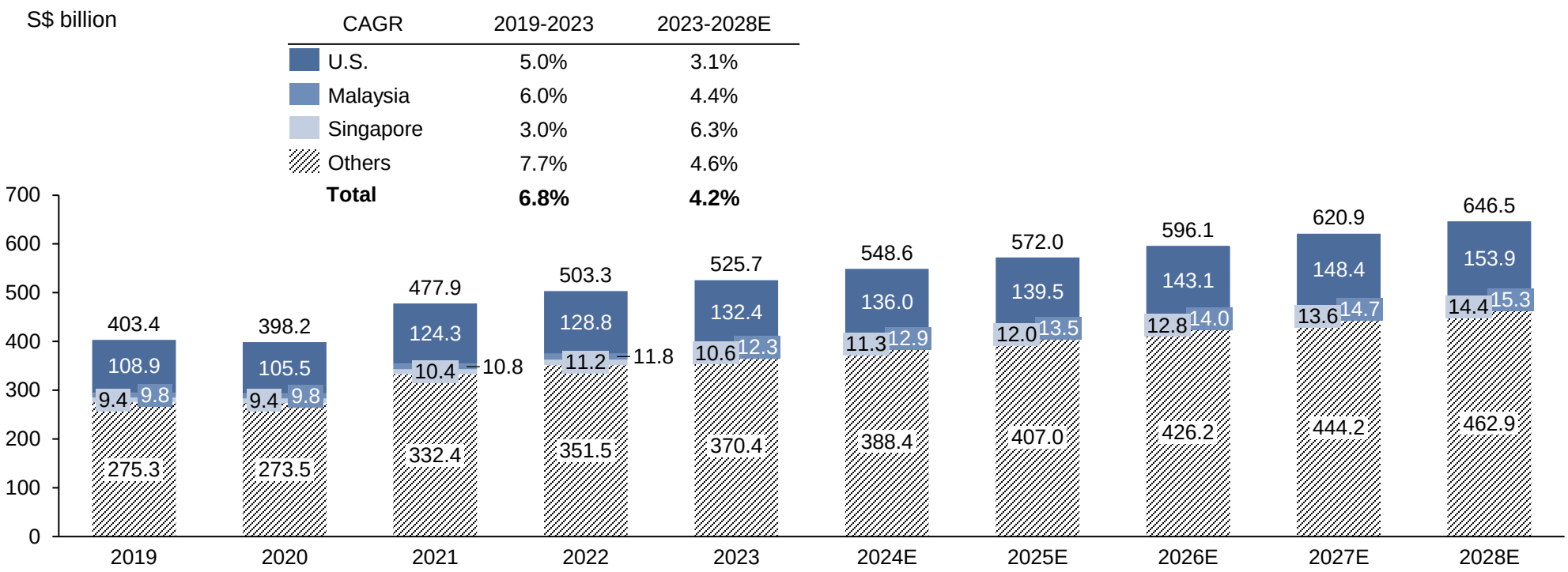
- The global output value of the precision engineering industry increased from S$403.4 billion in 2019 to S$525.7 billion in 2023 at a CAGR of 6.8%, and is expected to increase to S$646.5 billion in 2028, indicating a CAGR of 4.2% between 2023 and 2028. The global semiconductor industry and the global semiconductor manufacturing equipment industry are cyclical in nature driven by fluctuation of inventory and worldwide economic growth. The volatility and uncertainty within the global semiconductor industry and the global semiconductor manufacturing equipment industry are in turn driven by changes in economic, political or financial conditions and other factors such as impact of tariffs and/or trade barriers. As a result, the semiconductor manufacturing equipment industry has experienced steady growth over the last five years from 2019 to 2023 and is expected to sustain the growth in the long term. The semiconductor sector of the precision engineering industry is generally affected by the cyclical nature of the semiconductor industry and does not present significant seasonality. Despite experiencing a temporary downturn in 2023 due to the cyclical de-stocking of inventories accumulated since 2022 in the semiconductor market, the semiconductor sector of the global precision engineering industry has witnessed robust growth between 2019 and 2023, with a CAGR of 17.7%. Hence, the global semiconductor manufacturing industry is expected to resume growth, starting from the third quarter of 2024, fueled by the surge in demand for artificial intelligence and sales of electronics products and integrated circuits. Looking forward, the global output value of semiconductor sector of the precision engineering industry is expected to reach S$109.6 billion by 2028 with a CAGR of 14.2% between 2023 and 2028. The oil & gas sector of the precision engineering industry is expected to register a CAGR of 9.9% between 2023 and 2028 considering the oil & gas industry is currently and will remain critical to the global economic activity and prosperity. Although the industry did not exhibit any significant seasonality, there are fluctuations caused by the global industry trade cycle of downstream customers. For example, semiconductor industry is a highly cyclical and subject to periodic booms and busts due to the relatively short lifespan of semiconductor products.
- The operating hours of precision engineering industry in Singapore are generally shorter during the first quarter of each calendar year as a result of the Chinese New Year holiday season, whereas demand is stronger for products in the end-use industries (such as electronic products) during festive seasons such as Thanksgiving Day and Christmas, which drives the procurement of parts and components for manufacturing equipment of semiconductor during the second half of the year.
- During FY2021, FY2022 and FY2023, a significant portion of the Company's revenue was derived from major customers in the semiconductor manufacturing equipment industry.

Source: SEMI, China Insights Consultancy

Market size and growth rate analysis of the precision engineering industry by geographical location

- Singapore and Malaysia represent 2.0% and 2.3% of the global precision engineering industry in 2023, respectively

Total output value of the precision engineering industry, by geographic location, Global, 2019-2028E



Note: Others include China, Japan and Germany, etc.

Analysis

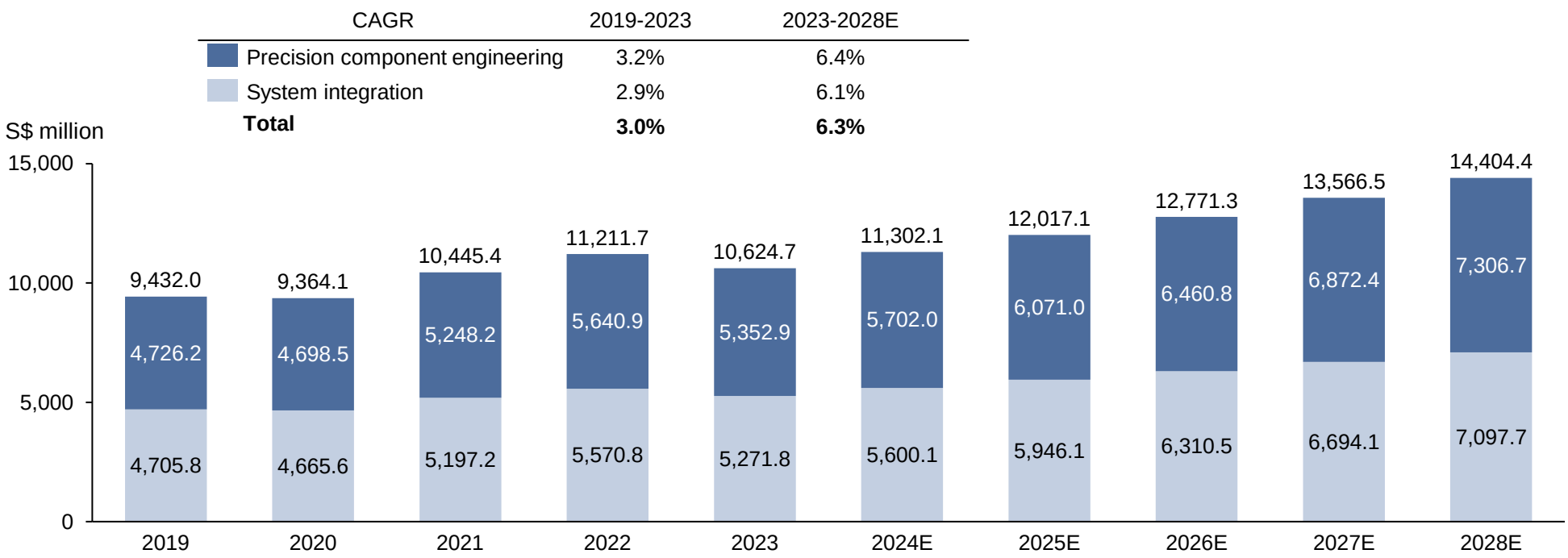
- The U.S. represented the largest market in the global precision engineering industry in 2023. Its output value increased from S$108.9 billion in 2019 to S$132.4 billion in 2023, registering a CAGR of 5.0% during the period, and is expected to further increase to S$153.9 billion in 2028, indicating a CAGR of 3.1% between 2023 and 2028. With the support of local government and the development of the local industry, Singapore and Malaysia represent 2.0% and 2.3% of the global precision engineering industry in 2023, respectively, and are expected to grow at a CAGR of 6.3% and 4.4%, respectively, between 2023 and 2028. Other countries include China, Japan and Germany, etc.

Source: The World Bank, Singapore Department of Statistics, Department of Statistics Malaysia, China Insights Consultancy

Market size and growth rate analysis of the Singapore precision engineering industry

- The total output value of the precision engineering industry in Singapore increased from S$9,432.0 million in 2019 to S$10,624.7 million in 2023 and is expected to increase to S$14,404.4 million in 2028

Total output value of the precision engineering industry, Singapore , 2019-2028E



Analysis

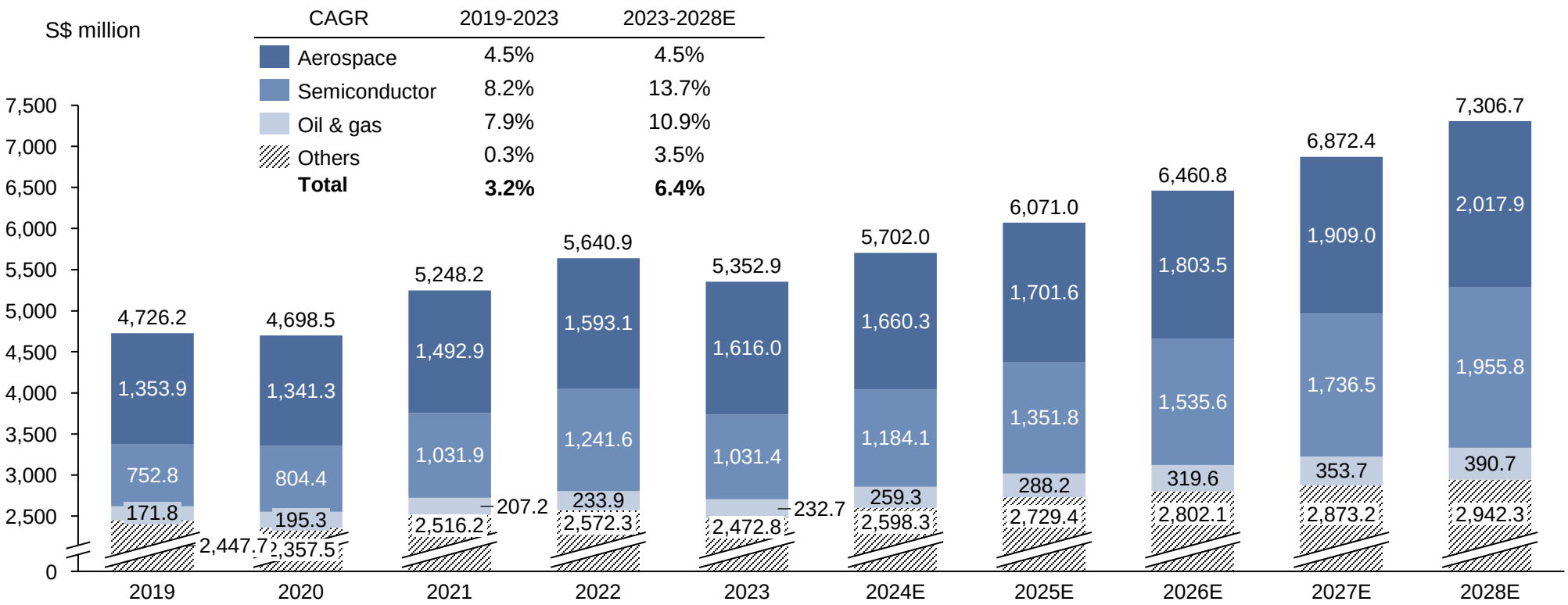
- The Singapore government values the importance of the precision engineering industry and has introduced favourable policies and measures such as Industry Transformation Maps (ITMs) and Precision Engineering Industry Digital Plan (IDP) to support the development and growth of the industry. The precision engineering industry comprises precision component engineering and system integration. The output value of precision component engineering in Singapore increased from S$4,726.2 million in 2019 to S$5,352.9 million in 2023, registering a CAGR of 3.2% during the period. It is expected to further increase to S$7,306.7 million in 2028, indicating a CAGR of 6.4% between 2023 and 2028. The output value of system integration in Singapore also increased from S$4,705.8 million in 2019 to S$5,271.8 million in 2023, registering a CAGR of 2.9% during the period and is expected to increase to S$7,097.7 million in 2028 with a CAGR of 6.1% between 2023 and 2028.

Source: Economic Development Board, China Insights Consultancy

Market size and growth rate analysis of the Singapore precision component engineering industry by industry sector

- The total output value of the precision component engineering industry increased from S$4,726.2 million in 2019 to S$5,352.9 million in 2023, and is expected to increase to S$7,306.7 million in 2028, indicating a CAGR of 6.4% between 2023 and 2028

Total output value of the precision component engineering industry, by industry sector, Singapore, 2019-2028E



Note: Others include consumer electronics and automotive, etc.

Analysis

- The downstream segments of the precision component engineering industry include aerospace, semiconductor and oil & gas industry. The aerospace represents the largest segment in the precision component engineering industry in Singapore as Singapore is the leading aerospace hub within Asia, offering a comprehensive range of maintenance, repair and overhaul (MRO) services and advanced manufacturing capabilities. As a one-stop shop for all aerospace needs, many of the world's leading aerospace related OEMs and MRO service providers have been consolidating their presence in Singapore as a regional hub in Asia. In the semiconductor segment in Singapore, the output value increased from S$752.8 million in 2019 to S$1,241.6 million in 2022, and slightly declined to S$1,031.4 million in 2023, with a CAGR of 8.2% between 2019 and 2023. The decline in output value in 2023 was due to the cyclical de-stocking of inventories accumulated since 2022 in the global and Singapore's semiconductor industry. The global and Singapore's semiconductor market is expected to resume growth trend starting from the third quarter of 2024, fueled by a surge in demand for artificial intelligence technologies and sales of electronic products and integrated circuits. Manufacturing equipment used to fabricate integrated circuits (ICs) and displays are sophisticated and require stringent technical specifications and high quality standard. The semiconductor sector of the precision component engineering industry in Singapore is expected to further grow to S$1,955.8 million in 2028, indicating a CAGR of 13.7% between 2023 and 2028, due to the rapid development of downstream industries such as AI, 5G technology, consumer electronics and cloud service.

Source: Economic Development Board, China Insights Consultancy

Market drivers of Singapore's precision component engineering industry

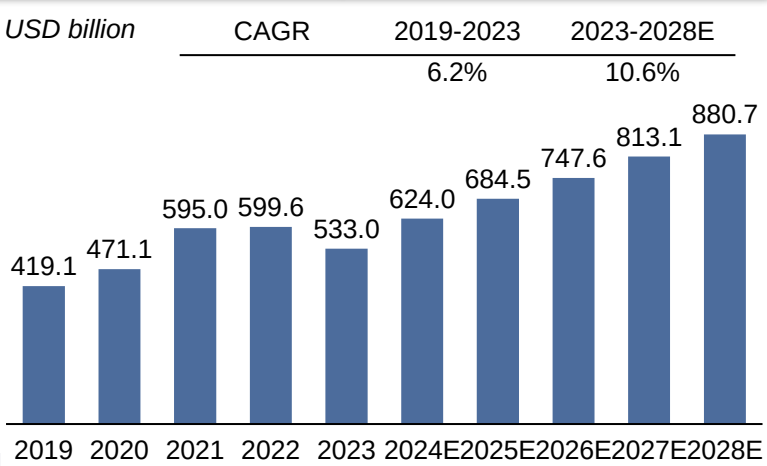
Market drivers	Analysis
1  **The rapid growth of downstream industries such as semiconductor, aerospace, and oil & gas industry**	• Precision component engineering is widely applied to produce components with complex structures or certain special technical items in many growing industries including the semiconductor, aerospace, and oil & gas industry. Revenue of global semiconductor industry is projected to reach USD880.7 billion in 2028 with a CAGR of 10.6% between 2023 and 2028. Global sales of semiconductor manufacturing equipment increased from USD61.7 billion in 2019 to USD106.3 billion in 2023, registering a CAGR of 14.6% between 2019 and 2023. According to SEMI, 2024 will be a transition year and a strong rebound in 2025 is expected. In 2022 and 2023, due to the instability of the global economy post-COVID, subdued consumer demand, increased industry risks, and disruptions in the supply chain, the semiconductor industry experienced low inventory levels with companies actively reducing inventory. However, by early 2024, with the gradual recovery of the economy and stabilization of the market, inventory levels are expected to gradually normalize, driving an increase in demand for advanced technologies and solutions across front-end and back-end segments. Driven by capacity expansion, new fab projects, and high demand for advanced technologies and solutions across the front-end and back-end segments, global sale of semiconductor manufacturing equipment is expected to increase to USD180.6 billion in 2028, registering a CAGR of 11.2% between 2023 and 2028. The global aerospace and defence market is expected to register a CAGR of 4.3% between 2023 and 2028 due to increase in air travel and aviation activities. The global energy investment (including investment in the oil & gas industry) is expected to register a CAGR of 9.8% between 2023 and 2028. The continual growth of the semiconductor, aerospace, and oil & gas industry in the world drives up the demand and presents more opportunities for precision components and supports the further development of Singapore's precision component engineering industry. There has been an increase in demand from customers for precision machining services in Singapore and Malaysia due to recovery from the COVID-19 pandemic. • During FY2021 and FY2022, a significant portion of the Company's revenue was derived from major customers in the semiconductor manufacturing equipment industry.
2  **The advancement of high-precision machine tools provides a higher level of accuracy, repeatability, and efficiency**	• The scope of the precision component engineering industry is expanding due to the advancement of high-precision machine tools. Major advancements include (i) multi-axis CNC machines; (ii) more automated operations; and (iii) more integrated machining centres. These advancements provide a higher level of accuracy, repeatability and efficiency during production. Currently, major downstream sectors of the precision component engineering industry, such as automobile and semiconductor industries, are showing a trend toward more precise and miniaturized components, which poses the need for advanced high-precision machine tools. With the rising technological capabilities, further development of high-precision machine tools is expected and will continue to fuel the industry in the long run.
3  **Favourable business environment that support the development of the precision component engineering industry in Singapore**	• The favourable policies and incentives in Singapore promises the precision component engineering industry a high potential future and drives this industry towards a digital revolution and global expansion. The Singapore government values the importance of the precision component engineering industry and has introduced various encouraging policies and measures to help the industry prosper. Under the *Research, Innovation and Enterprise (RIE) 2025 Plan*, the Singapore government planned to invest S$25 billion in research, innovation, and enterprise between 2021 and 2025. One of the objective is to leverage research and development to reinforce Singapore's position as a global business and innovation hub for advanced manufacturing and connectivity. *Precision Engineering Industry Digital Plan (IDP) was* developed in 2021 to support small-to-medium companies in Singapore that provide precision engineering services with digital solutions and training to enhance employees digital skills. The favourable business environment for the precision component engineering industry in Singapore is expected to continue in the future, and therefore will support the further development of the industry.

Source: China Insights Consultancy

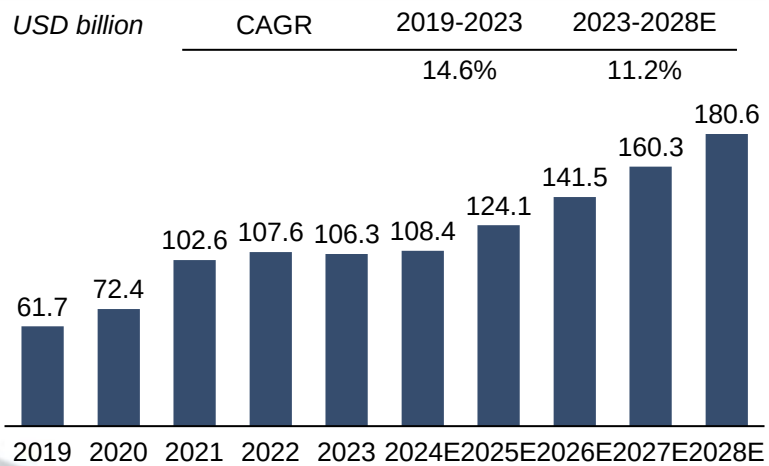
Market drivers of the precision component engineering industry (1/2)

- The rapid growth of downstream industries such as semiconductor, aerospace, and oil & gas industry

Semiconductor industry market size, in terms of revenue, Global, 2019-2028E



Semiconductor manufacturing equipment market size, in terms of revenue, Global, 2019-2028E



Key analysis

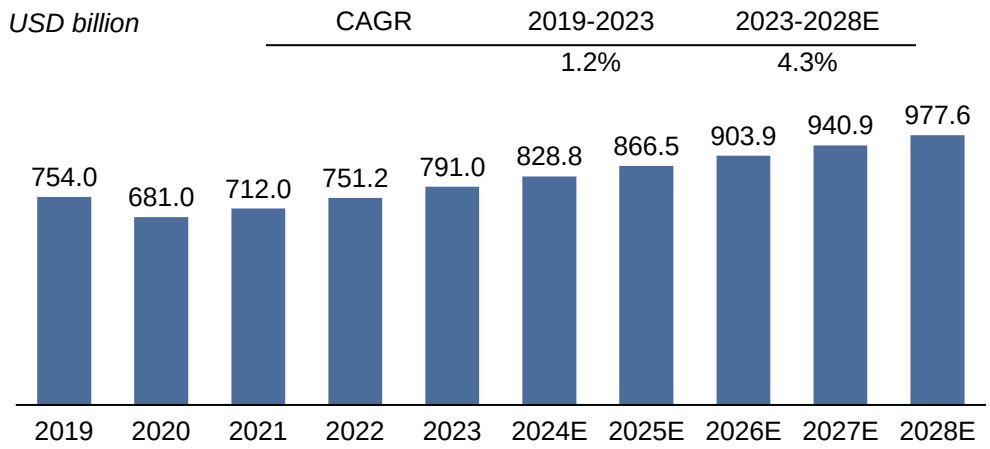
- Precision engineering is widely applied to produce components with complex structures or certain special technical properties in many growing industries including semiconductor, aerospace, and oil & gas industry.
- With a broad range of drivers including mobile demand driven by 5G, new CPU architectures, and the development of cloud, artificial intelligence, and Machine Learning applications, the global semiconductor market has witnessed fast growth during 2021 and 2022. The market size of semiconductor industry increased from USD419.1 billion in 2019 to USD599.6 billion in 2022 and decreased to USD533.0 billion in 2023 due to weaker demand from memory products. It is expected to increase to USD880.7 billion in 2028, indicating a CAGR of 10.6% between 2023 and 2028.
- The semiconductor market's periodic cycle is influenced by global economic cycle, demand-supply relationship, technology upgrade, geopolitical issues, etc. For example, the U.S. has imposed wide restrictions on semiconductors trade with China. Such trade barriers may add to the uncertainties in the industry, and accelerate the development of a more resilient, diverse supply chain.
- The growth of the semiconductor industry during the Track Record Period was affected by the global chip shortage which was largely attributable to the lingering effect of COVID-19 together with surged demand for electronics and disrupted supply. The chip shortage was further fuelled by the military conflicts in Ukraine in 2022 which have put a strain on supplies of important ingredients for chip production such as neon and palladium. There has been an increase in demand for precision engineering services from the customers in the semiconductor industry as their businesses recovered from the COVID-19 pandemic.
- Semiconductor manufacturing equipment industry is the downstream customer of semiconductor sector of precision component engineering industry. Worldwide sales of semiconductor manufacturing equipment increased from USD61.7 billion in 2019 to USD107.6 billion in 2022 and decreased to USD106.3 billion in 2023, indicating a CAGR of 14.6% between 2019 and 2023. According to SEMI, 2024 will be a transition year from the cyclical de-stocking of inventories accumulated since 2022 and a strong rebound in 2025 is expected, driven by capacity expansion, new fabrication projects, and demand for advanced equipment and solutions across the front-end and back-end segments, including wafer processing, test, assembly, package, etc., of the semiconductor industry, and supportive policies of the semiconductor industry across the world, including Singapore Manufacturing 2030 vision, CHIPS and Science Act., The European Chips Act, etc., the global sale of semiconductor manufacturing equipment is expected to further increase to US$180.6 billion in 2028, registering a CAGR of 11.2% between 2023 and 2028. The global aerospace and defence market and the global energy investment (including investment in the oil & gas industry) are expected to register a CAGR of 4.3% and 9.8% between 2023 and 2028, respectively. More supportive policies, including the refreshed Industry Transformation Maps (ITMs) which reflected Singapore's 2025 ambition for building a vibrant ecosystem of digitalised precision engineering enterprises with a global footprint, are expected to be carried out to support the development of Singapore's precision component engineering industry, providing a supportive regulatory environment for future growth. The continual growth of the semiconductor, aerospace, and oil & gas industry in the world drives up the demand and presents more opportunities for precision components and supports the further development of Singapore's precision component engineering industry.
- In 2022 and 2023, the global economy faced instability following the COVID-19 pandemic, resulting in subdued consumer demand, heightened industry risks, and disruptions in the supply chain. Consequently, the semiconductor industry underwent a period of de-stocking, impacting upstream processes like precision machining. Despite this, precision welding activity remained intact in 2023 and will continue to be essential once components or sub-assemblies progress to that stage in the production chain, irrespective of any previous delays or inventory accumulation. By early 2024, as the economy gradually recovers and the market stabilizes, inventory levels are anticipated to normalize, driving increased demand for advanced technologies and solutions across both front-end and back-end segments.
- Worldwide sale of semiconductor manufacturing equipment is expected to increase to USD180.6 billion in 2028, registering a CAGR of 11.2% between 2023 and 2028. After staggering increase in 2021 and 2022, expansion of the semiconductor manufacturing equipment industry is expected to slow down in 2023 due to weak demand for memory chips and programmable logic chips. As excessive inventories of chips are consumed, the semiconductor industry cycle is predicted to head for another round of expansion in 2024, driven by both the front-end and back-end segments.
- According to the RIE 2025, innovation is and will continue to be critical to the nextbound of Singapore's industry transformation and economic growth. To reinforce this initiative, ITM 2025 (Industry Transformation Maps 2025) also provides that "EDB (Economic Development Board) will continue to attract manufacturing investments to strengthen Singapore's leadership position in high-value components such as semiconductors" and "enable the precision engineering industry to capitalise on digital manufacturing technologies and platforms to innovate and deliver competitive products and services for global markets". Such plans are expected to bolster the development of the precision engineering industry in Singapore and hence the Group's business and future prospects. RIE 2025 efforts will be organised along four strategic domains, among which the Manufacturing, Trade and Connectivity (MTC) is the key focus area. To support the manufacturing activities in Singapore, Agency for Science, Technology and Research (A*STAR), Singapore's lead public sector R&D agency, has established three public-private partnership platforms to drive innovation, knowledge transfer and Industry 4.0 technology adoption, which aim to provide continuous support to companies, including those in precision engineering industry, to gain access to research infrastructure and expertise. RIE 2025 also pays great attention to strengthening the R&D capabilities in the semiconductor industry in Singapore
- **Customer A is an industry leader in the global semiconductor manufacturing equipment industry with a market share of approximately 19.5%, in terms of revenue, in 2023.** As the core display equipment provider, Customer A is expected to further grow due to the expansion of the global OLED display industry, which is expected to register a CAGR of 11.1% between 2023 and 2028.

Source: SEMI, China Insights Consultancy

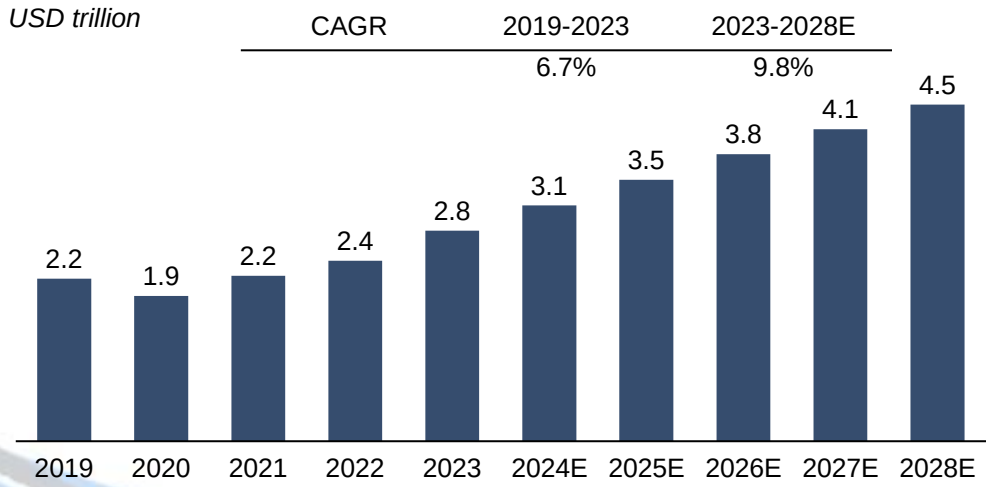
Market drivers of the precision component engineering industry (2/2)

- The rapid growth of downstream industries such as semiconductor, aerospace, and oil & gas industry

Aerospace and defence market size, Global, 2019-2028E



Energy investment, Global, 2019-2028E



Key analysis

- **Precision engineering is widely applied to produce components with complex structures or certain special technical properties** in many growing industries including semiconductor, aerospace, and oil & gas industry.
- The aerospace industry is highly dependent on economic conditions, particularly on the health of the global economy. As passengers' need have gradually been restored after COVID-19 pandemic, the industry is expected to grow in the near future. The oil & gas industry is highly dependent on global demand and supply. Changes in supply, such as production cuts by OPEC, can lead to price fluctuations, while changes in demand, such as the shift towards renewable energy sources, can affect long-term demand for oil and gas.
- The aerospace and defence market has enjoyed a stable growth before the COVID-19 pandemic in 2020. Despite the headwinds, the aerospace and defence market is expect to recover to pre-pandemic levels of output driven by increasing demand for commercial aircrafts. In 2023, the global aerospace and defence market size increased to USD791.0 billion, up from USD751.2 billion in 2022, driven by the resurgence in demand for air travel. It is expected to grow from USD791.0 billion in 2023 to USD977.6 billion in 2028, indicating a CAGR of 4.3% between 2023 and 2028 due to increase in air travel and aviation activities.
- The oil & gas industry will remain critical to economic activity and prosperity. Rapid technological advancements, which have led to the increasing usage of oilfield equipment in the market, resulted in the adoption of advanced drilling techniques and in leads to the growth of the industry. Global energy investment, including investment in the oil & gas industry, is expected to increase from USD2.8 trillion in 2023 to USD4.5 trillion in 2028, indicating a CAGR of 9.8% during the period.
- Based on the Oil 2023 medium-term market report forecasts, based on current government policies and market trends, global oil demand will rise by 6% between 2022 and 2028 and reach 105.7 million barrels per day, supported by robust demand from the petrochemical and aviation sectors.
- The vibrant growth of including the semiconductor, aerospace, and oil & gas industry drives up the demand and presents more opportunities for precision components and modules, fueling the further development of the precision component engineering industry.

Source: IEA, China Insights Consultancy

Market drivers of the precision component engineering industry

- The advancement of high-precision machine tools provides a higher level of accuracy, repeatability, and efficiency

Major advancements in high-precision machine tools include the followings:

1 Multi-axis CNC machines

- They can machine parts on more than four surfaces simultaneously, allowing manufacturers to produce more complex components.

2 More automated operations

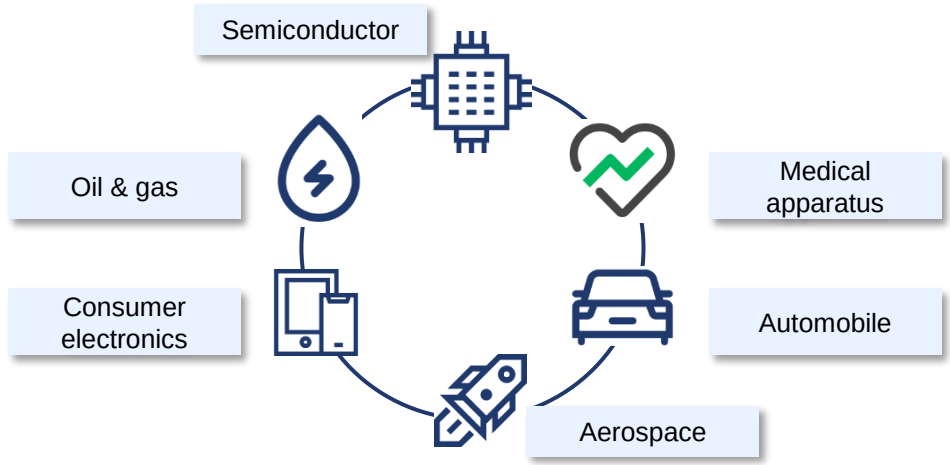
- More machining processes are completed by automated machines, reducing human errors and increasing efficiency.

3 More integrated machining centers

- They can operate a variety of machining operations without changing the attachment of the workpiece, which increase operational efficiency.

Providing solutions for downstream industries

- Currently, major downstream sectors of the precision component engineering industry are **showing a trend toward using more precise components in smaller structures**, which poses the need for advanced high precision machine tools.



Accuracy

- The maximum deviation from the ideal outcome

Repeatability

- The variation in the result over many attempts to produce the same outcome

Efficiency

- The ability to achieve a task with the least amount of cost and effort

- The advancements of high-precision machine tools **provide a high level of accuracy, repeatability, and efficiency**, which in turn makes the process highly cost-effective and scalable. These advancements are desired by downstream industries so that more precise components can be used in their equipment and machines.

Source: China Insights Consultancy

Market drivers of the precision component engineering industry

- Preferable business environment that support the development of the precision component engineering industry in Singapore

Policy overview of Singapore's precision engineering industry

Policy / incentives	Date	Brief	
Industry Transformation Maps (ITMs)	2022	The refreshed ITMs outlined the strategies for five sectors including PE industry. It reflected Singapore's 2025 ambition for a vibrant ecosystem of digitalised PE enterprises with a global footprint. This will be done by focusing on innovation, embracing sustainability and training talent to seize job opportunities.	1 2 4
Precision Engineering Industry Digital Plan (IDP)	2021	The Digital Roadmap maps out different digital solutions that SMEs can adopt at different stages of their business growth and digital maturity. It also offers a corresponding roadmap of training programs to equip employees with the right skill sets.	1 4
Research, Innovation and Enterprise (RIE) 2025 plan	2020	Government planned to invest S$25 billion in research, innovation, and enterprise between 2021 and 2025. One of the objective is to leverage R&D to reinforce Singapore's position as a global business and innovation hub for advanced manufacturing and connectivity.	3
TAP (Train And Place) and Grow initiative	2020	Yellow Ribbon Singapore (YRSG) works with employers across various industries, training institutions, and community partners to set up training academies in prison to help the inmates with employment assistance.	4
Productivity Solutions Grant (PSG)	2018	The Productivity Solutions Grant supports companies keen on adopting IT solutions and equipment to enhance business processes and to improve productivity. PSG solutions have been pre-scoped by various government agencies, comprising both sector-specific solutions and solutions that cut across industries including advanced manufacturing.	1 3
SME Centre @ SCCCI	2018	The SME Centre @ SCCCI is a one-stop business service center that supports Singapore enterprises in venturing into the overseas markets through a suite of integrated services including business advisory, market information, and business matching.	2
Industry 4.0 incentives	2017	Singapore government set aside S$2.4 billion to support the initiative.	

With the business support from the Singapore government and local institutions, the precision engineering industry in Singapore is likely to further expand.

1 **Digitalization**

- The government is urging precision engineering companies to shift to a digitalized manufacturing style.
- Government has provided guidance and financial incentives to help companies equipped with digital solutions.

2 **Overseas expansion**

- SME Centre can help companies enter the overseas market easily with their sufficient experience and knowledge.

3 **Financial incentives**

- Singapore government is offering financial incentives to qualified precision engineering companies. etc.

4 **Human capital**

- Shortage of experienced workers is a great headache for the precision engineering industry. Institutions in Singapore are carrying out a program to train prisoners as skilled workers.
- Singapore government is also setting up standard employee training programs for the precision engineering industry.

Source: China Insights Consultancy

Future trends of Singapore's precision component engineering industry

- Future trends include (i) One-stop-shop manufacturing service; (ii) increasing requirements for high-end equipment and skilled manpower; and (iii) continuous supportive regulatory environment in Singapore

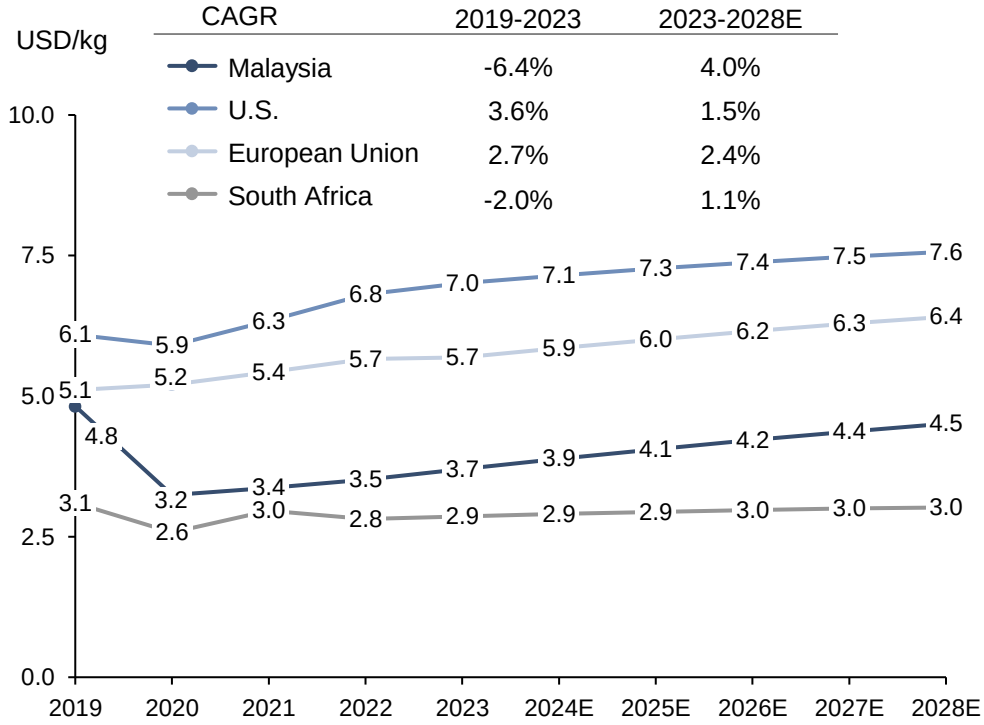
Future trends	Analysis
1 **One-stop-shop manufacturing service**	• The production of precision engineering equipment involves many manufacturing processes including metal fabrication, precision machining, precision welding, surface treatment, cleaning & packaging, assembly, etc. Service providers and CMs usually have a different mix of in-house manufacturing capabilities which consist of one or more of such services. Major downstream customers have been streamlining and consolidating their supply chains due to convenience and cost-effectiveness considerations. They are looking for manufacturers who can provide a one-stop-shop manufacturing service, covering an extensive range of services. Manufacturers may also strengthen their competitiveness by expanding their service scopes through vertical integration of different manufacturing processes. One-stop-shop manufacturing service providers can reduce the lead time spent on production and transportation, reduce operational costs, ensure stability of the deliverables and increase overall efficiency.
2 **Increasing requirements for high-end equipment and skilled manpower**	• The end-use industries of the precision component engineering industry are continuously evolving in technology, applications and equipment. The downstream industries of the Group's customers, including semiconductors, aerospace and data storage industries, are constantly evolving and the technical requirements for the Group's products utilised in such industries are ever-changing. As a result, the technical requirements and the product specifications in the precision engineering industry are subject to continuous evolutions and changes. Also, in order to minimize massive capital commitment in each manufacturing process, high-end precision manufacturers are dividing the entire production processes into more parts and outsourcing to different midstream CMs and service providers. Therefore, midstream CMs and service providers in the precision component engineering industry are expected to demand for more advanced capabilities in high-end equipment and skilled manpower to meet their customer's requirements.
3 **Continuous supportive regulatory environment in Singapore**	• Precision component engineering has been identified as one of the key growth factors for Singapore's manufacturing sector, supporting the production of various complex components required in end-use industries including semiconductors, oil & gas, aerospace, and consumer electronics. More supportive policies are expected to be carried out to support the development of Singapore's precision component engineering industry, providing a supportive regulatory environment for future growth.

Source: China Insights Consultancy

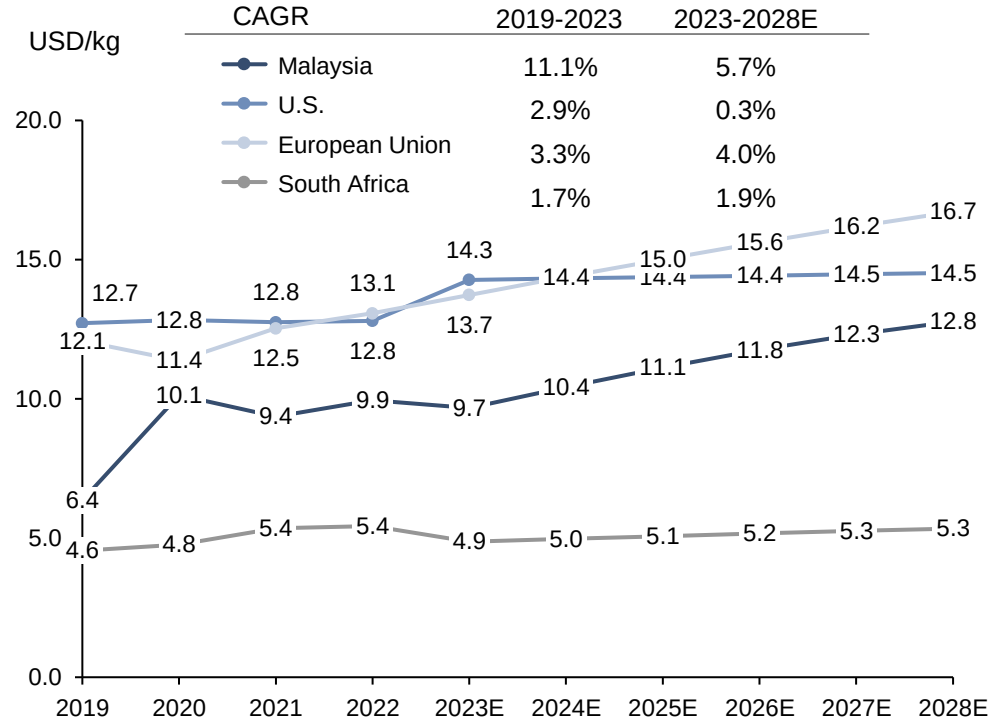
Cost analysis of raw materials

- The primary raw materials for precision component engineering products are iron, steel and aluminium. Therefore, the fluctuation of the products price index of steel and aluminium can impose a direct impact on the cost of raw materials of precision components

Price of iron & steel(1), Malaysia, U.S., EU and South Africa, 2019-2028E



Price of aluminium(1), Malaysia, U.S., EU and South Africa, 2019-2028E



Note: (1) The prices are based on average import and export prices in Malaysia, the U.S. , the EU, and South Africa

Analysis

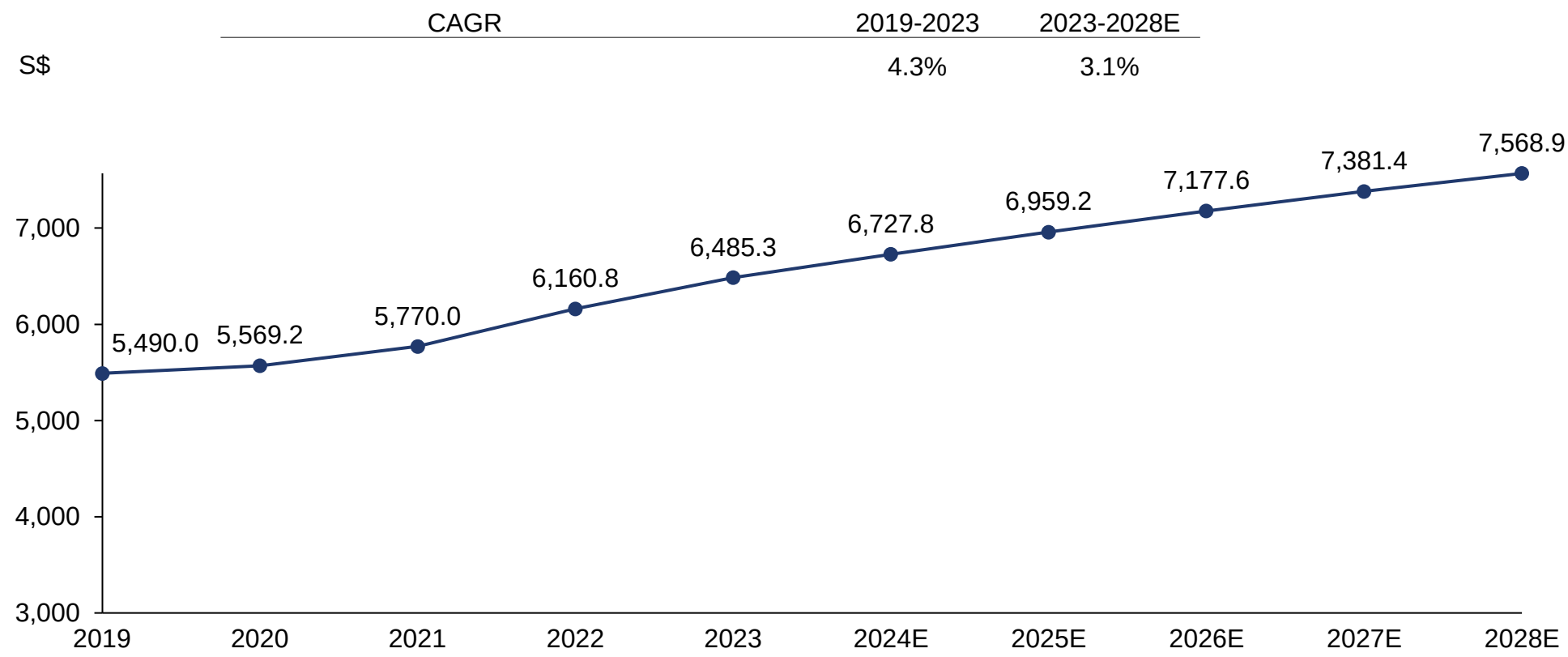
- The primary cost of precision component engineering service providers include raw material costs and labour costs. Raw materials mainly include iron, steel and aluminium. The provision of precision welding services generally require more inputs of standard parts which increase the direct material cost.
- The prices of iron & steel and aluminium directly affect the cost of raw materials in the precision component engineering industry in Singapore. Metal raw materials in Singapore mainly rely on imports from certain major economies such as Malaysia, the European Union (EU), the United States and South Africa. Prices of iron & steel and aluminium in the United States, the European Union and South Africa generally maintained an upward trend from 2019 to 2023 without much fluctuation, with the exception that Malaysia's iron & steel price dropped in 2020 which could affect the operation costs of the service providers in the precision engineering industry in Singapore and Malaysia, owing to several factors including the excess steel production capacity in Malaysia, and the lockdown measures during COVID-19 pandemic that reduced demand and prices for steel in key end-use industries, while the rise in aluminium prices was due to a large amount of aluminium being demanded and exported to China from Malaysia as China was then under pressure of environmental protection commitment and limited the production of aluminium domestically, which drove up demand and prices of aluminium imported from Malaysia. With the gradual recovery of the global economy, the prices of iron & steel and aluminium are expected to grow further at CAGRs ranging from 1.1% to 4.0% and 0.3% to 5.7% in Malaysia, the United States, the European Union and South Africa over the period from 2023 to 2028.

Source: The World Bank, China Insights Consultancy

Price analysis of labour cost in the manufacturing industry in Singapore

- With the continuous development of Singapore‘s economy, the average monthly salaries in the manufacturing industry in Singapore has been increasing during 2019 to 2023. In particular, the average monthly salaries in the manufacturing industry increased by 3.5% and 2.8% in Singapore and Malaysia, respectively in 2023 due to economic growth in both countries. With the expected gradual recovery of the global economy (including Singapore and Malaysia from the COVID-19 pandemic), the average monthly salaries in the manufacturing industry in Singapore and Malaysia are expected to maintain steady growth in the next five years. The average monthly salaries in the manufacturing industry increased by 6.8% and 31.0% in Singapore and Malaysia, respectively in 2022 due to economic recovery from COIVD-19 pandemic in both countries and the increase in minimum wage in Malaysia

Average monthly salary in the manufacturing industry, Singapore, 2019-2028E



Analysis

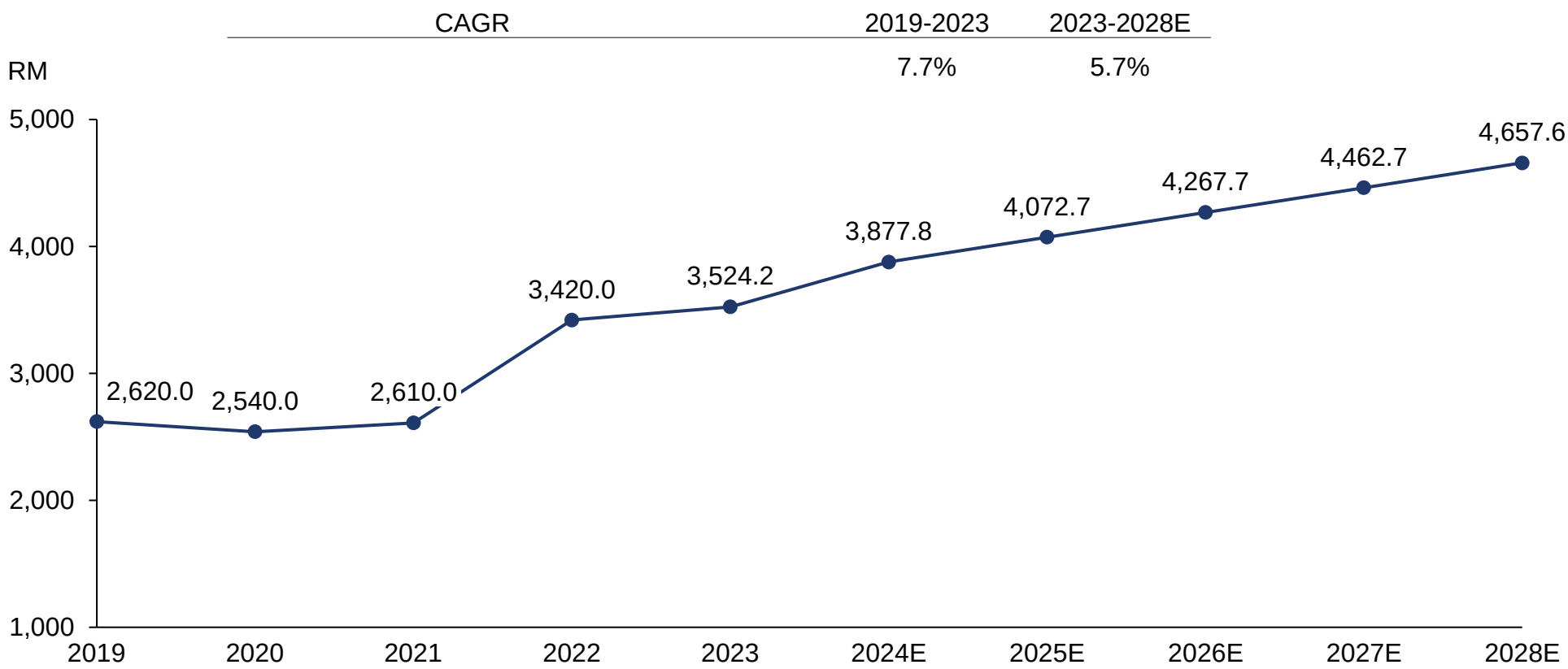
- Singapore’s average monthly salary in the manufacturing industry has increased from S$5,490.0 in 2019 to approximately S$6,485.3 in 2023, representing a CAGR of 4.3% during this period. With the continuous development of Singapore‘s economy, the average monthly salary in the manufacturing industry in Singapore is expected to keep the growth trend from 2023 onwards to reach S$7,568.9 by 2028, representing a CAGR of 3.1% over the period of 2023 to 2028.

Source: Singapore Department of Statistics, China Insights Consultancy

Price analysis of labour cost in the manufacturing industry in Malaysia

- With Malaysia's rapid economic growth, average monthly salaries in the manufacturing industry in Malaysia are expected to keep the growth trend over the next five years

Average monthly salaries in the manufacturing industry, Malaysia, 2019-2028E



Analysis

- Affected by the COVID-19 epidemic, the average monthly salary in the manufacturing industry has experienced a brief decline in 2020. With the gradual recovery of the Malaysian economy, the average monthly salary in the manufacturing industry in Malaysia is expected to maintain the pre-epidemic growth trend to reach RM4,657.6 by 2028, representing a CAGR of 5.7% over the period of 2023 to 2028.

Source: Department of Statistics Malaysia, China Insights Consultancy

3. Competitive Landscape of Precision Component Engineering Industry in Singapore

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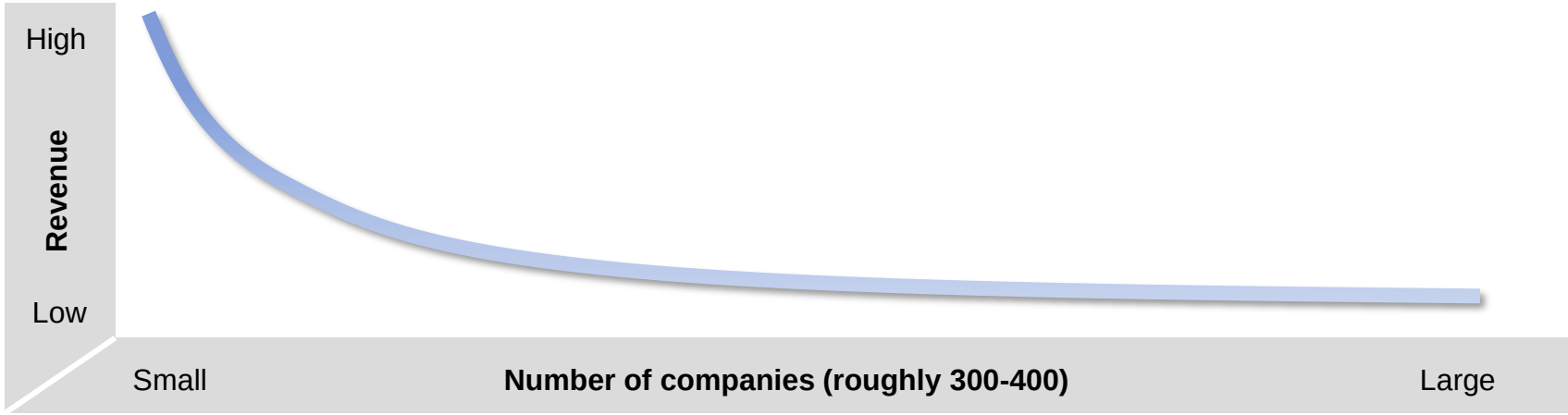
Nature of competition

- The competitive landscape of Singapore’s precision component engineering industry is characterised by a long-tail phenomenon in the semiconductor segment with 48.5% of the market share taken by the Top 10 players

Competitive landscape of Singapore’s precision component engineering industry in the semiconductor segment



Key analysis

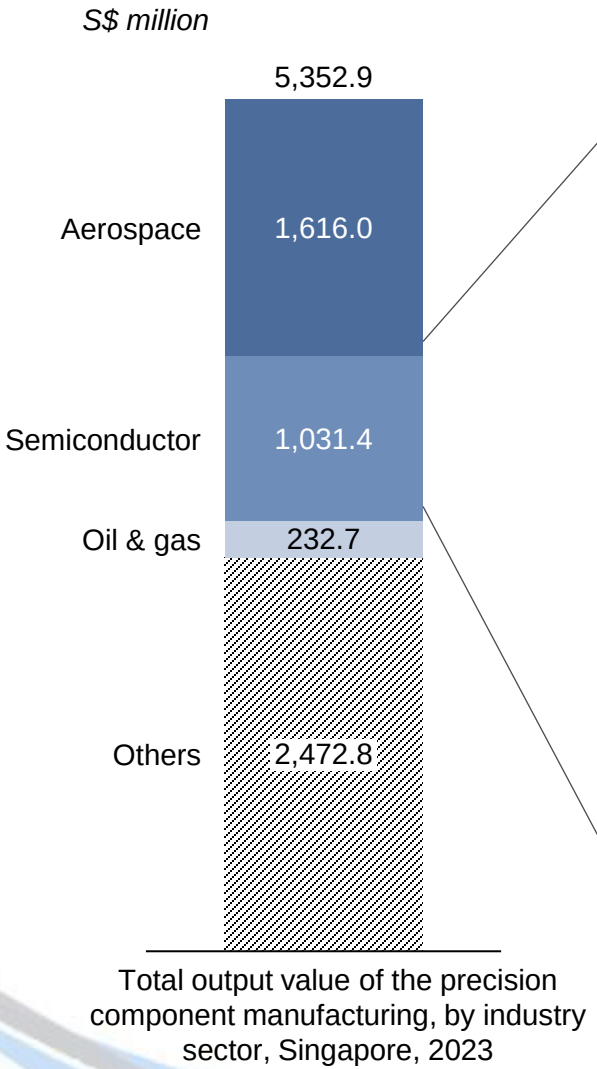
- Singapore's world-class manufacturing ecosystem combines advanced technology, manufacturing excellence, and global operation. It has attracted many multinational advanced manufacturing companies to establish their Asia Pacific headquarters in Singapore. To estimate the market share and ranking of the Company/Metasurface Technologies Holdings Limited compared to other comparable companies in the semiconductor segment, where the Company/Metasurface Technologies Holdings Limited mainly operates , the following metrics are considered: (i) similar industry segment focus (i.e. the semiconductor equipment industry); (ii) similar manufacturing capabilities (i.e. manufacturing precision components mainly through precision machining and precision welding); (iii) the interview result of estimated ranking, revenue, and business segmentation from verified industry experts; and (iv) the research result from annual reports, articles, and government database such as Singapore Department of Statistics.
- The competitive landscape of Singapore's precision component engineering industry involves both domestic and international companies providing the precision component engineering services in Singapore and these companies primarily compete in product quality, technical level, production capacity, pricing terms, in-time delivery, span of one-stop services offerings, experience and after sales-services.
- The competitive landscape of Singapore’s precision component engineering industry in the semiconductor segment is fragmented **with at least 300 market participants and dominated by the leading players. In 2023, the top ten market players, in terms of revenue, accounted for approximately 48.5% of the market share of semiconductor segment of precision component engineering industry in Singapore**. Market participants include service providers and CMs with in-house production capabilities, including internationally renowned companies with advanced manufacturing capabilities. It is not uncommon for market participants in the semiconductor segment of precision component engineering industry to have a highly concentrated customer base since the end-use industry (i.e. semiconductor manufacturing equipment industry) is concentrated and dominated by a small pool of the world leading semiconductor equipment manufacturers with the top three market players accounting for more than 40% of the global market share in terms of revenue in 2023 and precision components are often customised to meet the specific needs of a particular customer, which leads to a strong mutual relationship between the supplier and the customer. The semiconductor industry requires a high level of accuracy repeatability and efficiency in the production process of precision component engineering and is thus, characterised by significant barriers to entry, including advanced technologies and know-how, requisite licenses and certificates, large capital investments, and well-established customer relationships. Service providers, CMs and OEMs build a **mutual dependence and complementary business relationship**, which poses OEMs a high switching cost to assess and perform due diligence on new suppliers and to ensure the quality of products supplied by new suppliers conforms with their requirements, resulting in more and more market share gradually accumulated by top players over time.

Source: China Insights Consultancy

Competitive landscape

- In 2023, the Company/Metasurface Technologies Holdings Limited ranked seventh in Singapore's precision component engineering industry in the semiconductor segment with a market share of 3.3%, in terms of revenue

Top ten market participants of the precision component engineering industry in the semiconductor segment, in terms of revenue, Singapore, 2023



Total output value of the precision component manufacturing, by industry sector, Singapore, 2023

#	Company	Segmented revenue[1], Singapore, 2023, S$ million	Market share, 2023
1	Company A	120.0	11.6%
2	Company B	102.7	10.0%
3	Company C	96.9	9.4%
4	Company D	53.9	5.2%
5	**The Company/Metasurface Technologies Holdings Limited**	**34.1**	**3.3%**
6	Company E	33.6	3.3%
7	Company F	28.4	2.7%
8	Company G	13.1	1.3%
9	Company H	9.5	0.9%
10	Company I	8.3	0.8%
	Top 10	500.5	48.5%
	Others	530.9	51.5%
	Total	1,031.4	100.0%

Note: 1. Segmented revenue includes revenue of precision component engineering in the semiconductor segment

Source: China Insights Consultancy

Introduction of the top participants in Singapore's precision component engineering industry (1/2)

Introduction of top participants

Company	Main business	Major products	Introduction to business models
The Company/ Metasurface Technologies Holdings Limited	**Service provider**	**Large format vacuum chambers and other precision components**	**Established in 2000, MetaSurface is a one-stop build-to-print precision engineering services provider principally based in Singapore, specialising in providing complex integrated precision machining and welding services for reputable international customers.**
Company A	Service provider	Vacuum chambers and other semiconductor equipment components, system integration	Established in 2000, Company A is a Singapore Exchange-listed company headquartered in Singapore specialising in manufacturing semiconductor equipment components and (sub) systems.
Company B	CM	Gasket, integrated gas and chemical delivery solutions	Established in 1999, Company B is a Nasdaq-listed company headquartered in the United States specialising in manufacturing fluid delivery components and (sub)systems
Company C	Service provider	Fitting products and other components used in flow control systems	Established in 2005, Company C is a non-listed company headquartered in Singapore specialising in manufacturing precision flow control components and (sub)systems.
Company D	Service provider	Camber body and other precision components for various end-use industries	Established in 1992, Company D is a non-listed company headquartered in Singapore specialising in manufacturing precision metal components and (sub)systems for various end-use industries including the aerospace, oil & gas, and semiconductor industries

Source: China Insights Consultancy

Introduction of the top participants in Singapore's precision component engineering industry (2/2)

Introduction of top participants

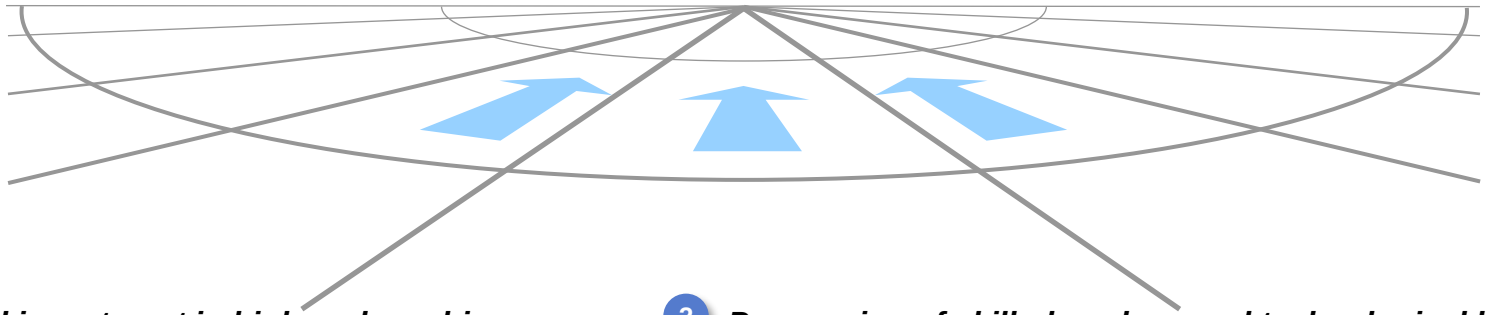
Company	Type	Major products	Business models
Company E	CM	System integration, plastic precision components	Established in 1999, Company E is a Singapore Exchange-listed company headquartered in Singapore specialising in manufacturing metal and plastic components and (sub)systems for various end-used industries including the automotive, medical & healthcare, and semiconductor industries.
Company F	CM	Wafer and frame probing stations	Established in 2000, Company F is a Singapore Exchange-listed company headquartered in Singapore specialising in manufacturing precision metal components and (sub)systems for the semiconductor and electronics test industries.
Company G	Service provider	Die attach, wire-bonding, and encapsulation	Established in 1983, Company G is a Singapore Exchange-listed company headquartered in Singapore specialising in manufacturing high precision components and tools for the wafer-fabrication and assembly processes
Company H	Service provider	Sheet metal fabrication with a focus on precision engineering	Established in 1980, Company H is a Hong Kong Exchange-listed company headquartered in Singapore specialising in manufacturing precision metal components for the semiconductor and machinery industries.
Company I	Service provider	Wafer handling systems, back-end chip packaging and testing	Established in 1989, Company I is a non-listed company headquartered in Singapore specialising in manufacturing precision metal components and (sub)systems for the data storage, automotive, and semiconductor industries.

Source: China Insights Consultancy

Entry barriers of the precision component engineering industry

- Entry barriers of the precision component engineering industry consist of (i) large capital investment in high-end machinery; (ii) possession of skilled workers and technological know-how; (iii) proven capability and steady relationship with customers; and (iv) qualification and certification requirements

Entry barriers of the precision component engineering industry



1 *Large capital investment in high-end machinery*

- Existing market participants have continuously invested significantly over the years. To compete with existing market participants, new entrants need to invest a large amount of capital in purchasing advanced equipment and building the relevant infrastructure to achieve high accuracy repeatability, and efficiency. For instance, a five-axis CNC cutting machine costs millions of SGD. Also, the cost related to equipment maintenance and upgrading is substantial, making it difficult for new entrants to compete with existing players if they do not possess the ability to make such huge capital commitment.
- It is not uncommon to have cashflow mismatch for industry players in the precision engineering industry - due to the requirement of suppliers for upfront payment when purchasing raw materials and relatively longer credit period.

2 *Possession of skilled workers and technological know-how*

- The precision component engineering industry serves highly technical sectors, such as the semiconductor industry. Due to the high technical skills required by the industry, there is only a limited number of skilled workers available on the market. **Technicians for precision component engineering are under intense competition in Singapore and Malaysia, making it hard for new entrants to recruit a sizeable pool of qualified workers.** Also, existing market participants have accumulated considerable technological know-how, which is essential to their success of the business, through years of operations. It requires new entrants an extended period to acquire sufficient knowledge and experience to compete with existing players.

3 *Proven capability and stable relationship with customers*

- Downstream customers of the precision component engineering industry are mostly leading companies in semiconductors, aerospace, automobile, and oil & gas industry. Due to the necessity to obtain the required components on a consistent and reliable basis, downstream customers generally prefer to work with a limited number of reliable and reputable suppliers with proven capability and product quality. The mutual dependence and complementary business relationship between suppliers and customers in the industry is established based on trust and reliability. It is hard for new entrants to compete with existing players because they lack the relative experience and are unable to establish a stable relationship with downstream customers within a short period of time.

4 *Qualification and certification requirements*

- Market participants need to comply with local regulations and are expected to obtain certain qualifications and certifications, such as ISO 9001:2015. Also, professional standard organizations, such as American Society of Mechanical Engineering (ASME) and American Welding Society (AWS) and Semiconductor Equipment and Materials International (SEMI), issue qualifications for the provision of certain precision welding services and make rules and classifications for welding positions, techniques and procedures. ASME provides ASME Boiler and Pressure Vessel Code (BPVC) certification and AWS provides Certified Welder (CW) certification and Certified Welding Inspector (CWI) certification. Welders must be certified in each welding position to perform the respective type of welds. Leading downstream customers also require their suppliers to obtain certain industry-specific certifications, such as SSQA for the semiconductor industry. The whole process of obtaining such certifications is time-consuming and may last from six months to two or three years, deterring new entrants from entering the market easily.

Source: China Insights Consultancy

Key success factors of the precision component engineering industry

- Key success factors of the precision component engineering industry include (i) ability to train and sustain skilled and experienced employees; (ii) reliable and cost-advantageous supply chain for sourcing raw materials; (iii) continuously upgrading equipment and software to maintain competitiveness; (iv) consistent production of quality components; and (vi) stable relationship with customers

Key success factors	Analysis
1 **Ability to train and sustain skilled and experienced employees**	• The precision component engineering industry is a highly technical industry. The success of a business depends on the retention and/or recruitment of new skilled and experienced employees. Companies with more competitive compensation packages and systematic training courses are more likely to attract and recruit skilled and experienced employees, and thus, contributing to their long-term development.
2 **Reliable and cost-advantageous supply chain for sourcing raw materials and service providers**	• Reasonable level of raw material stock and a list of reliable services providers are important to the operation of the business. Therefore, it is important to have a reliable supply chain to ensure stability of the cost and transportation time in order to avoid or minimize any delay or shortage in the supply of raw material or delay in delivery of products, which may undermine the company's reputation.
3 **Continuously upgrading equipment and software to maintain competitiveness**	• The technology keeps evolving and downstream customers are posing higher requirements for precision components. To maintain competitiveness, companies may need to upgrade and debottleneck the existing equipment and software in a timely manner.
4 **Consistent production of quality components**	• As the downstream customers are highly concentrated and usually prefer to work with only a limited number of reliable suppliers, companies that prove their ability to deliver high-quality products consistently are likely to receive more orders and gain more market shares in the long term.
5 **Strong and long-standing relationship with customers**	• It is important for service providers and CMs to maintain strategic and long-term relationship with the OEMs for business opportunities. Therefore, the establishment of mutual dependence and complementary business relationship with customers provides for more sustainable business growth in the future.

Source: China Insights Consultancy

Future opportunities, threats & challenges of the precision component engineering industry

Future opportunities, threats & challenges of the precision component engineering industry

New emerging end-use industry applications
- New emerging end-use industry applications increases demand for new products, posing opportunities for companies with relevant equipment, experience and technological know-how.

Regional preferable government policies
- Preferable government policies in countries like Singapore will reinforce the strategic position of the precision component engineering industry, providing more opportunities for future growth.

Advancement of high precision machine tools
- Advancement of high precision machine tools will explore the greater opportunities of various end-use industries.

Shortage of skilled and experienced manpower
- The precision component engineering industry in Singapore generally faces a shortage of skilled and experienced manpower, attributable to factors, including the Singapore government's policy restricting foreign manpower hiring and the ageing working population.

Regional competition
- The precision component engineering industry is fragmented and highly competitive. Singapore's position in the precision component engineering industry is threatened by the growth and entry of service providers and CMs from overseas countries.

Digitalisation
- The precision component engineering industry is becoming increasingly digital, with the use of digital design tools and simulation software. This presents opportunities to improve efficiency and quality, but also requires new skills and knowledge.

Influence by end-use industries
- The major end-use industries of precision component engineering industry, including semiconductor, aerospace and oil & gas, are highly dependent on the factors such as global economic cycle, political issues and demand-supply relationship, which can ultimately affect the precision component engineering industry.

Source: China Insights Consultancy

Competitive advantages of the Company/Metasurface Technologies Holdings Limited

Established long-standing business relationships with reputable international customers

- The Company/Metasurface has over 20 years of operation and has established and maintained a strategic and long-term supplier as they posses strong relationship with world-class OEMs and CMs customers for many years. Of the Company's top five customers in FY2022 and FY2023, customer A, customer D, and Intevac Asia Pte. Ltd. have production bases in Singapore, while customer B and customer C have production bases in Malaysia.

- The Company/Metasurface has been selected by its customers as an essential industry-specific certifications and have passed customers' stringent and lengthy internal supplier qualification processes.
- The Company/Metasurface has established a proven track record in providing quality and efficient precision component engineering services to its customers.

Seasoned and visionary management team supported by technical talents

- The management team has been working in the precision component engineering industry for years and has accumulated an extensive experience of operational and managerial experience in the industry.
- In addition, the Company/Metasurface has built a dedicated and experienced workforce and provides training to staff to improve managerial and technical skills.

Advanced machinery and technological know-how

- The Company has advanced machinery and accumulated efficient technological know-how through years of operation.
- Advanced machinery and equipment allow the Company to produce highly complex components efficiently. The Company has acquired 70 CNC machines, including large and multi-axis CNC machines for producing precision components and large format vacuum chambers. The Group achieves higher production efficiency at lower costs than industry average due to its utilization of 5-axis CNC machines. The accuracy for large format vacuum chambers is around ±100 μm to ±10 μm. The lower the μm, the higher the accuracy. The Company can achieve an accuracy of ±10 μm, which is considered to be an advanced capability in the industry.
- The production capacity and volume of the Company's precision component engineering services are measured by machine hours and man hours as products of the Company's precision machining and precision welding are highly customised and have diverse shapes, sizes and weights subject to the customers' requirements. The Company's calculation basis of the production capacity and the measurement of the utilization of production facilities are in line with the industry norm.

Possession of necessary certifications and qualifications

- The precision component engineering industry attaches great importance to the certifications and qualifications acquired by the Company.
- The Company has been accredited with industry-essential qualifications in the production technologies and quality control system and has been become an approved supplier of Applied Material with a superior SSQA score of 5.6 while the industry considers a score of more than 5.5 to be high*. The whole process of obtaining such certifications and becoming a qualified supplier take time and are testimony of recognition in the industry.

- The time required for a new supplier to apply for SSQA certification and be admitted as an approved supplier of Customer A typically ranges from six months to two or three years.
- Suppliers usually have to obtain the SSQA certification in order to be listed as approved suppliers and gain potential cooperation opportunities with Customer A.

*Note: according to expert interview with the experts in the industry.

Source: China Insights Consultancy

4. Overview of Optical Metalens Industry

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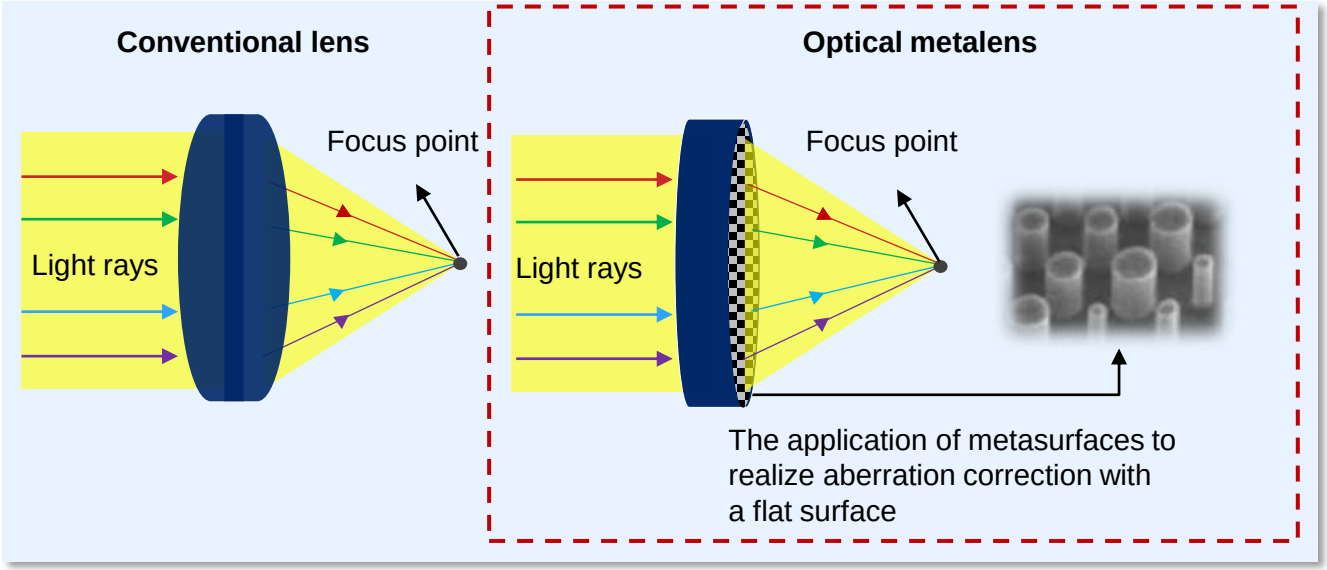
Definition and functionality of optical metalenses

- The optical metalens is a flat lens technology that uses metasurfaces to focus light and has the advantages of planarization, aberration correction, higher focusing efficiency, tunability, etc.

Definition

- Metasurfaces, the corresponding two-dimensional metamaterials, can flexibly control the amplitude, phase, and polarization of light through sub-wavelength units.
- **The optical metalens is a flat lens technology that uses metasurfaces to focus light.** The technology can be used in optical applications that take advantage of the flat surface with higher focusing efficiency , turnability, etc. to reduce thickness and increase optical performance, compared to classic, curved refractive lenses mainly used in conventional optical devices.

Principle of optical metalens



Functionality of optical metalenses

- Conventional lenses are designed based on classical refractive optics, which results in inevitable imaging aberrations, such as chromatic aberration, spherical aberration and coma. To solve these problems, conventional imaging systems impose multiple curved lenses with different thicknesses and materials to eliminate these aberrations, resulting in the bulkiness of imaging systems.
- In an optical metalens, when light interacts with its metasurface, the transmitted and reflected waves can be arbitrarily modulated by engineering the physical shape of nanostructures (called nanoantennas) on the metasurface, **thus chromatic aberration could be fixed with single-layer and flat lens structure while the lens thickness is reduced from millimetre and centimetre scale to micrometre scale**. Therefore, optical metalenses can realize the flexible design of phase, amplitude, and polarization in the sub-wavelength scale and have the advantages of planarization, aberration correction, higher focusing efficiency, tunability, etc.

Planarization | **Aberration correction** | **Higher focusing efficiency** | **Tunability, etc.**

Source: China Insights Consultancy

Value chain of the optical metalens industry

- The value chain of the optical metalens industry includes raw material procurement in the upstream, product manufacturing in the midstream and end-use applications in the downstream

Value chain

The upstream of the optical metalens industry value chain is composed of raw materials for substrate and metasurfaces. The midstream of the optical metalens industry value chain is the manufacturing of optical metalenses. Based on metasurface materials, optical metalenses are normally categorized into dielectric optical metalenses and plasmonic optical metalenses. The downstream industries of optical metalenses include end-use industries such as new energy vehicle (NEV), smartphone, AR/VR, IoT, biomedical, security monitoring, aerospace, industrials, etc. NEV and smartphone industries require both the use of semiconductor and metalens.

Upstream

Raw material

Substrate

- Silicon dioxide (SiO_2)
- Silicon (Si)
- Germanium (Ge)
- ……

Metasurface

- Titanium dioxide (TiO_2)
- Silicon nitride (Si_3N_4)
- Amorphous silicon (a-Si)
- ……

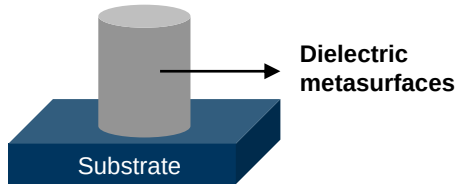
Midstream

Manufacturing

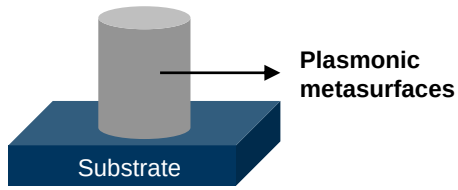
Optical metalenses

By metasurface material

Dielectric optical metalenses



Plasmonic optical metalenses



Downstream

End-use industries

- New energy vehicle
- Smartphone
- AR/VR
- IoT
- Biomedical
- Security monitoring
- Aerospace
- Industrials
- …..

Source: China Insights Consultancy

Application of optical metalenses

- The major application fields of optical metalenses include new energy vehicle (NEV), smartphone, AR/VR, Internet of Things (IoT), military, biomedical, etc.

Major applications of optical metalenses

1 New energy vehicle (NEV):

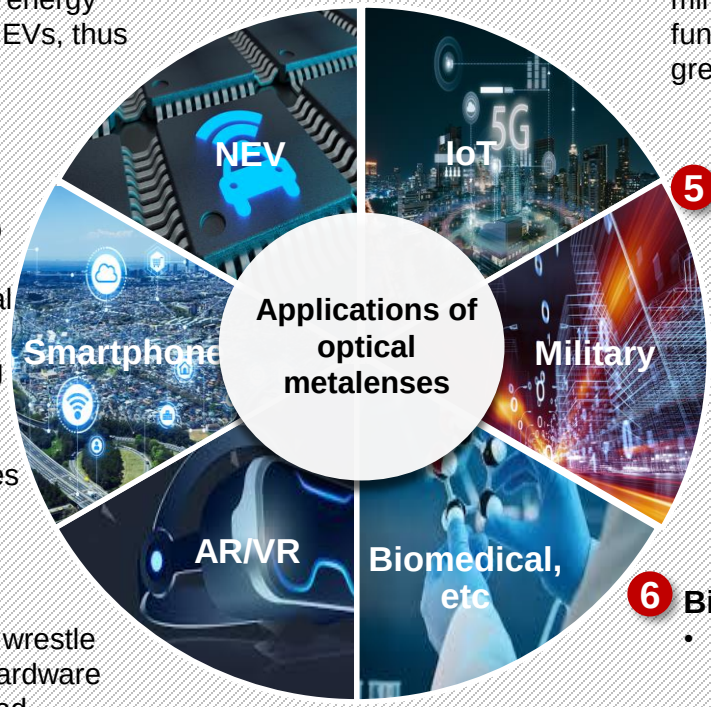
- Optical sensors are rapidly becoming standard equipment in NEVs to assist the operations of evolving NEV functions. Compared to conventional optical lenses, optical metalenses are able to provide higher thermal stability and higher energy efficiency while taking smaller spaces in NEVs, thus gaining increasing attention from NEV manufacturers.

2 Smartphone:

- As the technology of smartphones evolves, so does the amount of space and energy its imaging and sensing systems take. The optical metalens technology is able to fix chromatic aberration with thin and flat structures, helping achieve smaller sizes of optical imaging and sensing systems in smartphones, thus are expected to replace conventional optical lenses in smartphones to reduce product thickness.

3 AR/VR:

- Developers of AR/VR systems continue to wrestle with the challenge of incorporating bulky hardware systems into devices to be worn on the head. Optical metalenses offer the prospect of tiny optical elements incorporated into small, high-performing, lightweight headsets and smart glasses, thus gaining increasing popularity in the AR/VR field.



4 Internet of Things (IoT):

- With the fast development of 5G, the IoT technology has been rapidly evolving, which has put forward higher requirement for the performance of IoT optical sensors. Optical metalenses allow for greater miniaturization as well as enhance and expand the functionality of optical fibres of IoT systems, creating greater potential for IoT technology.

5 Military:

- Optical metalenses can be applied on drones to reduce the weight burden of their imaging and sensing systems for prolonging flight time. The flat, lightweight, ultrathin, compact, and easy-to-integrate advantages of optical metalenses enable their widely potential usages in the military field.

6 Biomedical:

- The enhanced optical capabilities of metalenses can enable more precise and higher-resolution diagnostic imaging. The higher-resolution imaging tools such as endoscopes could enable radiologists, physicians and lab technicians to see details that were previously invisible. Therefore, the functionality of optical metalenses has put forward its application potential for biomedical usage.

Source: China Insights Consultancy

1 Technology and application of optical metalenses in new energy vehicles (NEVs)

- The application of optical metalenses in NEVs could provide their optical systems with higher energy efficiency, greater miniaturization and higher thermal stability

The application of optical metalenses in new energy vehicles (NEVs)

Advantages of optical metalenses

	Conventional optical lens	Optical metalens
Imaging performance	Clear image	Brighter and sharper image
Structure	Curved surface with bulky structure	Flat surface with thin structure and smaller size
Quantity	Multiple lenses required in an optical component	Single lens required in an optical component
Thermal stability	Low thermal stability	High thermal stability
Energy efficiency	Low energy efficiency	Relatively higher energy efficiency

Advantages of metalenses that can be applied in NEVs

Increases energy efficiency and takes up less space:

- The optical metalens technology could reduce the energy consumption with higher energy efficiency while achieve greater miniaturisation of NEV optical systems with flat and thin structures

Provides better thermal management ability:

- Without additional assemblies to compensate, optical metalenses provide higher thermal stability for NEVs to operate more efficiently across a broad range of temperatures

Analysis

- Optical systems are applied inside and outside of NEVs for various imaging and sensing purposes. Currently, NEV head-up display (HUD) uses pico projectors, which is the micro-LED display. However, LED is relatively energy intensive, which results in high energy consumption of optical systems in NEVs. The application of optical metalens would help increase the energy efficiency of HUD and reduce the overall energy consumption of optical systems in NEVs, prolonging the battery life of NEVs. Meanwhile, with flat and single-layer structures, optical metalenses can be applied in multiple optical systems in NEVs, such as microelectromechanical system (MEMS), to achieve greater system miniaturizations while reducing system assembly complexities.
- Increasing number of optical sensors are used inside of NEVs to monitor the driver's state or for gestures control. One challenge for these optical systems is to operate across a broad range of temperatures. Traditional optical lenses are very susceptible to thermal changes because their optical properties vary. Optical metalenses have higher thermal stability compared to conventional optical lenses without requiring additional assemblies to compensate, thus becoming promising applications in NEVs to improve the thermal performances of their optical systems.

Source: China Insights Consultancy

2 Technology and application of optical metalenses in smartphones

- The application of optical metalenses in smartphones could help achieve greater product miniaturization and enable higher efficiency in smartphone optical imaging and sensing systems

The application of optical metalenses in smartphones

Advantages of optical metalenses

	Conventional optical lens	Optical metalens
Imaging performance	Clear image	Brighter and sharper image
Structure	Curved surface with bulky structure	Flat surface with thin structure and smaller size
Quantity	Multiple lenses required in an optical component	Single lens required in an optical component
Thermal stability	Low thermal stability	High thermal stability
Energy efficiency	Low energy efficiency	Relatively higher energy efficiency

Advantages of metalenses that can be applied in smartphones

Provides reduced thickness:

- Optical metalens technology could replace conventional multi-lens optical systems with a single lens in smartphones, achieving reduced thickness and greater miniaturization for smartphones

Enables higher efficiency in optical imaging and sensing systems:

- Optical metalenses could help create more robust imaging and sensing systems with better light collection efficiency, a wider field of view, more dots on targets, and better contrast

Analysis

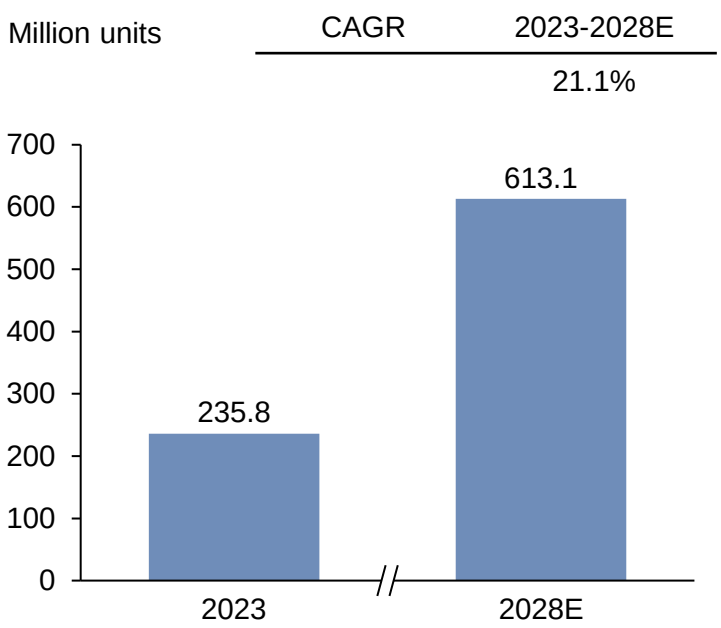
- To avoid imaging aberration, each camera on a smartphone has multiple lenses or lens elements stacked on top of each other, taking up a certain space in a smartphone and inevitably resulting in smartphone bulkiness. With the capability of aberration correction in a compact manner, optical metalens technology can replace complex multi-lens systems with a single lens, simplifying assembly complexity and realizing much thinner camera structures on smartphones. Moreover, smartphone cameras with optical metalenses can potentially deliver more light back to the image sensor with better focusing, allowing for brighter and sharper images than what traditional lens elements could bring.
- The sensors of smartphones contain sophisticated optical systems that include transmit and receive channels. Optical metalens technology ensures better light collection efficiency, a wider field of view, better focus on targets and better contrast, enabling better optical sensing system performance with higher resolution as well as addressing the challenge of face or fingerprint recognition difficulty in certain scenes. Therefore, optical metalenses are great substitutes for conventional multi-lens optical sensing systems with the capability of providing better performances in a more compact manner.

Source: China Insights Consultancy

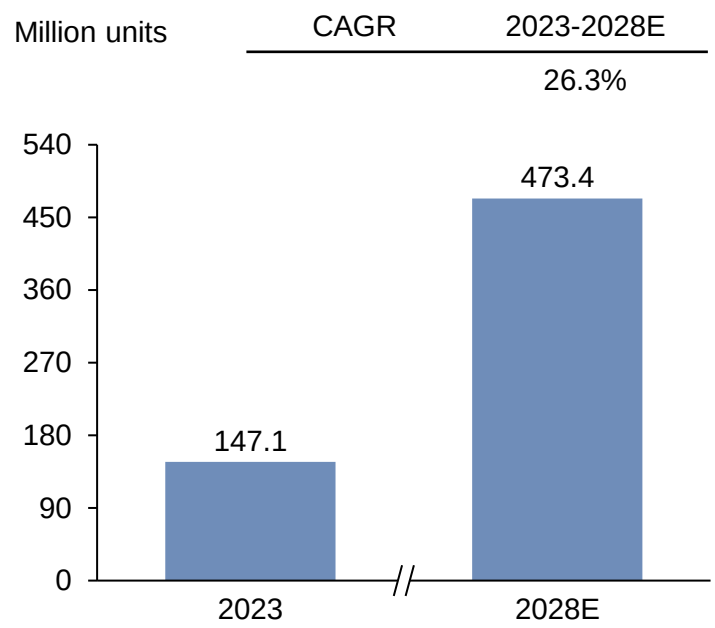
Total addressable market (1/2)

- Driven by political support and technological advancement, the consumption volume of new energy vehicle (NEV) optical components in China and across the world is expected to continuously rise over the next five years, demonstrating a great market potential for optical metalens

NEV optical components*, Global, 2023-2028E



NEV optical components*, China, 2023-2028E



Analysis

- With the rapid development of the NEV markets in China and across the world, the functions of NEVs are being constantly upgraded where more intelligent features are being added to cater to diverse market demands. As the imaging, monitoring, sensing, etc. systems in NEVs are becoming more intelligent, the average number of optical components applied in each NEV is expected to continuously grow. It is estimated that the average number of optical components applied in each NEV will increase to around 21 by 2028 from around 17 in 2023. Meanwhile, driven by policy support and technological advancement of NEV, the sales volume of NEV in China and around the world is expected to present a growth trend over the next five years. With the continuous growth of both the average number of optical components applied in each NEV and NEV sales volume, the total consumption volume of NEV optical components worldwide is expected to grow from 235.8 million in 2023 to 613.1 million by 2028 at a CAGR of 21.1% from 2023 to 2028. The total consumption volume of NEV optical components in China is also expected to grow from 147.1 million in 2023 to 473.4 million by 2028 at a CAGR of 26.3% from 2023 to 2028.
- Providing higher optical system energy efficiency and higher thermal stability with compactness, optical metalenses are great substitutes for NEV conventional optical components to achieve better system performances. Therefore, the rapidly developing NEV optical components market demonstrate great potential for the optical metalens market over the next five years.

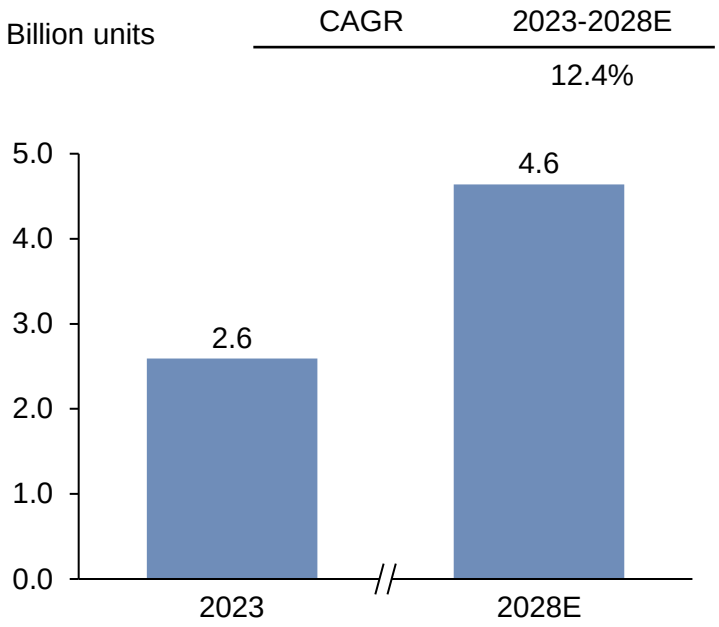
* Optical components: comprise of a single lens or a group of lenses, and operate as a system in devices to alter the state of light through a variety of means including focusing, filtering, reflecting, polarizing, and etc.

Source: China Passenger Car Association (CPCA), China Insights Consultancy

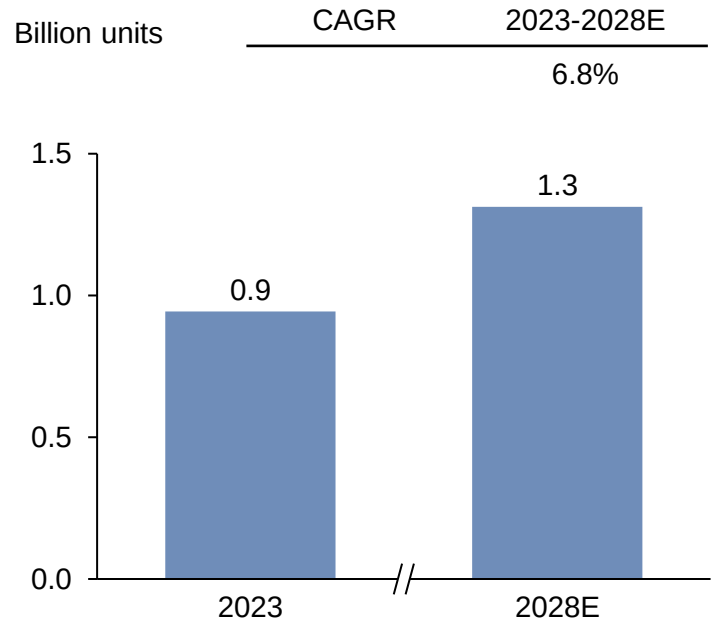
Total addressable market (2/2)

- With the rapid development of 5G technology and 5G smartphone penetration rate, the consumption volume of 5G smartphone optical components in China and across the world is expected to continuously grow over the next five years, and this is projected to provide the optical metalens market with strong growth momentum

5G smartphone optical components*,Global, 2023-2028E



5G smartphone optical components*, China, 2023-2028E



Analysis

- With the rapid development of the 5G smartphone market, optical innovation has become an important way for smartphone manufacturers to increase their brand competitiveness. An increasing number of optical components are being applied in 5G smartphones to upgrade product optical functionality. The average number of optical components applied in each 5G smartphone has reached approximately 3.9 units in 2023 and is expected to further increase to 4.0 units by 2028. At the same time, driven by the rapid development of 5G technology and infrastructure as well as the rising 5G smartphone penetration rate, the 5G smartphone shipment volume in China and across the world has been continuously growing and is expected to further increase over the next five years. Therefore, driven by the growing average number of optical components applied in each 5G smartphone and the rising 5G smartphone shipment volume, the consumption volume of 5G smartphone optical components across the world is expected to increase from 2.6 billion in 2023 to 4.6 billion by 2028 at a CAGR of 12.4% from 2023 to 2028. The consumption volume of 5G smartphone optical components in China is also expected to reach 1.3 billion by 2028, increasing from 0.9 billion in 2023 at a CAGR of 6.8% from 2023 to 2028.
- Enabling reduced thickness and higher imaging and sensing efficiency, optical metalenses have the potential to replace conventional optical components in 5G smartphones to promote product miniaturization and to improve optical system performances. Therefore, the continuously rising 5G smartphone optical components market is expected to provide the optical metalens market in China and across the world with strong growth momentum.
- In 2023, the optical metalens market was at a very early stage and the commercial market for it barely existed. The global market size of metamaterials, including metalenses, is forecast to reach USD6.0 billion by 2028.

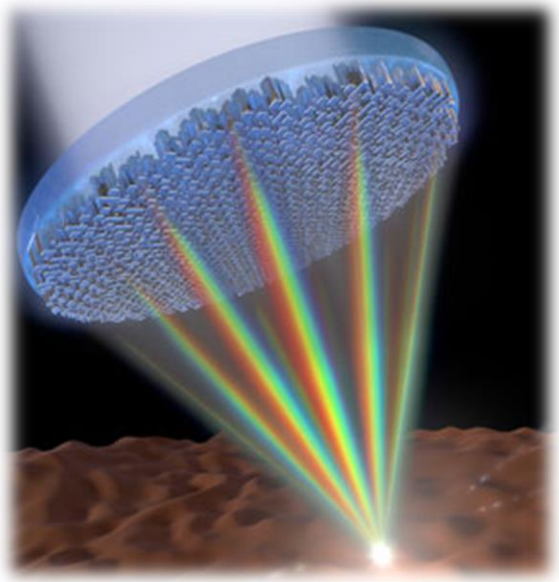
* Optical components: comprise of a single lens or a group of lenses, and operate as a system in devices to alter the state of light through a variety of means including focusing, filtering, reflecting, polarizing, and etc.

Source: CAICT, China Insights Consultancy

Nature of competition in optical metalens industry

- The current global optical metalens market is relatively fragmented with China and the U.S. at the forefront of the market development. As the design and manufacturing technology mature, it is likely that more companies will enter the field and the market is expected to become concentrated in the long term

Optical metalens companies in the U.S.	
Metalenz	metalenz
Tunoptix	TUNOPTIX
Vadient Optics	VADIENTOPTICS
……	……



Optical metalens companies in China	
MetalenX	MetaLenX
Shan He Photonics	山河光电 Shan He Photonics
Seetrum	与光科技 SEETRUM
……	……

Analysis

- Currently, China and the U.S. are at the forefront of the global optical metalens market development. For the Chinese optical metalens market, the manufacturing resources regarding to human capital and infrastructure are relatively more abundant and the production supply chain is more integrated compared with other markets. This has equipped optical metalens companies in China with stronger capabilities to manufacture and optimize optical metalens products. For the U.S. optical metalens market, since the optical metalens technology originated from an American company, there is relatively more technology and product awareness in the U.S. This has equipped companies in the U.S. with more opportunities to obtain funds or investments for further technological development.

- With high technological barriers and with the difficulty of achieving mass production, there are not many players in the field and the current market is relatively fragmented. **Since the market is still at its early stage of commercialization, the ranking cannot be provided at this point.** As the design and manufacturing technology gradually gets mature and as the technology awareness increases across the global market, it is expected that more companies will enter the field in the future. Meanwhile, as the market rapidly develops, the competitive advantages of companies with strong R&D and mass production capabilities are likely to be further highlighted, and it is expected that the market will gradually become concentrated in the long term.

Source: China Insights Consultancy

Market drivers for the optical metalens industry

- The rapid growth in downstream application industries and the continuous upgrading of manufacturing technologies are expected to drive the growth of the optical metalens market

1 **Rapid growth of NEV industry**	Primarily driven by policy support and NEV technological advancement, the global sales volume of NEV has been continuously increasing, reaching 14.3 million in 2023 and is expected to further grow up to 29.5 million by 2028 at a CAGR of 15.6%. The application of optical metalenses in NEVs could increase thermal stability and system energy efficiency with compactness, thus are expected to become substitutes for conventional optical components in NEVs to improve NEV optical system performance. Therefore, the rapid development of the NEV industry is expected to provide the optical metalens market with strong growth momentum.
2 **Development of 5G smartphone industry**	With the rapid development of 5G technology and 5G smartphone penetration rate, the global 5G smartphone shipment volume has been rising rapidly, reaching 0.7 billion in 2023 and is expected to continue the growth trend to climb up to 1.1 billion by 2028 at a CAGR of 11.8%. The optical metalens technology is able to achieve reduced thickness of smartphones and number of camera lenses required as well as increase the efficiency of smartphone imaging and sensing systems, thus are expected to be applied in smartphones for greater product miniaturization and better product functionality. Therefore, the continuous development of the 5G smartphone industry is expected to drive the growth of the optical metalens market in the future.
3 **Continuous expansions of other downstream industries**	Other downstream industries including AR/VR, biomedical, security monitoring, etc. have been experiencing rapid growth, and this is expected to further drive the optical metalens across the world to grow in the future. For example, with the technological advancement and wider of AR/VR technology, the market size of AR/VR products, such as AR/VR smart glasses, across the world has been growing rapidly. With the advantages of smaller size, lighter weight and higher focusing efficiency compared to conventional optical components, optical metalenses are expected to be applied in AR/VR glasses to reduce the system bulkiness. Other industries, such as biomedical, security monitoring, etc. are also expanding continuously, providing the optical metalens industry with strong growth momentum.
4 **Advancement of global manufacturing technology**	The production of optical metalenses requires advanced manufacturing technology. As information technology, including robotics, Internet of Things (IoT), big data analytics, artificial intelligence (AI), autonomous systems, etc. quickly evolves, global advanced manufacturing technology is rapidly developing, shifting toward advanced manufacturing capabilities and higher manufacturing efficiency. Therefore, with the progress constantly made in information technology, global manufacturing technologies are expected to be further improved and upgraded, providing the optical metalens industry with more advanced manufacturing techniques and resources and ultimately driving the market to grow.

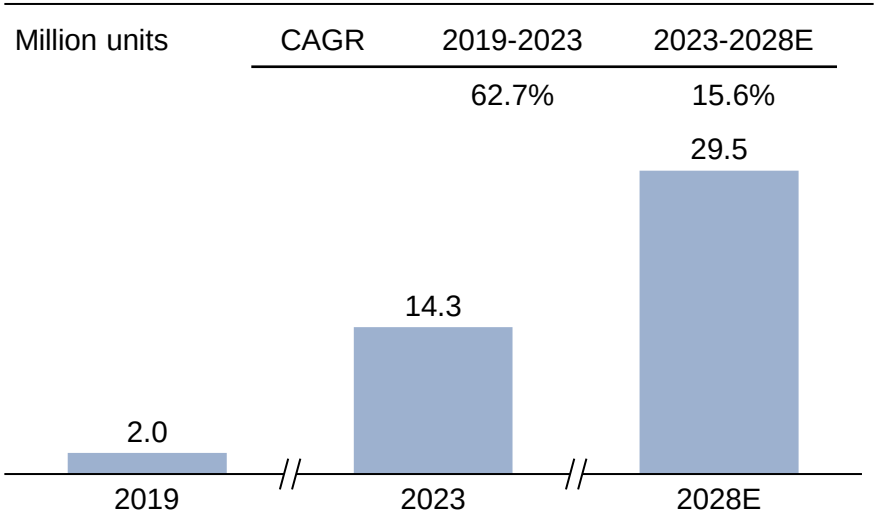
Source: China Insights Consultancy

1

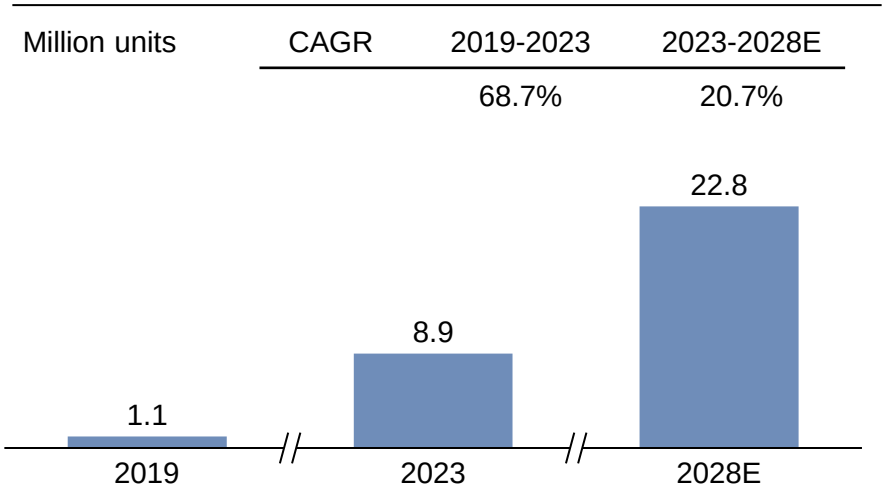
Market drivers for the optical metalens industry

- The rapid development of new energy vehicle (NEV) business and surging sales volume of NEV globally demonstrate promising growth potential for the optical metalens market

NEV sales volume, Global, 2019-2028E



NEV sales volume, China, 2019-2028E



The rapid development of NEV business of major vehicle manufactures is expected to drive the growth of the optical metalens market

In 2023, BYD sold a total of 3.0 million NEVs, increasing 58% from last year. Meanwhile, BYD became the world's first automaker to completely stop production of fuel vehicles.

In 2023, NEV sales volume accounted for 28.9% of the total sales volume of vehicles.

NEV sales volume accounted for 22.4% of total sales volume of vehicles in 2023 and the proportion is expected to reach 40% by 2025.

In 2023, NEV sales volume accounted for 21.9% of the total sales volume of vehicles.

	Global NEV business plan	NEV business plan in China
	Invest about USD131 billion on the development of NEVs and new digital technology	Form strategic alliances and offer specific products
	The sales volume of NEV accounts for 15%-25% of the company's total sales volume by 2025	Increase China's NEV sector with fresh USD1.4 billion investment
	Aim to go all-electric by 2030 and achieve a carbon neutral new passenger car fleet by 2039	From 2025, new entry-level electric models and EVs built on the self-developed MB. EA electric platform will be produced in Beijing.
	70% of $10 trillion for a global shift to electric vehicles	Started production at its Shanghai plant
	Revenue from EVs to reach more than $50 billion in 2025	To launch 15 new models by 2025 with the annual sales volume goal of 100 thousand units

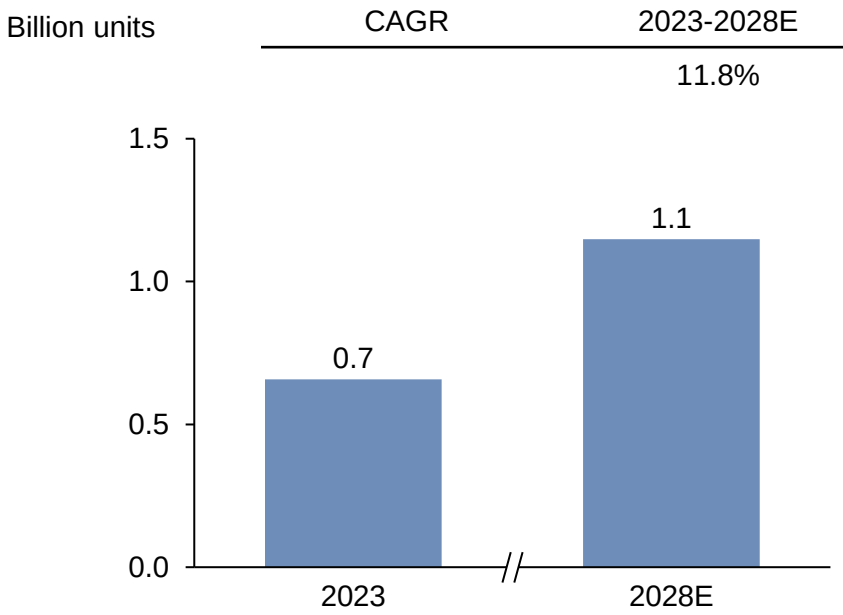
Source: The China Passenger Car Association (CPCA), China Insights Consultancy

2

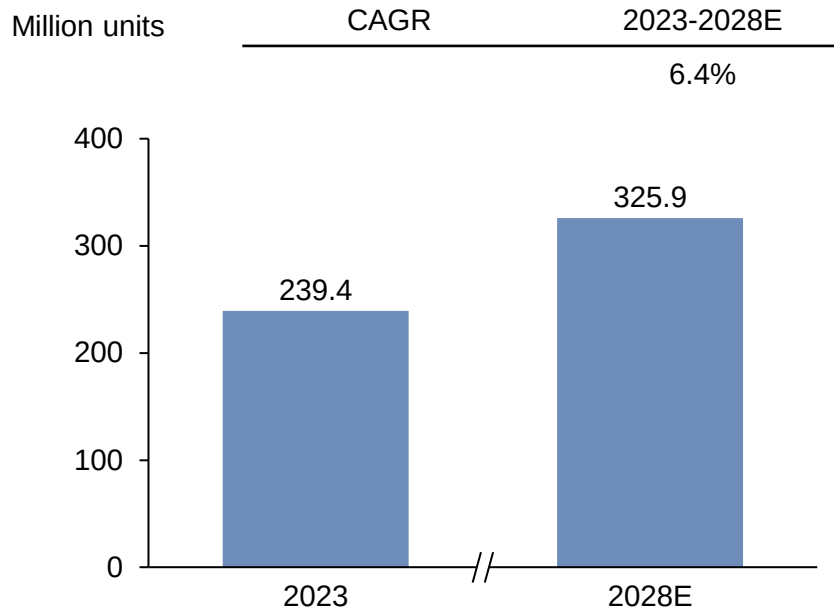
Market drivers for the optical metalens industry

- With the rapid development of 5G smartphone industry, the shipment volume of 5G smartphone globally has been increasing, providing the optical metalens market with strong growth momentum

5G smartphone shipment volume, Global, 2023-2028E



5G smartphone shipment volume, China, 2023-2028E



Key finding

- With the rapid development of 5G technology and the continuously rising 5G smartphone penetration rate, the shipment volume of 5G smartphones has been rapidly increasing. The global 5G smartphone shipment volume is expected to increase from 0.7 billion in 2023 to 1.1 billion by 2028 at a CAGR of 11.8% from 2023 to 2028. Meanwhile, the 5G smartphone shipment volume in China is expected to increase to approximately 325.9 million by 2028 from 239.4 million in 2023 at a CAGR of 6.4%.
- **Optical metalenses can be applied in smartphone optical systems to replace conventional optical components to realize greater product compactness and better optical system functionality. Therefore, the continuous development of the 5G smartphone industry is expected to drive the growth of the optical metalens market in the future.**

Source: CAICT, China Insights Consultancy

Future trends for the optical metalens industry

- Future trends of the optical metalens industry include enhancement in fabrication technology, improvement in optical metalens functions, growing penetration rate and wider application of optical metalenses

1

Enhancement in fabrication technology

Currently, the mass production of optical metalenses is challenging to realize with relatively high production and scale-up costs. To lower the production and scale-up costs and to accelerate the commercialization of optical metalenses, fabrication technologies such as nanoimprint lithography (NIL) and direct laser writing (DLW) are gradually being applied. NIL and DLW have the advantages of low cost, high throughput and large-scale patterning, and the application of such technologies could potentially increase the cost and manufacturing efficiency of optical metalens mass production. Meanwhile, DLW technology is currently being upgraded to realize the semi-automation/automation of the writing process in 3D with resolution in nanometers to further increase the manufacturing efficiency and expand the market application. To facilitate the product commercialization, it is expected that the R&D of optical metalens fabrication technology will continue in the future.

2

Improvement in function

With the research and development, the functions of optical metalenses have been continuously improved, promising new development progress in the future. For example, more advanced metamaterials such as transparent dielectric materials have been applied to improve the performance of optical metalenses. Meanwhile, recent research has demonstrated that computational methods can be used in optical metalens imaging systems for design, optimization, and signal processing which could further improve the functions of optical metalenses. As the number of optical metalens research laboratories and start-ups grow, and with the funding for optical metalens continuously increase, it is expected that the functions of optical metalenses will be further improved in the future to achieve more sophisticated capabilities and more efficient applications.

3

Growing penetration rate & wider application

With modern technology progressing continuously towards miniaturization, the demand for smaller optical system with better performance and more features in cameras, microscopes, telescopes, and other optical equipment is expected to grow. Having the ability of aberration correction with single ultrathin lenses, optical metalenses are great substitutes for multi-lens optical systems for a range of applications to realize more compact device configurations. Furthermore, with its expanding functionalities, optical metalens can even be incorporated into many existing optical systems to promote integration, improve reliability and achieve new features of optical systems. As the design and manufacturing technology of optical metalenses has been continuously improved, it is expected that the penetration rate of optical metalenses will continuously grow in current applications. Meanwhile, its planarization, aberration correction, higher focusing efficiency and tunability advantages also demonstrate its tremendous potential for more applications such as in IoT, military, and quantum information technologies.

Source: China Insights Consultancy

Entry barriers for the optical metalens industry

- Entry barriers for the optical metalens industry include R&D capability, fabrication technology & resource and capital capability

1 R&D capability

- The optical metalens technology is a technology that involves a high level of complexity. This has put forward high requirement of a company's R&D capability for successful product design. Especially, as the market is still at its early stage of commercialization and the product awareness is still relatively low, companies need to have strong R&D capabilities to demonstrate their technological know-how and the potential for product development to successfully penetrate the existing and potential application fields.

2 Fabrication technology & resource

- The successful launch of optical metalens products also requires effective fabrication technology that could cater to complex product design and bring high cost efficiency. Currently, the fabrication resources are relatively constrained and the overall production cost is still high which has put forward challenges for many companies with prototypes to achieve mass production in a cost effective way. Without advanced production technology that could achieve both manufacturing efficiency and cost efficiency, it is difficult for companies to successfully enter the field.

3 Capital capability

- A large amount of capital is required to cover the cost from product design and development to product manufacture and distribution. Especially, product fabrication cost is still high at this point, and companies need to have strong capital capability to achieve successful product launches. For example, in order to successfully implement business plans, many optical metalens start-ups are collaborating with big corporations to gain funding support and strengthen their capital capabilities. Therefore, this high capital requirement has set a barrier for companies to successfully enter the field.

Source: China Insights Consultancy

Key success factors for the optical metalens industry

- Key success factors for the optical metalens industry include advanced manufacturing technology, to obtain first-mover advantage and customer relations

1 **Advanced manufacturing technology**

- The mass production of optical metalens has been challenging to realize with high costs incurred during the production process. With the advantages of low cost and high throughput, technologies such as nanoimprint lithography (NIL) and direct laser writing (DLW) have been gradually applied in the field. Technologies such as DLW allow the master mold fabrication and mass production processes to be completed under one production methodology while having the potentials to be upgraded to achieve higher resolutions, thus could help increase the manufacturing and cost efficiency of optical metalens companies as well as improve the product performances. It is significant for companies to apply such advanced manufacturing technologies to maintain competitiveness in the market.

2 **Obtain first-mover advantage**

- Since the optical metalens market is still at its early stage of commercialization and the market competition is not fierce yet, it is significant for companies to enter the field early in order to gain first-mover advantage. The first-mover advantage enables a company to more effectively establish strong brand recognition and product loyalty before others enter the market. Moreover, with strong technological impact of optical metalens, entering the field early would provide more opportunities for optical metalens companies to collaborate with reputable downstream corporations, thus would help companies to develop more rapidly and capture significant market shares.

3 **Customer relations**

- Since the optical metalens market is still in its early stage of development, it is important for companies to actively expand their potential customer base and develop solid relations with their downstream customers. Currently, the technology is still new for many downstream companies and making changes in these companies' supply chains could take a relatively long time. Therefore, it is important for optical metalens companies to maintain strong relationships with downstream customers to form long-term collaborations and ultimately expand their brand impact.

Source: China Insights Consultancy

5. Appendix

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Verifications

- The global demand for precision engineering components, driven by sectors like semiconductor, aerospace, oil and gas industry, medical devices and automotive, ensures a steady stream of opportunities for the Group's products and services. Semiconductor manufacturing equipment industry is one of the main downstream sectors, of which the global sales increased from USD64.5 billion in 2018 to USD107.6 billion in 2022, registering a CAGR of 13.6% during the period. It is expected to further increase to USD159.4 billion in 2027 due to the increasing global demand for semiconductors and other electronic components. The vast end-use market is expected to bring adequate demand for the Group's services. Additionally, some major semiconductor manufacturing equipment suppliers such as Applied Materials and Lam Research are shifting their businesses from China to Southeast Asian countries, making Singapore and Singaporean service providers more competitive in the world. For instance, Applied Materials announced "Singapore 2030" in December 2022. As part of the plan, Applied Materials is investing S$$600 million in a new facility in Singapore, which is about 700,000 square feet and will include more than 200,000 square feet of equipment manufacturing clean room space, to strengthen its manufacturing capacity, R&D, ecosystem partnerships and workforce development in Singapore. Such shifting trend is expected to bring more demand for services and products of the Group.
- The global precision component engineering industry is highly fragmented and dominated by regional small and medium enterprises, which normally focus on certain end-markets and/or product segments. The Singapore's precision component engineering industry is highly fragmented and dominated by small and medium enterprises. As a high value-added process in the precision engineering industry, manufacturing know-how and proven record of success are important to the end-customer and also require a significant period of time to accumulate. Due to the necessity to obtain components on a consistent and reliable basis, downstream customers generally prefer to work with a limited number of reliable and reputable suppliers with proven capability and product quality. The mutual dependence and complementary business relationship between suppliers and customers is established based on trust and reliability. Therefore, proven capability and established long-standing business relationships with internationally renowned customers are the core competitive advantages to the Group in the highly fragmented market.

- It is the industry norm in the precision machining industry to measure production capacity and actual output by hour and calculate utilisation rate as the actual output divided by the production capacity on the following basis: (1) According to the prospectus of Impro Precision Industries Limited (1286.HK), the production capacity and volume of precision-machined components are measured by machine hours. Utilization rate is calculated as actual production volume for the year divided by the production capacity for the year; and (2) According to the prospectus of the FSM Holdings Limited (1721.HK), production capacity is calculated as the lower of effective man hours and machines hours. The actual output is based on the lower of the estimated effective man hours and machine hours required for each product series.

Verifications

- Singapore is known for its robust manufacturing and technology sectors and provides a fertile ground for the Group to cater to a diverse range of end-use sectors locally and globally. In the semiconductor sector alone, there are more than 300 companies involved in manufacturing and repairing of semiconductor related equipment in Singapore, including local companies and multinational corporations. In Malaysia, there are approximately 200 companies involved in the production of semiconductor machinery and equipment. Such companies are readily available alternative customers for the Group.

- There are more than 200 suppliers based in Singapore involved in manufacturing and trading of machines such as CNC lathe machines and CNC milling machines, who are potential alternative suppliers of the Group.

- Singapore has an established metal material market with transparent pricing. There are approximately 50 to 100 alternative suppliers involved in metal material (e.g., aluminium) services based in Singapore who can provide metal material to the Group with comparable prices, terms and quality, and the Group could also import metal materials from abroad. There are more than 200 suppliers involved in treatment and processing of metals based in Singapore, who are readily available alternative suppliers to the Group with comparable prices, terms and quality.

- The Company has established long standing and strong business relationships with reputable international customers and is located at the Singapore, a place with sophisticated precision engineering capabilities and has strengths as a leading regional hub for advanced manufacturing. The Company has advanced production technologies and manufacturing capabilities to produce products that meet various specifications required by the customers and is possession of industry-specific qualifications and certifications for precision machining and precision welding services. Therefore, the Company is well-positioned to seize market opportunities and expand long-term market share.

- The shifting trend and strengthening of production base by the global semiconductor manufacturers and semiconductor equipment manufacturers in Singapore are expected to bring more demand for services and products of the Group.

- Precision machining is a machining process of removing materials from a workpiece with high accuracy to create parts and components with tight tolerance with accuracy in the range of hundreds of micrometer.

- With regard to the Group’s capabilities to capture the increasing trend of customers’ demand, by leveraging its sophisticated precision engineering services, the Company has established long standing and strong business relationships with reputable international customers. The Group is equipped with advanced production technologies and manufacturing capabilities to produce products that meet various specifications required by the customers and possesses industry-specific qualifications and certifications for precision machining and precision welding services. Besides, the industry has relatively high entry barriers including (i) large capital investment in high-end machinery; (ii) possession of skilled workers and technological know-how; (iii) proven capability and steady relationship with customers; and (iv) qualification and certification requirements, making it challenging for new entrants to enter and reinforcing the Group's role in capturing emerging demands. Therefore, the Group is well-positioned to seize market opportunities and expand long-term market share.

Verifications

- The global demand for precision engineering components, driven by the advancement and ever-evolving technological developments in sectors such as semiconductor, aerospace, oil and gas industry, medical devices and automotive, ensures a steady stream of opportunities and recurring demand for our products and services. Semiconductor manufacturing equipment industry is one of the main downstream sectors, of which the global sales increased from US$61.7 billion in 2019 to US$106.3 billion in 2023, registering a CAGR of 14.6% during the period. It is expected to further increase to US$180.6 billion in 2028 driven by capacity expansion, new fabrication projects, and high demand for advanced technologies and solutions across the front-end and back-end segments of the semiconductor industry.
- In the precision engineering industry, the labour services provided to customers in the oil and gas industry requires specific industry knowledge and technical experiences because of the sensitive and hazardous chemical and fluid that the end-products (such as pipelines) are intended to handle.
- In the oil and gas industry, tubulars are pipes and tubing used in exploration, drilling, and transportation of oil and natural gas. These components must be robust and reliable to withstand demanding environment encountered during oil and gas operations. Pipe inspections are critical to ensuring the quality and integrity of pipes, defecting defects, such as cracks, scratches, corrosions or other structural defects in pipes.
- Additionally, due to factors such as dynamic international situations, certain global major semiconductor manufacturers and/or semiconductor equipment manufacturers have been shifting their manufacturing bases and operations from China to Southeast Asian countries, providing more business opportunities for Singapore, as a leading regional hub for advanced manufacturing, and Singaporean service providers. Within the wafer manufacturing sector in the semiconductor industry, integrated device manufacturers (IDM) companies such as Micron, Infineon, NXP Semiconductors, STMicroelectronics, and along with foundry companies such as Global Foundries, United Microelectronics Corporation(UMC) and Vanguard had been expanding their manufacturing facilities in Singapore.
- In particular, Customer A announced ‘‘Singapore 2030’’ in December 2022. As part of the plan, Customer A planned to invest S$600million in a new facility at Tampines Industrial Crescent in Singapore by 2024, which is expected to be a 700,000 square feet plant and include more than 200,000 square feet of equipment manufacturing clean room space, to expand its chip-making operations in the next eight years and strengthen its manufacturing capacity, R&D, ecosystem partnerships and workforce development in Singapore.
- The two largest customers of Customer A are Taiwan Semiconductor Manufacturing Company Limited (TSMC) and Samsung Electronics Co. Ltd, which together accounted for more than 30% of Customer A’s total net sales for each of its financial years ended 31 October 2021, 2022 and 2023.
- As an affiliate of and owned as to approximately 28.3% interest by TSMC, Vanguard announced in October 2023 its plan to further build a 12-inch chip plant in Singapore following its acquisition of a 8-inch chip plant in Singapore from GlobalFoundries in 2019. Another customer of Customer A, UMC announced in 2022 its plan to invest US$5 billion in a chip-making factory in Singapore, to manufacture 22 and 28 nanometer chips for cars, IoT devices and PCs. The UMC’s new facility in Singapore is expected to be completed by mid-2024, with initial production to commence in early 2025. Such shifting trend and strengthening of production base by the global semiconductor manufacturers and semiconductor equipment manufacturers in Singapore are expected to bring more demand for services and products of our Group.
- Furthermore, apart from that the vast end-use market is expected to bring adequate and recurring demand for our services, the precision components engineering industry has relatively high entry barriers including (i) large capital investment in high-end machinery; (ii) the requirement for skilled workers and technological know-how; (iii) proven capability and stable relationship with customers; and (iv) qualification and certification requirements, making it challenging for new entrants to enter and reinforcing our Group’s role in capturing emerging demands.
- The COVID-19 has disrupted global supply chains, leading to global chip shortage. The lingering effect of the global chip shortage and the surge in demand for electronics have led to growth in the semiconductor industry in 2022 during the Track Record Period. To meet the growing demand, semiconductor companies increased its capital expenditure and investment in semiconductor manufacturing equipment in 2022. However the surge in production and inventories in 2022 resulted in oversupply towards the end of 2022. The oversupply caused semiconductor companies and semiconductor equipment manufacturing companies to cut production and initiating destocking measures in 2023 to keep supply and demand balanced, leading to decrease in demand of our products.

Verifications

Singapore is a the hub for MRO and manufacturing, providing one-stop MRO services and capturing a significant share of the regional and global MRO market. Singapore's aerospace industry reached a total output produced of S$12.9 billion in 2019, and increased to S$15.4 billion in 2023 at a CAGR of 4.5%, where MRO contributing to about 15% of the output. The aerospace MRO market in Singapore accounted for about 25% of the Asia-Pacific MRO market and 10% ot the global MRO market in terms of total annual output. Singapore's MRO industry is driven by factors such as the country's strategic location, well-developed and more accommodated aviation infrastructure, skilled workforce, supportive government policies, etc. Major investments in capacity expansions and the integration of advanced technologies are key trends shaping the industry's future, including the expansion of infrastructure, adoption of automation, digital technologies, data analytics, and advanced materials to drive innovation and improve processes.

In Singapore, aerospace MRO involves the maintenance, repair, and overhaul of various components and systems, including but not limited to repair and overhaul of aircraft engines (such as turbofan, turboprop and turboshaft engines), maintenance and repair of avionics systems (such as navigation, communication and flight control systems), and airframe maintenance. Some prominent aerospace companies with MRO presence in Singapore include ST Engineering Aerospace, Rolls-Royce and SIA Engineering Company.

Customer B is a key player in the aerospace sector, specializing in the design, manufacturing, and testing of high-reliability electronic components and systems used in both commercial and military aircraft.

In the aerospace sector, precision engineering service providers play a crucial role in delivering high-quality precision components that meet the stringent requirements of aerospace manufacturers and operators. In Singapore, these precision engineering service providers have significant market opportunities due to (i) growing demand for precision components: with the increasing demand for aircraft globally, there is a growing need for precision engineering components in the aerospace sector, and precision engineering service providers are well-positioned to capitalize on this demand by offering specialised precision machining and welding services for aerospace applications; (ii) rising complexity of aerospace systems: modern aircraft and aerospace systems are becoming increasingly complex, requiring precision components that meet tight tolerances and exact specifications; and (iii) global supply chain integration: Singapore's position as a global aerospace hub provides precision engineering service providers with access to a well-connected supply chain network, which enables them to source materials and technologies from around the world, enhancing their capabilities and competitiveness in the aerospace market.

Precision engineering service providers in the aerospace sector in Singapore have several competitive advantages: (i) strategic position: Singapore's strategic position as a global aerospace hub allows Singaporean precision engineering service providers to easily access Asian and global markets efficiently; (ii) robust infrastructure: Singapore boasts a well-developed infrastructure, including state-of-the-art manufacturing facilities, advanced logistics networks, and world-class research institutions, which enables precision engineering service providers to operate efficiently and deliver high-quality products and services to aerospace customers; and (iii) skilled workforce: Singapore has a highly skilled and educated workforce and precision engineering service providers in Singapore can tap into this talent pool to drive innovation, enhance productivity, and maintain high-quality standards in aerospace manufacturing.

Verifications

- The precision engineering industry comprises precision component engineering and system integration. For the precision component engineering industry, it mainly involves the manufacturing of high-precision components for diverse applications spanning various sectors, while the system integration industry is mainly involves in manufacturing of full systems and subsystems that are assembled together with components and/or other subsystems. According to CIC Report, the precision component engineering industry and system integration industry have different requirements to the market players including (i) technical know-how: precision component engineering industry mainly focuses on material science and manufacturing processes while system integration industry mainly focuses on electronics and electrical engineering, such as wiring and power distribution, and software development; (ii) manufacturing technology: precision component engineering industry mainly uses CNC machines and inspection equipment to make to ensure that components meet specified tolerances, while the system integration industry mainly uses automation equipment related to motion control and testing systems to ensure the product meets performance specifications; and (iii) capital requirement. precision component engineering industry usually have higher upfront capital requirements due to the need for specialized machinery and infrastructure. Having considered that (i) during the Track Record Period, the Group's revenue was all generated from manufacturing of high-precision components by precision machining and precision welding, and (ii) the difference of requirements to the market players in the two sub-segments, therefore it is fair and accurate to present market ranking in this sub-segment.
- Non-critical components: standard machining parts in the semiconductor manufacturing equipment without high intellectual property contents in their design which therefore do not come into direct contact with wafers, such as cables, connectors and metal cabinets.
- As the Group is primarily supplying critical components (being specific custom-designed machining parts with high intellectual property contents which have direct contact with wafers) for the semiconductor manufacturing equipment, the industry expertise in non-critical components of MMI may allow us to leverage the Group's manufacturing capabilities to diversify and expand our business to providing non-critical components in the semiconductor manufacturing equipment industry.
- Tubular management services per se does not involve precision machining or precision welding processes.
- Parts that the Group intend to produce for its oil and gas customers require high tolerance levels and resistance to extreme environments to be used in the oil and gas exploration, production and refining processes.
- The Group is employing more 5-axis CNC machines than the industry peers in general. Multi-axis CNC machines, in particular, CNC machines with more axes (directions of movements), allow for machining in multiple directions simultaneously. The 5-axis CNC machines the Group use in their production can move in five different directions, being three linear areas (up and down, left and right, back and forth) and two rotational axes. Compared to 3-axis or 4-axis CNC machines, which can only move in three directions or four directions respectively, 5-axis CNC machines can reach more angles and create more complex and detailed parts without the need to manually moving the machined parts for multiple processes. With more machining steps to be completed in the same timeframe, use of multi-axis CNC machines can reduce machining cycles and operational costs in terms of the labour hours spent on manually moving the machined parts for multiple processes and the total lead time on production. Multi-axis systems facilitate more complex machining operations such as simultaneous milling, drilling and cutting, thus enhancing both production efficiency and ensuring machining accuracy
- Comparation of operating time and cost of CNC machines.

	2-axis	3-axis	4-axis	5-axis
Operating cost per hour	USD10-40	USD 20-80	USD 60-140	USD 40-200
Operating time	4x-20x	2x-10x	2x-5x	1x

**Operating cost and operating time is subject to the complexity of the component.*

Verifications

- The industry average utilisation rates of the production facilities of precision machining and precision welding industry both ranged between 40% to 80% during the Track Record Period. This wide range reflects varying operational circumstances and industry demands. Companies focused on the semiconductor industry operate at lower utilisation rates of 40% to 60% as the parts and components produced for the semiconductor industry are less standardised and more complex. These parts require the use of different types of CNC machines and other machines and tools for each step of the production process. The machines required for different product may also vary widely, leading to lower utilisation rates for the higher varieties of machines. In contrast, companies mainly serving the aerospace industry and automobile industry operate at higher utilisation rates of 60% to 80%. The parts produced for these industries are relatively more standardised and more streamlined, requiring less varieties of machines, and thus leading to higher utilisation rates.
- The COVID-19 pandemic has disrupted global supply chains, leading to global chip shortage. The lingering effect of the global chip shortage and the surge in demand for electronic products have consequently led to increase in demand in the semiconductor industry in 2022. In 2022, with the eventual uplift of COVID-19 preventive and lock-down measures by governments in different countries, in order to secure the production capacity of their suppliers in the post COVID-19 period to cope with the expected growing demand for chips, semiconductor companies increased its capital expenditure and investment in semiconductor manufacturing equipment. Therefore, the surge in production and demand resulted in accumulation of inventories during 2022. This then caused semiconductor companies and semiconductor equipment manufacturing companies to slow down their purchases and undertake periodic de-stocking measures in 2023.
- The global semiconductor manufacturing equipment market is expected to witness a transition year in 2024 from the de-stocking of inventories accumulated starting in 2023 and have a strong rebound in 2025. Driven by capacity expansion, new fabrication projects, and demand for advanced equipment and solutions across the front-end and back-end segments, including wafer processing, testing, assembly, packaging, etc., of the semiconductor industry, and supportive policies of the semiconductor industry across the world, including (i) Singapore Manufacturing 2030 vision (the government's 10 year plan to increase the manufacturing value-add of Singapore by 50% by 2030 and for Singapore to become a global business, innovation and talent hub for advanced manufacturing). In this regard, Singapore has successfully attracted leading international semiconductor companies, such as Global Foundries, Siltronic and UMC to set up operations in Singapore. As a result, the Group, which possesses advanced manufacturing capability to provide precision engineering services for international companies in the semiconductor and other sectors, is considered one of the advanced manufacturing players to benefit from the favourable government policies. (ii) CHIPS and Science Act (a U.S. federal statute enacted in 2022 which provides support to develop domestic production of semiconductors with incentives such as subsidies and investment tax credits in the U.S.). It was announced in April 2024 that a U.S. memory chip maker Micron Technology would receive US$6.1 billion in grant under the act from the U.S. Commerce Department to support its plan for the domestic chip factory projects in New York and Idalo; and (iii) The European Chips Act (an act came into force in 2023 to incentivise public and private investments in semiconductor manufacturing facilities in Europe). Under the chip act, additional public and private investments of more than €15 billion will complement existing programmes and actions in research and innovation in semiconductors such as Horizon Europe and Digital Europe Programme), the global sale of semiconductor manufacturing equipment is expected to further increase to US$180.6 billion in 2028, registering a CAGR of 11.2% between 2023 and 2028.
- The COVID-19 pandemic has disrupted global supply chains, leading to global chip shortage. The lingering effect of the global chip shortage and the surge in demand for electronic products have consequently led to increase in demand in the semiconductor industry in 2022. In 2022, with the eventual uplift of COVID-19 preventive and lock-down measures by governments in different countries, in order to secure the production capacity of their suppliers in the post COVID-19 period to cope with the expected growing demand for chips, semiconductor companies increased its capital expenditure and investment in semiconductor manufacturing equipment. Therefore, the surge in production and demand resulted in accumulation of inventories during 2022. This then caused semiconductor companies and semiconductor equipment manufacturing companies to slow down their purchases and undertake periodic de-stocking measures in 2023, leading to decrease in demand of the Group's precision machining parts and components during the year ended 31 December 2023.

Verifications

- According to the International Air Transport Association (IATA), due to aircraft's production constraints, airline capacity will remain in shortages until 2025 by the earliest. As a result, the airlines are now increasingly reliant on the existing fleets, and this has bolstered demand for MRO services. At the same time, the key MRO service providers are also facing capacity constraints due to labor shortages, which created opportunities for new entrants such as Metasurface.

- Precision welding involves using advanced welding methods and specialised processes such as laser and electron beam to join materials together according to strict specifications and tolerance

- Compared to other qualified suppliers for large format vacuum chamber used in semiconductor industry, Metasurface stands out for its inventory management capabilities, and accurate estimates on forward demand thanks to its close relationship with its clients. Metasurface's core products in the semiconductor industry is the core structure of the vacuum chamber of various sizes and more than 1000 kinds of related components. Vacuum chambers are a crucial component in almost all procedures of chip fabrication, all the way from deposition, etching, ion implementation, testing and cleanroom, as a vacuum environment enables a higher level of precision, reduce contamination, and protects the factory from various forms of toxic gases used during the fabrication processes.

- Vacuum chambers used in front-end processes receives a lot of tear and wear, and in order to ensure the quality of chip fabrication, vacuum chamber systems usually have to undergo a maintenance every 3-6 months.

- Large vacuum chamber is a core component for wafer transfer equipment which is commonly used in all levels of the front-end process.

- Singapore is one of the largest aerospace maintenance hubs in Asia, with the region capturing over 10% of the global MRO service market, according to the US International Trade Administration. Due to the aircraft industry's production constraints, and the recovery in post-pandemic air travel demand, airlines are increasingly reliant on their older existing fleets. This has bolstered demand for MRO services as aircraft generally have to undergo an MRO session according to flight hours or frequency.

- Driven by a robust surge in GenAI-related applications, and a gradual recovery in consumer electronics' end-demand, the front-end semiconductor equipment industry is expected to start recovering from 2025 onwards.

- The global MRO market is expected to grow 19.4% in 2024-34 to US$124b (1.8% CAGR), whereas the engine MRO sub-segment is expected to grow at a faster rate at 25.7% to US63b (2.3% CAGR).

- Aerospace Engine MRO demand is rising due to: a) post-COVID recovery of air travel, b) production strain, and c) quality problems with new engine models which led to higher mileage with older fleets

Verifications

- The aerospace engine maintenance, repair and overhaul service sub-sector is heavily reliant on foreign capacity – MRO service providers have to send the engine to Japan or Germany for maintenance before shipping back to Singapore, and this is where local service providers comes in. This is raising transportation costs and increase off time for airplanes under maintenance, and as such, some airplane engine makers are seeking to localise the supply chain, and Metasurface is one of the prime potential suppliers in the local market. The business has a high barrier to entry, with a lengthy verification process that can take more than 2 years, according to Aerospace engine supplier Pratt and Whitney, such that the customer stickiness is relatively high. Given the high safety requirements (i.e. core components for commercial aircrafts), it takes around 2 years to pass the verification process, and another 2 years of testing to achieve a supplier approval. ASP and margins are significantly higher for Aerospace engine MRO market. Metasurface does not need to bare any raw material costs, such that the business is also margin accretive.

- While it is true that the precision engineering component industry is extremely fragmented, each maker plays into its own niche products. The entry barrier is also relatively high, with a lengthy verification period of around 2 years, strict quality control, capacity utilisation and various cashflow/balance sheet/inventory management requirement.

- Precision components used in aerospace engineering has a lot of similarities with the semi industry, such as the use of large sized CNC machines, higher precision and quality control requirements, the use of vacuum chambers, and an even higher entry barrier i.e. a very long 3-4 years verification process.

- Unlike conventional lens which has a multi-layer curved lens 3D stacking structure over a CMOS sensor, Metalens is a flat lens technology that uses nanostructured surfaces (Metasurface) on a dielectric surface to manipulate incident light. The technology can be used in optical applications that take advantage of the flat surface, with higher focusing efficiency, tunability, etc. to reduce thickness and increase optical performance, compared to classic curved refractive lenses mainly used in conventional optical devices. Currently, Metalens are primarily used in sensor modules (i.e. face ID scanners,) where image quality is less important, but in the longer term, the market generally has higher expectations on its application in devices with a strict form factor requirements, such as the next generation smart glasses.

- Aerospace engine has to accommodate for a vacuum environment as well. Airplane engines functions through utilising a vacuum pump to generation suction through the intact of air, which are then utilised in the combustion with fuel. As such, the engine's chamber has similarities with the vacuum chambers utilised in semiconductor industry as well.

- Precision machining primarily involves the sale of CNC machine processed parts, and has a more diversified client mix and exposure to different downstream verticals.

- Precision welding involves the sale of more labour-intensive, smaller precision welding parts.

- Coordinate measuring machine is crucial in ensuring the quality of the parts we produce, especially as precision machining requires high precision in terms of dimensions.

- Both precision both precision machining and precision welding are integral to the precision engineering process.

- Processes which do not involve the application of high-purity precision welds can generally be produced outside the cleanroom.

Thank you!

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