Confidential

Global SiC Market

Industry Report

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For and on behalf of
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Glossary

Terms	Description
SiC	➢ SiC stands for silicon carbide, which is a hard chemical compound containing silicon and carbon.
Band gap	➢ Band gap refers to the energy difference between the top of the valence band and the bottom of the conduction band in a semiconductor. Compared with traditional semiconductors, wide-bandgap semiconductors enable devices to operate at higher voltages, frequencies, and temperatures.
Breakdown field strength	➢ The breakdown field strength of a semiconductor is the critical electric field strength in the semiconductor material that can cause avalanche breakdown. A higher breakdown field strength indicates that the semiconductor device can operate at higher voltages without breakdown, thus having a larger operating range and power range.
Saturated electron velocity	➢ The saturated electron velocity of a semiconductor is the maximum drift velocity that electrons can reach in a semiconductor material under a high-electric field. A high saturated electron velocity helps improve the switching speed and high-frequency performance of the device.
Thermal conductivity	➢ The thermal conductivity of a semiconductor material refers to the material's ability to conduct heat. The higher the thermal conductivity, the more efficient the material is at conducting heat.
Heat resistance	➢ Heat resistance refers to the ability of a material to resist significant deformation or degradation when heated. The higher the heat resistance of a material, the higher its reliability in a high-temperature environment.
Voltage resistance	➢ The voltage resistance of a semiconductor material refers to the ability of a semiconductor device to withstand over-voltage. It is usually characterized by the voltage value at which the device breaks down or the current reaches a specific value. The higher the voltage resistance of a semiconductor, the higher its reliability in a high-voltage environment.
Radiation resistance	➢ The radiation resistance of a semiconductor material refers to the ability of a semiconductor device to withstand and operate normally in a high-radiation environment. The higher the radiation resistance of a semiconductor material, the higher its reliability in a high-radiation environment.
Switching frequency	➢ Switching frequency refers to the rate at which a switching-mode power supply turns on and off. It affects the performance of the device, including its efficiency and power output, and plays a crucial role in designing compact and low-cost circuits. The higher the switching frequency of semiconductor material, the faster the switching speed of the material in the device.
Heat dissipation	➢ Heat dissipation refers to the ability to transfer heat away from the heat source. The better the heat dissipation, the more conducive it is to reduce the local temperature of the device and improving the device's performance and reliability.

Source: Frost & Sullivan

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Silicon Carbide Materials: Empowering the Critical Engines of Future Technology Revolution (1/2)

Energy transition and artificial intelligence (AI) are two critical engines driving the future technology revolution. Building a world of growth, innovation, and sustainability stands as the core objective of the advancement and integrated development of energy transition and AI technologies. Silicon carbide materials have emerged as one of the cornerstones empowering energy transition and AI to achieve their core development goals.

Silicon carbide materials serve as the "energy efficiency multiplier" for empowering energy transition.

- Energy transition refers to the global shift of the energy structure from traditional fossil fuels to clean and renewable energy sources such as solar and wind energy. It also emphasizes improving energy efficiency through technological advancements, which is a crucial strategy for achieving global "carbon neutrality." For energy supply, energy transition emphasizes reducing reliance on fossil fuels and developing clean and renewable energy sources like solar and wind energy. In 2024, renewable energy accounted for over 40% of the global total electricity generation, and this proportion is expected to rise further in the future. The combined contribution of electricity generation from solar photovoltaics and wind power is projected to reach 40% in 2035 and 60% in 2050. For energy consumption, the trend of electrification is driving the growth of electricity consumption demand and changing the energy consumption structure. From 2020 to 2024, the proportion of global electricity consumption in total global energy consumption increased from 19.8% to over 20% and is expected to further increase to 23% in 2028. The increase in the total amount of electricity consumption makes the conversion efficiency of electricity particularly crucial. It is estimated that by 2028, every 1% increase in the conversion efficiency of electricity will save 348.3 TWh of electricity annually, equivalent to the annual power generation of more than 40 medium-sized nuclear power plants. Improving the conversion efficiency of electricity is quite urgent.
- Thanks to the advantages of silicon carbide materials, such as high frequency, low loss, high-voltage resistance, and high-temperature resistance, silicon carbide power semiconductor devices can enhance the conversion efficiency of electricity in the generation and consumption, achieve a smaller system size and higher power density, and also less demand for cooling systems. They have become the "energy efficiency multipliers" in fields such as new energy vehicles, photovoltaic and energy storage system, power supply, and data centers, driving the energy system to transition towards low-carbonization.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Silicon Carbide Materials: Empowering the Critical Engines of Future Technology Revolution (2/2)

Silicon carbide materials are an inevitable choice for the growth and innovation of the AI industry.

- Silicon carbide materials enable the AI industry to address power supply challenges. As a transformative foundational technology, AI is leading the development of the fourth industrial revolution. Currently, AI is being integrated into various aspects of industries and people's daily lives, exerting a profound impact on human development. With the advancement of large language model technology, generative AI has stronger reasoning and intelligent capabilities, further accelerating the rapid penetration of AI. The explosive growth of AI will reshape the global power landscape. AI model training and inference highly rely on the supply of massive computing power resources, and high computing power demands mean high power consumption. Compared with traditional software applications, AI applications consume more power. Taking search Q&A as an example, the power consumption of a single ChatGPT question-answering is 6-10 times that of a single Google search. As an important infrastructure supporting the development of AI, data centers are expected to account for 10% of global power consumption by 2030. Compared with traditional silicon-based power semiconductor devices, silicon carbide-based power semiconductor devices can provide higher power conversion efficiency and higher power density. The application of silicon carbide-based power semiconductor devices in data centers is an inevitable choice to alleviate the global power supply challenges for AI and achieve the low-carbonization of data centers.
- On the other hand, silicon carbide materials empower the innovation of AI-enabled smart products. The development of AI technology continuously gives rise to innovations in AI-enabled smart products, which in turn create application opportunities for new materials represented by silicon carbide. For example, silicon carbide materials are applied to the innovation of AI glasses. AI glasses are smart glasses integrated with artificial intelligence technology. They can acquire environmental information in real-time, analyze data, and provide intelligent feedback or services according to users' needs. They can also achieve visual interaction through the integration of display technology. The refractive index of silicon carbide materials is significantly higher than that of high-refractive-index glass, lithium niobate, and other materials. The application of silicon-carbide-based optical waveguides in AI glasses can achieve a larger field of view and a simpler structured full-color display. This can reduce the size, weight, manufacturing cost, and complexity of AI glasses, and significantly enhance the user experience. The application of silicon carbide materials will directly promote the large-scale commercialization of the global AI glasses market. AI glasses are expected to replace smartphones as the next-generation intelligent terminal and computing platform for individual users.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market

Introduction to Silicon Carbide Materials: Key Fundamental Materials Empowering Energy Efficiency Improvement and Smart Product Innovation

Silicon carbide (SiC), a compound composed of carbon and silicon elements, features high hardness and excellent physical and chemical properties. Characterized by high-voltage resistance, high-frequency resistance, high thermal conductivity, high-temperature stability, and a high refractive index, silicon carbide materials serve as crucial materials for cost-reduction and efficiency-enhancement in numerous industries.

Features	Explanation	Application Examples
High-voltage Resistance	SiC material can withstand high voltages without breakdown, with a maximum withstand voltage of over 10 kV.	• It can be applied in fields such as new energy vehicles, rail transit, power grids, and ultra-fast charging piles. • In the converters and inverters of high-voltage direct-current (HVDC) transmission systems, it reduces energy losses during long-distance power transmission.
High-frequency Resistance	SiC material supports high switching frequencies (usually ranging from tens of kHz to several MHz), has low on-resistance, can reduce switching losses, minimize high-frequency signal losses, and improve circuit response speed.	• Applicable in fields like new energy vehicles, data centers (AI server power supplies), communication, and industry. • In the motor drive of new energy vehicles, it reduces switching losses, significantly improves energy conversion efficiency, extends the driving range, and reduces battery consumption.
High Thermal Conductivity	SiC material exhibits high thermal conductivity, enabling rapid heat conduction.	• It can be used in areas such as new energy vehicles, data centers, and heat-dissipation components. • In high-power-density devices like LED lighting and semiconductor lasers, it helps with effective heat dissipation, maintaining the stability of device performance and extending the device's service life.
High-temperature Stability	SiC material maintains stable physical and chemical properties at high temperatures.	• Applied in fields such as new energy vehicles and rail transit. • In the motor drive of new energy vehicles, it can still maintain stable power output in high-temperature environments.
High Refractive Index	SiC material can better confine light propagation in waveguides or optical fibers, reducing light leakage and improving the efficiency of optical devices. It can also reduce the wavelength of light in the material, enabling the design of more compact optical devices. Moreover, it can achieve higher resolution and smaller optical aberrations	• Used in fields like AI glasses • In the optical waveguide optical solution of AI glasses, it transmits the images displayed on the micro-display to the user's eyes.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Advantages of Silicon Carbide over Traditional Materials in Different Application Fields

Benefiting from the above-mentioned excellent material properties, and with the advancement of silicon carbide material manufacturing technology and the innovation of downstream industry applications, the application fields of silicon carbide materials have been continuously expanding, especially attracting extensive attention in high-tech fields. Silicon carbide materials can be widely applied in downstream products such as power semiconductor devices, radio-frequency (RF) semiconductor devices, AI glasses optical waveguides, TF-SAW (Thin-Film Surface Acoustic Wave) high-end filters, and heat-dissipation components. The main application industries include new energy vehicles, photovoltaic energy storage, power supply, rail transit, mobile communication, satellite communication, consumer electronics, industry, and data centers, replacing or supplementing traditional materials in the above-mentioned fields.

Typical Application Fields	Advantages of Silicon Carbide
Power Semiconductor Devices and Radio-Frequency Semiconductor Devices	• Compared with silicon, the band-gap width of silicon carbide is approximately 2.9 times that of silicon, the thermal conductivity is about 3.3 times that of silicon, the breakdown voltage is around 9.3 times that of silicon, and the saturated electron velocity is roughly 2 times that of silicon. Therefore, silicon carbide has become a key material for power-electronics applications in high-temperature and high-voltage environments such as electric vehicles, photovoltaic energy storage, and rail transit.
Optical Waveguides	• Compared with high-refractive-index glass, the refractive index of silicon carbide is at least 1.2 times that of high-refractive-index glass. • Compared with lithium niobate, the refractive index of silicon carbide is 1.1-1.2 times that of lithium niobate. • Thanks to its higher refractive index, silicon carbide helps AI glasses achieve a larger field of view, reduce light loss, and realize a more lightweight full-color display based on a monolithic waveguide.
TF-SAW High-end Filters	• Compared with silicon, with its characteristics of high sound velocity, low loss, high thermal conductivity, and low coefficient of thermal expansion, silicon carbide improves frequency selectivity, pass-band performance, and filtering efficiency, while meeting the strict requirements of high power and temperature compensation.
Heat-dissipation Components	• Compared with traditional heat-dissipation materials such as aluminum and aluminum nitride, the thermal conductivity of silicon carbide is 1.2 times that of copper and about more than 2 times that of aluminum nitride. Therefore, silicon carbide is more suitable for scenarios where rapid heat dissipation is required to protect sensitive electronic components or to maintain stable operation in high-power-density devices.

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Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market

Silicon carbide materials take the lead in promoting the transformation of the semiconductor industry, and are beginning to replace and complement silicon-based technologies in more fields

The application innovation in downstream industries such as power electronics, along with the advancements in upstream materials science, jointly drive the progress and innovation of materials applied in the semiconductor field. Silicon (Si), as a representative of elemental semiconductor materials, has become the cornerstone of the semiconductor industry due to its abundant reserves, low cost, and mature manufacturing processes. However, due to the limitations of silicon materials themselves in terms of bandgap, thermal conductivity, breakdown field strength, and frequency performance, it has gradually become difficult to meet the performance requirements of semiconductors for downstream industry applications. This has given rise to the emergence and development of compound semiconductor materials, especially wide-bandgap semiconductor materials. The following figure shows the types, advantages, industrialization processes, and application scenarios of the main semiconductor materials of different generations.

Semiconductor	First generation semiconductor	Second generation semiconductor	Third generation semiconductor
Material	Elemental semiconductors: Silicon (Si), germanium(Ge)	Compound semiconductors: Gallium Arsenide (GaAs), Indium Phosphide (InP)	Compound semiconductors: Silicon Carbide (SiC), Gallium Nitride (GaN)
Advantage	• Abundant and low-cost, silicon is the most widely used semiconductor • Enabled the shift from vacuum tubes to compact electronics	• Faster electron mobility for high-frequency transmission • Direct bandgap for applications in light emission, including infrared lasers and high-brightness red LEDs	• Enhanced thermal and electronic properties • Improved electrical strength and radiation resistance • Energy-efficient and eco-friendly • Compact device size
Industrialization Process	• Elemental semiconductor manufacturing technology is mature and close to optimal, but has reached the physical limit, performance enhancement space is narrowed, industrialization is very mature	• Compound semiconductors in the field of high-frequency high-power industrialization, especially in the field of radio frequency, communications and other areas of significant development	• Wide-band semiconductors are in the early stage of industrialization, the production process is complex, there is still room for improvement, only a small number of companies with large-scale high-quality production capacity
Application	• Widely used in information processing and automation, including consumer electronics, telecommunications, photovoltaics	• In optoelectronics, including millimeter-wave devices, satellite communication, mobile communication, and GPS navigation	• In high-performance sensors • Applications span 5G, IoT, electric vehicles, optoelectronics, and display technology

Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market

Data Metrics and Main Characteristics of Silicon Carbide and Silicon

Compared with silicon-based semiconductors, wide-bandgap semiconductors represented by silicon carbide (SiC) and gallium nitride (GaN) have prominent performance advantages from the material to the device level. They feature high frequency, high efficiency, high power, high-voltage resistance, and high-temperature resistance, and are an important direction for the future development of the semiconductor industry. Among them, silicon carbide exhibits unique physical and chemical properties. Characteristics such as its high band-gap width, high breakdown electric field strength, high electron saturated drift velocity, and high thermal conductivity make it play a crucial role in applications such as power-electronic devices. These properties endow silicon carbide with significant advantages in high-performance application fields such as new energy vehicles and photovoltaic energy storage, especially in terms of stability and durability. The following figure shows the data indicators and main characteristics of silicon carbide and silicon.

In addition, compared with the importance and proportion of value contributed by silicon materials in the silicon-based semiconductor industry, silicon carbide materials are of even greater importance and contribute a larger proportion of value in the silicon-carbide-based semiconductor industry chain. The main reason is that the manufacturing process of silicon materials is relatively mature, leading to relatively low manufacturing costs. The performance of silicon-based semiconductors mainly depends on the capabilities in semiconductor design and manufacturing processes, such as more advanced IP and process nodes. In contrast, the manufacturing process of silicon carbide materials is more complex. The growth rate of silicon carbide materials is slow, and their yield is lower than that of silicon materials, resulting in a higher overall cost. Thus, the proportion of the material's value in the final semiconductor product's value is higher. Meanwhile, the manufacturing of silicon-carbide-based semiconductors mostly uses mature process nodes, making the quality of silicon carbide materials one of the key factors determining the performance of the final semiconductor product.

Data Metrics	Main Characteristics	Silicon	Silicon Carbide	The Index Multiples of Silicon Carbide Compared to Silicon
Band Gap （eV）	Heat Resistance、 Voltage Resistance、 adiation Resistance	1.12	3.26	~2.9x
Breakdown Field Strength （MV／cm）	Voltage Resistance	0.3	2.8	~9.3x
Saturated Electron Velocity （10^7 cm／Second）	Switching Frequency	1.0	2.0	2.0x
Thermal Conductivity （W/(cm*K)）	Heat Dissipation	1.5	4.9	~3.3x

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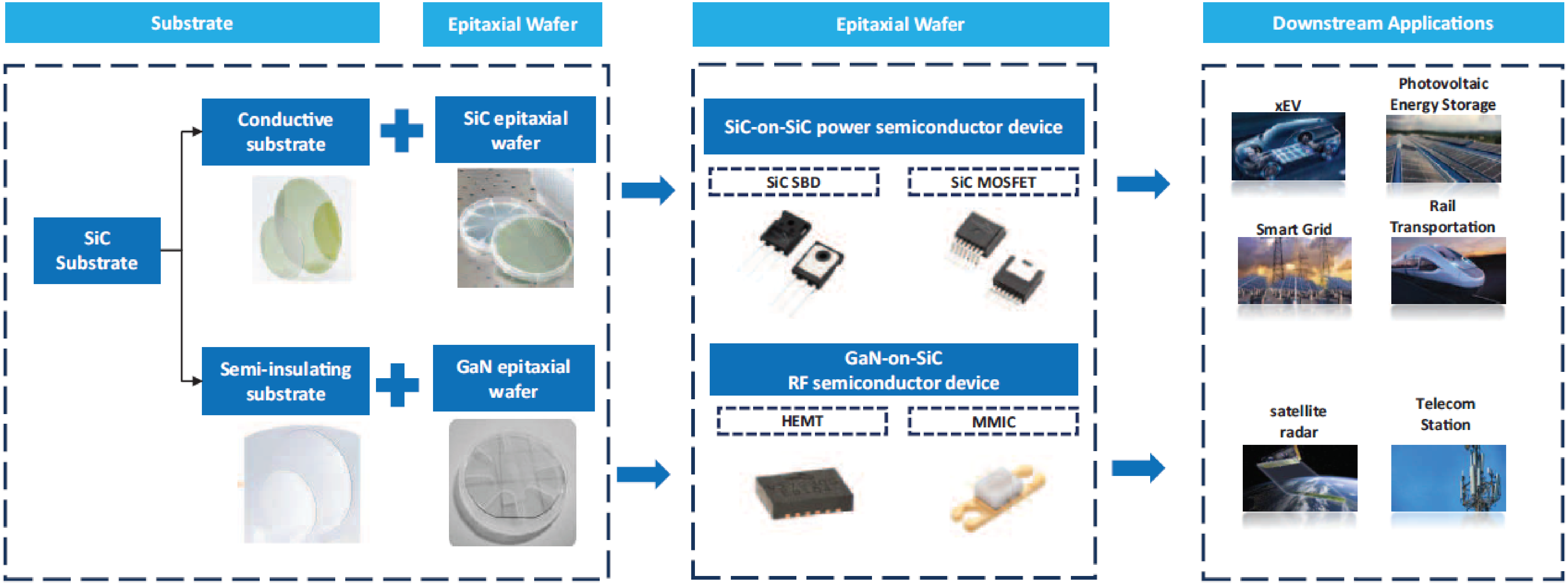
Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market

Silicon carbide materials have broad market application potential in power semiconductor devices, radio-frequency semiconductor devices, and emerging application fields

Silicon carbide materials are commonly used to produce silicon carbide substrates or silicon carbide epitaxial wafers. Among them, silicon carbide substrates can be widely applied in downstream products such as power semiconductor devices, radio-frequency semiconductor devices, optical waveguides, TF-SAW high-end filters, and heat-dissipation components. The main application industries include new energy vehicles, photovoltaic energy storage, power supply systems, rail transit, communications, AI glasses, smartphones, semiconductor lasers, etc. The following figure shows the types of products manufactured based on silicon carbide materials and their main existing and potential application fields.



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Source: Frost & Sullivan

SiC Power Devices - Overview

Source: Frost & Sullivan

Introduction of Power Semiconductor Devices and SiC Power Semiconductor Devices

- In the field of power semiconductor devices, silicon carbide (SiC) MOSFETs are expected to achieve large-scale replacement of silicon-based IGBT products in the future. In terms of product advantages, SiC MOSFETs have a relatively high switching frequency. This can reduce switching losses and the demand for passive components, thus enabling the realization of more miniaturized systems and higher power density. They also possess a relatively high energy conversion efficiency, with a maximum operating junction temperature of 200° C. This reduces the requirements for the heat dissipation system, allowing the use of smaller heat sinks. Moreover, SiC MOSFETs adopt a driving method extremely similar to that of silicon-based IGBTs, which is conducive to promoting industrial applications. Additionally, compared with silicon-based IGBTs, fewer SiC MOSFET devices are needed under the same power conditions.

	Silicon Carbide MOSFET	Silicon-based IGBT
Switching Frequency	- High switching frequency, which can reduce switching losses and the demand for passive components, enabling more miniaturized systems and higher power density.	- Low switching frequency, with a high demand for passive components, making it difficult to achieve system miniaturization and higher power density.
Efficiency and Performance	- Relatively high energy conversion efficiency. - The maximum operating junction temperature is 200° C, reducing the requirements for the heat dissipation system and allowing the use of smaller heat sinks.	- Relatively low energy conversion efficiency. - The maximum operating junction temperature is 175° C, imposing higher requirements on the heat dissipation system.
Application	- Adopts a driving method extremely similar to that of silicon-based IGBT, which is conducive to promoting industrial applications.	- More devices are required under the same power.

Source: Frost & Sullivan

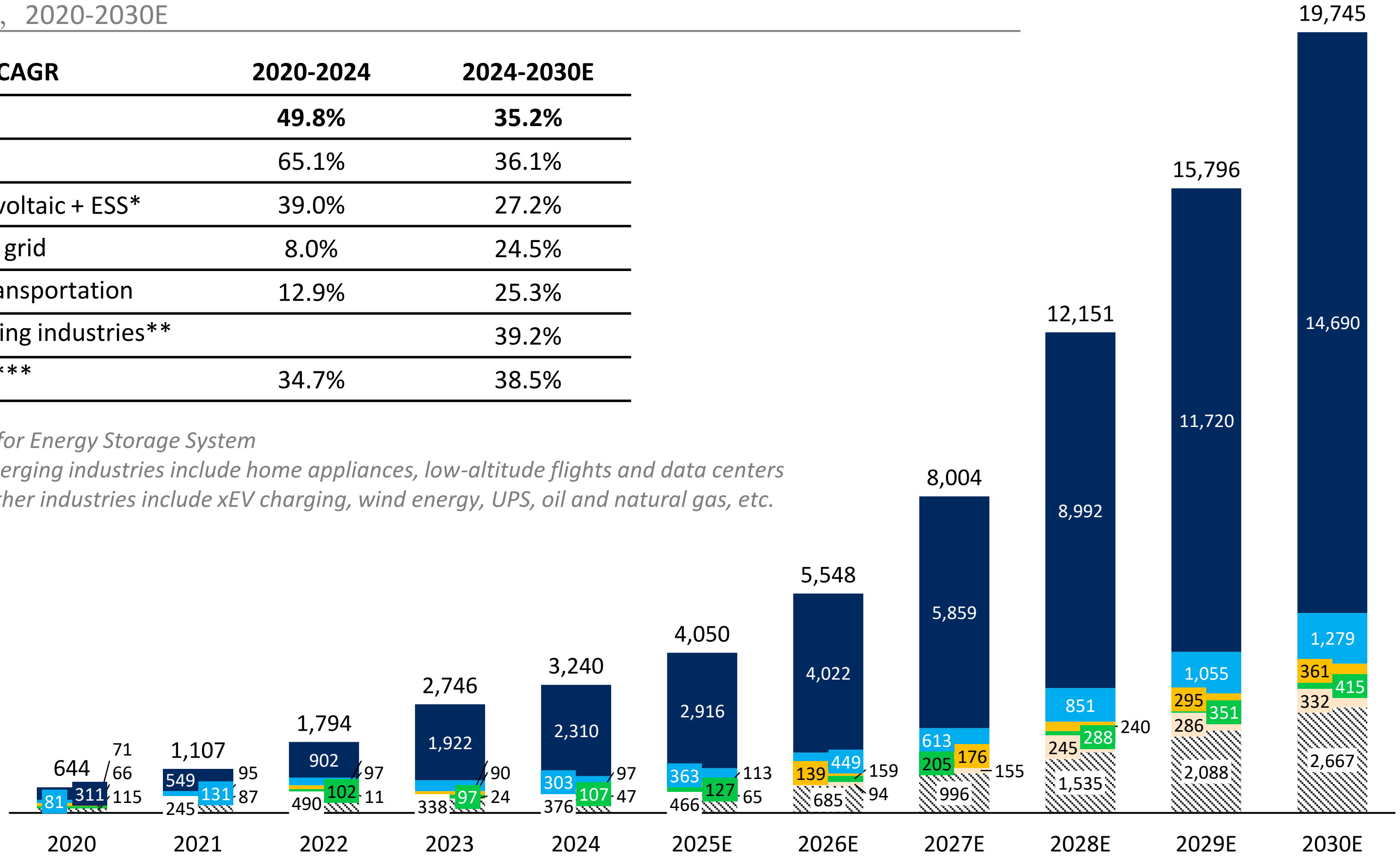
Overview of Global Silicon Carbide Materials and Applications Market
Market Size of Global SiC Power Semiconductor Devices, by application

Global SiC power semiconductor device market size, in terms of sales revenue

Million USD， 2020-2030E

CAGR	2020-2024	2024-2030E
Total	**49.8%**	**35.2%**
xEv	65.1%	36.1%
Photovoltaic + ESS*	39.0%	27.2%
Power grid	8.0%	24.5%
Rail transportation	12.9%	25.3%
Emerging industries**		39.2%
Other***	34.7%	38.5%

**Note: ESS for Energy Storage System*
***Note: Emerging industries include home appliances, low-altitude flights and data centers*
****Note: other industries include xEV charging, wind energy, UPS, oil and natural gas, etc.*



Penetration rate of global SiC power semiconductor devices out of global power semiconductors

2020	2021	2022	2023	2024	2025E	2026E	2027E	2028E	2029E	2030E
1.4%	2.4%	3.7%	5.8%	6.5%	7.6%	9.5%	12.5%	17.1%	20.1%	22.6%

Key Findings

- By application area, from 2020 to 2024, the global revenue of SiC power semiconductor devices used in xEV had a compound annual growth rate (CAGR) as high as 65.1%. From 2024 to 2030, the CAGR in the xEV vehicle sector will still be as high as 36.1%, continuing to lead the growth of the global SiC power semiconductor device market. The photovoltaic energy storage, power grid, and rail transit sectors also show strong growth momentum. The CAGRs in the future forecast period will reach 27.2%, 24.5%, and 25.3% respectively. Emerging application areas of SiC power semiconductor devices such as home appliances, low-altitude flight, and data centers will exhibit the fastest growth rate. The global revenue of SiC power semiconductor devices applied to these areas is expected to have a projected CAGR of 39.2%

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Source: Frost & Sullivan

SiC Power Devices – xEV

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC Power Semiconductor Devices in xEV

- Range, charging speed, and driving experience are crucial factors determining the popularity of new energy vehicles. Compared with traditional silicon-based power devices such as silicon-based IGBTs, silicon carbide power devices have significant advantages such as low on-resistance, high switching frequency, high heat resistance, and high thermal conductivity. These advantages can effectively reduce energy losses in the power conversion process, decrease the volume of passive components like inductors and capacitors, lower the weight and cost of power modules, reduce the need for heat dissipation and simplify the thermal management system, and improve the dynamic response of motor control. As a result, they enhance the range, charging speed, and driving experience of new energy vehicles. By 2024, well-known global automakers such as Tesla, Toyota, Mercedes-Benz, and Volkswagen had already used silicon carbide power devices in many of their new energy vehicle models. **The number of new energy vehicle models worldwide using silicon carbide power devices rapidly increased from 1 model in 2019 to over 200 models in 2024. The corresponding vehicle sales increased from approximately 300,000 units in 2019 to approximately 3,400,000 units in 2024, with a compound annual growth rate of 62.5%.**

- Silicon carbide power devices can be applied to various components in new energy vehicles, including motor drives, on-board chargers (OBCs), DC/DC converters, air-conditioning compressors, high-voltage PTC heaters, and pre-charge relays. Currently, they are mainly used in motor drives, OBCs, and DC/DC converters, replacing traditional silicon-based IGBT power modules:

Motor Drive:
The power module in the motor drive converts the direct current from the battery into alternating current to drive the motor. Compared with silicon-based IGBT power modules, silicon carbide power modules can significantly reduce the energy loss of the motor drive by 70-90%, increasing vehicle range by 10%. This substantially decreases the energy consumption in the conversion process, thereby increasing the range of new energy vehicles. Moreover, silicon carbide power modules can maintain stable high-power output in high-temperature environments and support higher rated voltages. The silicon carbide power devices in the motor drive contribute the most in terms of value, accounting for 97.2% of the total global market size of silicon carbide power devices for new energy vehicles in 2024.

OBC (On-Board Charger):
The power module of the OBC converts external alternating current into direct current to charge the battery. Compared with silicon-based IGBT power modules, silicon carbide power modules can reduce the charging loss of the OBC by 40%. This shortens the charging time, enables high-voltage fast charging, improves the user experience during the charging process, and solves the problem of low energy replenishment efficiency of new energy vehicles. The market size of silicon carbide power devices in the OBC segment accounts for 6.4 of the total global market size of silicon carbide power devices for new energy vehicles in 2024.

DC/DC Converter:
The DC/DC converter converts the direct current from the high-voltage battery into low-voltage direct current for use by in-vehicle electronic devices. Silicon carbide power modules can improve conversion efficiency, reduce energy loss and heat generation. Compared with silicon-based IGBT power modules, silicon carbide power modules can significantly reduce the energy loss of the DC/DC converter by 80-90%. This decreases the energy consumption in the conversion process, thereby improving the power usage efficiency and reducing the impact of the energy consumption of in-vehicle electronic devices on the vehicle's range. The market size of silicon carbide power devices in the DC/DC converter segment accounts for 0.4% of the total global market size of silicon carbide power devices for new energy vehicles in 2024.

Source: Frost & Sullivan

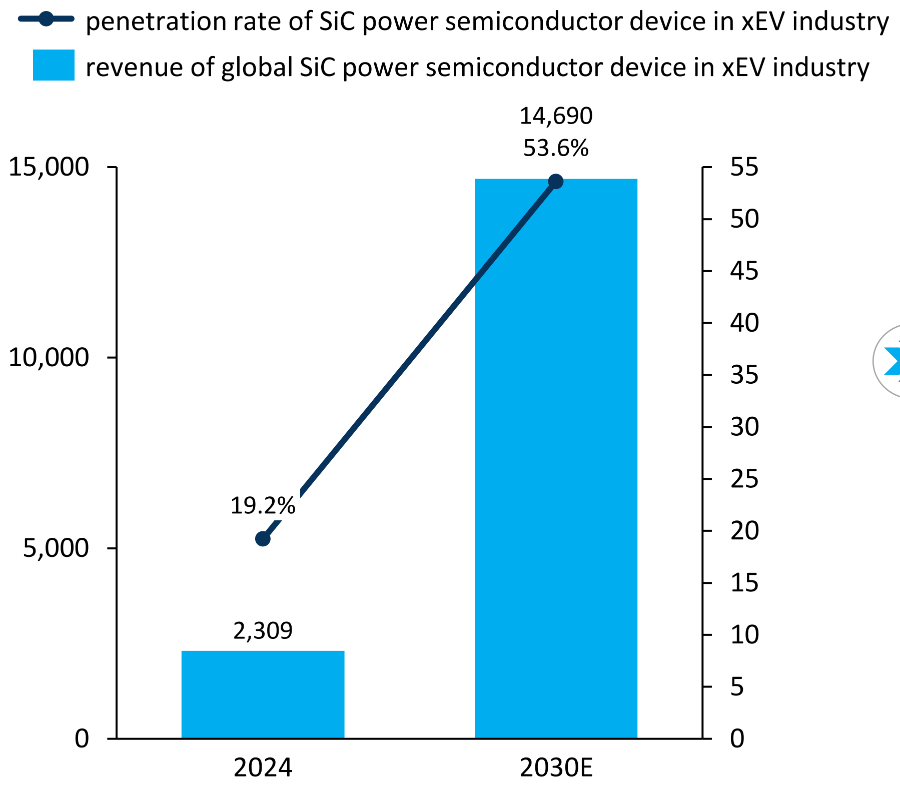
Overview of Global Silicon Carbide Materials and Applications Market

Applications of SiC Power Semiconductor Devices in xEV

Market Size of Global SiC Power Semiconductor Devices for xEV Industry, in terms of revenue

Million USD， 2024-2030E

CAGR	2024-2030E
Total	36.1%



Note: *Penetration rate in terms of percentage of xEV equipped with SiC power semiconductor components out of xEV equipped with power semiconductor components*

SiC Application

- The system cost advantage of silicon carbide power devices is gradually emerging and will be further enhanced.
- The improvement in energy utilization efficiency brought about by silicon carbide power devices gives them a competitive edge in terms of overall cost. Take the motor drive power module as an example. Compared with silicon-based IGBT power modules, silicon carbide power modules can increase the overall energy utilization efficiency by 10%. That is, for pure-electric vehicles with the same cruising range, the battery capacity can be reduced by 10% when using silicon carbide power modules. Calculated based on the battery capacity of approximately 65 kWh for mainstream pure-electric vehicles, a pure-electric vehicle using a silicon carbide power module can save 3,250 RMB in battery costs (calculated based on the cost of lithium iron phosphate batteries). The average reduction in this cost has exceeded the current price gap between silicon carbide power modules and silicon-based IGBT power modules, demonstrating that silicon carbide power modules are gradually gaining an advantage in terms of system cost.
- Secondly, as the technology and manufacturing processes mature and upgrade, the overall production and manufacturing costs of silicon carbide power devices will gradually decline. The cost gap between silicon carbide power devices and silicon-based IGBT power devices will continue to narrow, and the system cost advantage will be further enhanced, driving more new energy vehicles to adopt silicon carbide power devices.
- Furthermore, the application of silicon carbide power devices can significantly enhance the efficiency and user experience at the system level in new energy vehicles. The use of silicon carbide power devices can effectively reduce the number of passive components, thereby reducing the size and weight of systems such as the motor drive and OBC, and lowering the overall vehicle weight, thus improving energy efficiency. High-voltage systems based on silicon carbide power devices support faster charging rates, thereby enhancing user experience in charging.

SiC Penetration

- The market size of silicon carbide power devices applied in the new energy vehicle sector is expected to grow further. It is predicted that by 2030, the global sales revenue of silicon carbide power semiconductor devices for new energy vehicles will reach 14.7 billion USD, with a compound annual growth rate of 36.1% from 2024 to 2030. The penetration rate of silicon carbide power semiconductor devices in the new energy vehicle sector has been on the rise. It was 19.2% in 2024 and is expected to reach 53.6% in 2030.

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Source: Frost & Sullivan, Public Information Collection

SiC Power Devices – Photovoltaic Energy Storage

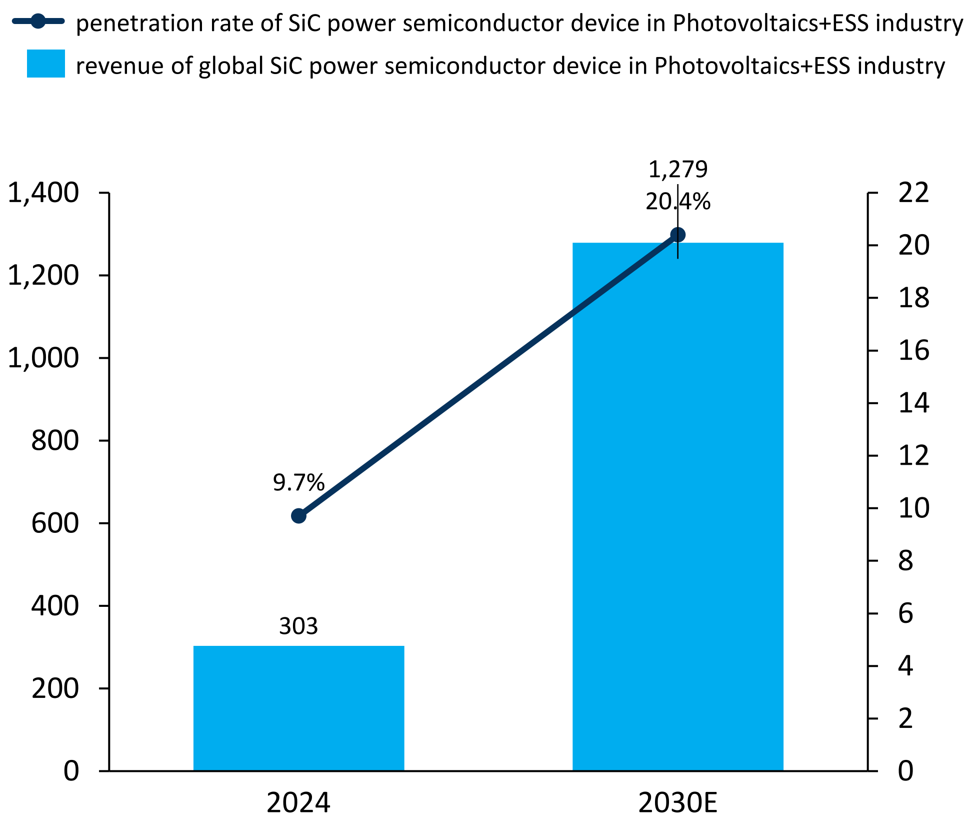
Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC Power Semiconductor Devices in Photovoltaic Energy Storage

Market Size of Global SiC Power Semiconductor Devices for Photovoltaics +ESS Industry, in terms of revenue

Million USD，2024-2030E

CAGR	2024-2030E
Total	27.2%



Note: *Penetration rate in terms of percentage of photovoltaic installations equipped with SiC power semiconductor components out of total global photovoltaic installations with power semiconductor components.*

SiC Application

- Silicon carbide power semiconductor devices can be used in photovoltaic components such as inverters, boost converters, and energy storage converters, as well as in energy storage systems. They improve energy conversion efficiency, reduce switching losses, decrease the volume of passive components like inductors and capacitors, and minimize the weight and size of the system to the greatest extent, thus facilitating the widespread application of photovoltaic energy storage systems. Compared with traditional silicon-based devices, silicon-carbide-based photovoltaic inverters can increase the conversion efficiency by 1%-3%. Their volume and weight can usually be reduced by 40%-60%, which is convenient for logistics transportation, simplifies the installation process, reduces logistics and labor costs. Moreover, the reduced volume enables the inverters to be applied in a more diverse range of scenarios.
- Taking photovoltaic power generation as an example, the increase in power generation revenue brought about by the improvement in conversion efficiency will largely offset or exceed the additional costs incurred by using silicon carbide power semiconductor devices, demonstrating the advantages of using such devices in the photovoltaic field. For instance, a 10-MW power station can generate 16 million kWh of electricity annually. Assuming that silicon carbide power semiconductor devices can increase the conversion efficiency by 2%, the annual additional power generation is 320,000 kWh, which is approximately worth 128,000 RMB. With an inverter service life of 10 years, the use of silicon carbide modules is conducive to improving the return on investment in photovoltaic power generation.

SiC Penetration

- In the energy storage sector, in 2024, the newly installed capacity of global new-type energy storage was approximately 43.7 GW, an increase of 24.9% compared to the previous year. Silicon carbide can drive the development of energy storage converters towards large-capacity and modular directions. Compared with traditional silicon-based IGBT solutions, silicon carbide devices can significantly simplify the design of energy storage converters. For example, in a 1000-kW commercial and industrial energy storage converter, the adoption of silicon carbide technology can reduce the number of required chips from 44 IGBTs to only 12 SiC devices, effectively balancing cost and efficiency.
- With the reduction in the cost of silicon carbide and the improvement of various technologies in photovoltaic power generation, the comprehensive cost-performance ratio of the silicon-carbide-based inverter solution will be further enhanced. The penetration rate of silicon carbide power semiconductor devices in the photovoltaic energy storage industry is expected to gradually increase, rising from 9.7% in 2024 to 20.4% in 2030.

Source: Frost & Sullivan

SiC Power Devices – Ultra-fast Chargers

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC Power Semiconductor Devices in Ultra-fast Chargers

- At present, DC fast-charging technology is a key step in improving the energy-replenishment experience of xEVs. As the electrical systems of xEVs are transitioning from 400V to 800V, the power level and power density of the power modules of ultra-fast chargers are gradually increasing from 20kW/30kW to 40kW/50kW and above to meet the needs of xEVs with higher voltages. Due to its excellent high-voltage and high-temperature resistance properties, SiC-based materials have a much lower on-resistance than silicon-based materials, reducing conduction losses and ensuring that ultra-fast chargers can provide a higher and wider output voltage range to cover the battery needs of various xEV models. At the same time, the low-junction-capacitance characteristic of SiC semiconductor materials allows for a higher switching frequency, which in ultra-fast chargers means faster charging speed and higher power density. In addition, the high thermal stability and wide operating temperature range (-55° C to +175° C) of SiC MOSFETs ensure the stable operation of ultra-fast chargers under various climatic conditions, meeting the market demand for efficient, fast, and stable charging solutions.

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Source: Frost & Sullivan

SiC Power Devices – Data Centers

Source: Frost & Sullivan

Applications of SiC Power Semiconductor Devices in Data Centers

SiC Application in Data Centers

- SiC is mainly applied to the AC/DC stage of the rack power supply in AI data center power supplies. SiC MOSFETs can be used to construct the power-factor-correction (PFC) circuit of the power-supply unit (PSU) to replace silicon-based MOSFETs. Compared with silicon-based MOSFETs, SiC MOSFETs have a higher switching frequency and lower reverse-recovery losses, which can effectively reduce the number of components, increase the power density of the power supply, and improve the energy-conversion efficiency of the AC/DC stage. The power density of a PSU using SiC MOSFETs can be more than twice that of a PSU using silicon-based power devices, and the power-conversion efficiency can be increased by up to about 1%.

Market Size of Global Data Center, in terms of Capacity

- Benefiting from the development of large language model technology and the rapid penetration of generative AI, the global AI market size is growing rapidly. By 2030, global data center capacity is expected to reach 299 GW, a net increase of 244 GW from 2023, at a CAGR of 27.4%. This growth will significantly increase data center power consumption from 1.4% to 10% of global electricity use from 2023 to 2030. Traditional silicon-based power supply systems in data centers have an efficiency of about 85%-88%, wasting 12%-15% of electricity as heat. SiC power semiconductor devices can help improve energy efficiency, reduce operating costs, and support sustainable development strategies in data centers.
- Additionally, the rise in AI workloads has increased the number of AI servers in data centers, which consume significantly more power than traditional servers. This has led to a higher power density requirement for rack power supplies, making SiC power devices a viable solution for increasing power output within existing rack spaces. It is expected that from 2025 to 2030, the global AI data-center scale will increase by 201 GW. Correspondingly, the potential market size of PSUs based on SiC power devices in the AI data-center field from 2025 to 2030 will exceed RMB80 billion, the penetration rate of SiC in the AI data-center is expected to reach 18.3% in 2030.

Source: Frost & Sullivan

SiC Power Devices – Power Grid

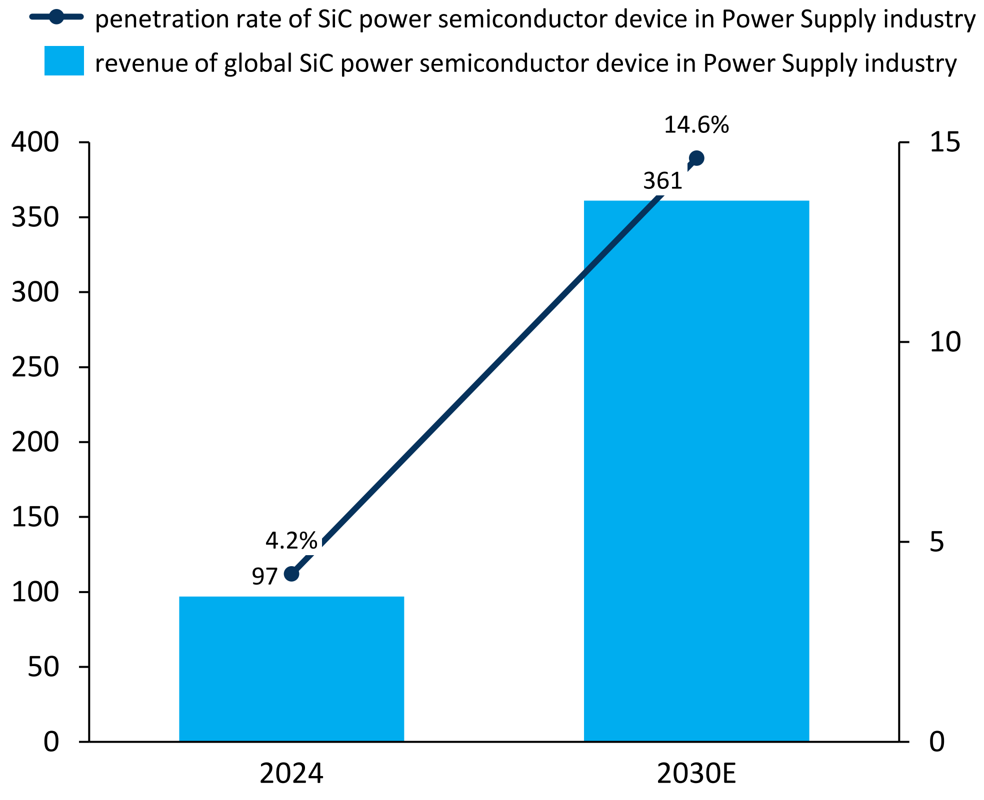
Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC Power Semiconductor Devices in Power Grid

Market Size of Global SiC Power Semiconductor Devices for Power Grid Industry, in terms of revenue

Million USD， 2024-2030E

CAGR	2024-2030E
Total	24.5%



***Note:** Penetration rate in terms of percentage of power generator installation equipped with SiC power semiconductor components out of total global power generator installations with power semiconductor components*

SiC Application

- Renewable energy sources such as solar and wind have been playing an increasingly important role in global power systems. In 2024, renewable energy contributed over 40% of the global total electricity generation, and this share is expected to rise further in the future. The power grid, as the primary carrier of electricity production, transmission, consumption, and utilization, faces growing demands for integration of distributed renewable energy and energy storage. As such, the development of smart grids with stronger and more flexible capabilities in regulation, control, and routing of power flows has become an inevitable trend. The construction of smart grids requires extensive use of power devices to meet the demands of applications such as power flexible DC transmission, power flow control, reactive voltage control, harmonic suppression, AC-DC hybrid active distribution networks, and DC distribution networks. Silicon carbide power semiconductor devices have overcome the limitations of silicon-based power semiconductors in terms of high voltage, high power, and high temperature, thereby addressing system constraints. This has driven the development and transformation of smart grids in various applications, including solid-state transformers, flexible AC transmission systems (FACTS), static VAR compensators (SVC), and high-voltage direct current (HVDC) transmission systems.

SiC Penetration

- SiC's penetration rate is on the rise, from 4.2% in 2024, and is projected to reach 14.6% in 2030
- Thanks to the advantages of silicon carbide, such as high switching frequency, low loss, high voltage resistance, and high temperature tolerance, the application of silicon carbide power semiconductor devices can significantly reduce the number of components required for power equipment, as well as the equipment's size, weight, energy loss, and system complexity. It also reduces the demand for cooling equipment, thereby lowering the overall construction cost of power systems. For example, in flexible DC transmission, compared to silicon-based devices, the use of kilovolt-level, kilampere-grade silicon carbide devices can significantly reduce the number of power devices required in the converter transformers, thereby decreasing the volume, weight, energy consumption, heat dissipation requirements, and overall system cost of the converter transformers. In Static VAR Compensators (STATCOMs), silicon carbide-based devices can simplify the structure and increase the switching frequency, thereby improving power quality and helping address power balancing pressures and voltage control issues in modern power systems.

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Source: Frost & Sullivan

SiC Power Devices – Rail Transportation

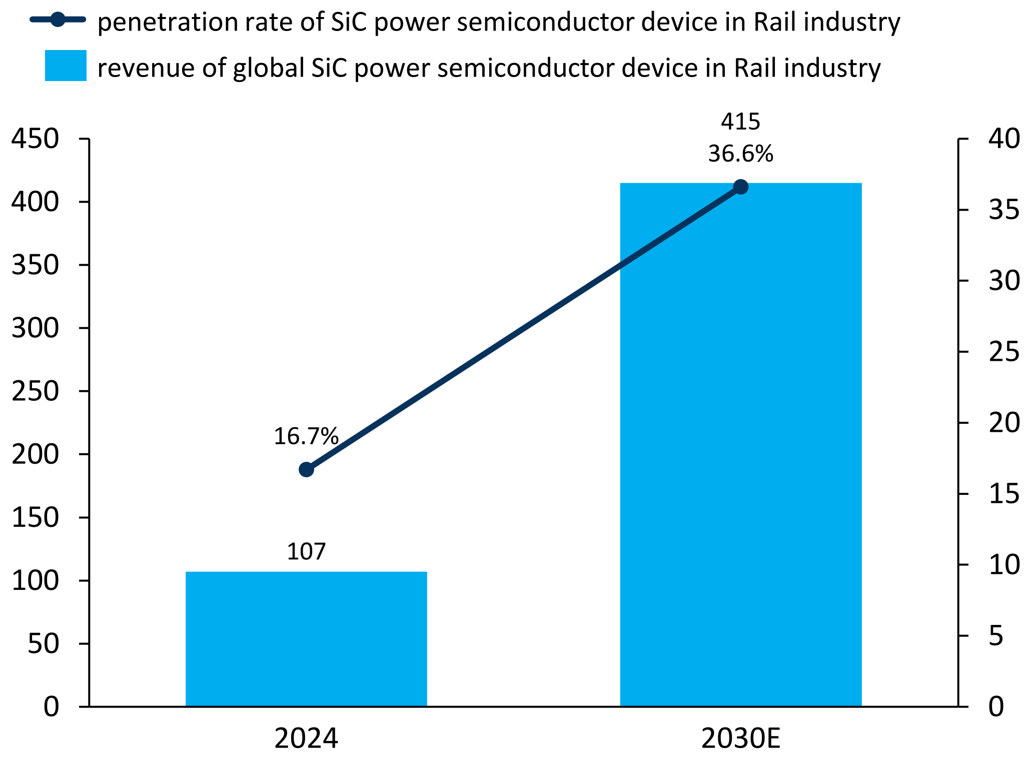
Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC Power Semiconductor Devices in Rail Transportation

Market Size of Global SiC Power Semiconductor Devices for Rail Industry, in terms of revenue

Million USD，2024-2030E

CAGR	2024-2030E
Total	25.3%



__Note:__ Penetration rate in terms of percentage of rail industry equipped with SiC power semiconductor components out of total global rail industry with power semiconductor components.

SiC Application

- The high critical field strength, high carrier saturation velocity, and high thermal conductivity of silicon carbide have enabled the miniaturization and lightweight development of the traction conversion system in rail transit. This is crucial for meeting the green and energy-saving requirements of rail vehicle operations.
- By using silicon carbide power semiconductor devices, the power-electronic devices of rail transit vehicles can be significantly reduced in volume and weight, which has a positive impact on increasing speed, acceleration, and extending the maintenance cycle and service life.
- At the same time, the high-efficiency and high-power-density characteristics of these devices also help to reduce operating costs and improve energy utilization efficiency.

SiC Penetration

- Starting from 16.7% in 2024, the penetration rate is projected to reach 36.6% in 2030. This growth is attributed to the advantages that SiC devices offer in terms of high-temperature tolerance and high-frequency switching capabilities
- Currently, SiC has been maturely applied in the rail transit field. On July 2020, Zhuhai Line 1 in China adopted SiC power devices, which led to a 50% reduction in equipment volume, a 56% decrease in weight, and an efficiency improvement to over 95.5%. Same month, the N700S train of the Tokaido Shinkansen in Japan was officially put into operation. This train adopted hybrid SiC modules, which reduced the size and weight of the traction inverter by 40% and decreased losses by 35%
- Compared with the transmission system of the traditional silicon-based IGBT traction inverter, the system based on silicon carbide power semiconductor devices reduced the comprehensive energy consumption by more than 10%. The noise of the traction motor decreased by more than 5 decibels in the medium-low-speed range, and the temperature rise decreased by more than 40° C.

Source: Frost & Sullivan

SiC Power Devices – Household Appliances

Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC Power Semiconductor Devices in Household Appliances

In the field of household appliances, SiC Schottky barrier diodes (SBDs) and SiC MOSFETs can be used in power-factor-correction (PFC) circuits, motor drives, boost circuits, high-voltage power supplies, etc., and are suitable for high-power household appliances. SiC power semiconductor devices can improve the energy-conversion efficiency of household appliances, thereby enhancing energy-efficiency performance and providing consumers with more environmentally friendly and efficient household appliances products.

At the same time, SiC power semiconductor devices can increase the power density of household appliances power supplies and reduce the size of heat sinks, thus reducing the volume and cost of magnetic components and thermal-management components and promoting the miniaturization of household appliances products. Taking air conditioners as an example, to meet higher energy-efficiency standards, the PFC frequency of variable-frequency air conditioners is constantly increasing. Traditional silicon-based IGBTs and fast-recovery diodes (FRDs) are gradually struggling to meet the requirements of high voltage, high switching frequency, and short reverse-recovery time. SiC SBDs have become the first choice to replace these silicon-based power devices.

Application in Air Conditioning

Air conditioning is expected to be a major sector to adopt SiC power semiconductor devices. In 2030, the potential shipments of SiC-based high-end home air conditioners could reach more than 80 million units, which account for approximately 30% of the global home air conditioner shipments in the same year. Going forward, it is possible for SiC power semiconductor devices to become more affordable and to penetrate into mass market of home air conditioners, which holds approximately 70% of the market share. SiC power semiconductor devices have great growth potential in the global household appliances market and will be more widely applied in the future in areas such as refrigerators, washing machines, microwave ovens, induction cookers, electric ovens, rice cookers, and televisions.

Source: Frost & Sullivan

SiC Power Devices – electric Vertical Take-off and Landing (eVTOL)

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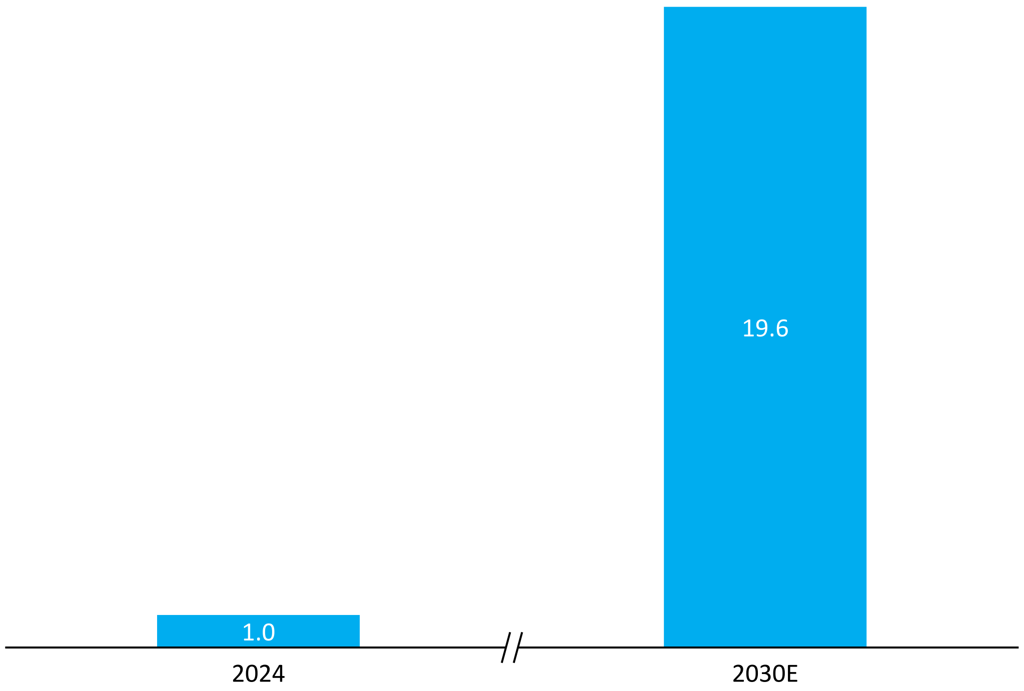
Source: Frost & Sullivan

Applications of SiC Power Semiconductor Devices in eVTOL

Market Size of Global eVTOL Market

Billion USD, 2024E-2030E



- The weight of the motor is an important indicator in the design requirements of eVTOL aircraft, which has a high demand for the power density of materials. The high-power-density, high-temperature-resistant, and high-voltage-resistant characteristics of SiC power semiconductor devices can meet the requirements of eVTOL aircraft for the voltage resistance and output power of electric control, making them an ideal choice for low-altitude aircraft and helping to improve flight performance and safety.

- The global low-altitude flight economy market size reached 1.0 billion USD in 2024 and is expected to reach 19.6 billion USD by 2030.

- The application of SiC power semiconductor devices in the eVTOL aircraft field has just started. With the growth of the low-altitude flight economy, the potential of SiC in this field is huge.

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Source: Frost & Sullivan

SiC RF Semiconductor Devices - Overview

Overview of Global Silicon Carbide Materials and Applications Market

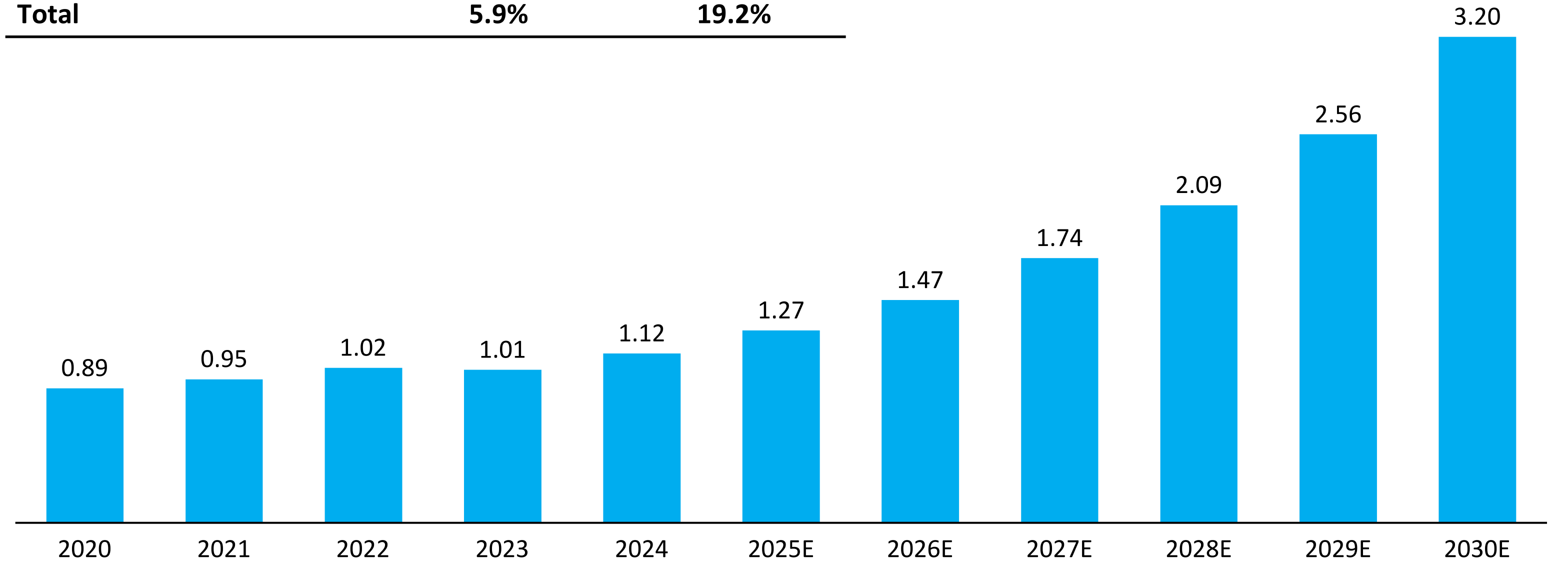
Definition

RF semiconductor devices play a crucial role in the wireless communication field. They are mainly responsible for signal conversion and processing and are indispensable basic components of wireless communication devices. These devices include power amplifiers, filters, switches, low-noise amplifiers, and duplexers, which jointly ensure the performance and efficiency of communication systems. Especially in the field of commercial mobile communication, gallium nitride RF semiconductor devices based on semi-insulating SiC substrates exhibit significant advantages. With their high-power, high-efficiency, and high-frequency characteristics, these devices are widely used in power amplifiers of communication base stations, significantly improving the quality and coverage of signal transmission. In addition, with the popularization of 5G networks and the development of Internet of Things technologies, gallium nitride RF semiconductor devices play a key role in increasing data transmission rates, reducing energy consumption, and supporting the connection of more devices.

Global semi-insulating SiC based RF semiconductor device market size

Billion USD， 2020-2030E

CAGR	2020-2024	2024-2030E
Total	**5.9%**	**19.2%**



Key Findings

- In 2024, the global market size of semi-insulating silicon carbide-based RF semiconductor devices reached 1.12 billion USD. In the next five years, driven by the 5G market, semi-insulating silicon carbide-based RF semiconductor devices will gradually capture the market share of LDMOS, and the global market for semi-insulating silicon carbide-based RF semiconductor devices is expected to enter a stage of accelerated growth. By 2030, the market is expected to reach a peak of 3.2 billion USD. During 2024 to 2030, the compound annual growth rate of the market is expected to reach 19.2%. This remarkable growth rate reflects the strong growth in market demand for semi-insulating silicon carbide-based RF semiconductor devices.

Source: Frost & Sullivan

SiC RF Semiconductor Devices – AI Glasses

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Source: Frost & Sullivan

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC in AI Glasses

- For AI glasses' optical systems, silicon-carbide-based SRG waveguides are a revolutionary innovation. Silicon carbide have traits like high refractive index, wide FOV, and full-color integration. Notably, silicon carbide's exceptional refractive index (2.6−2.7) enables single-layer integration of RGB color channels, effectively addressing rainbow effects and significantly reducing device weight, thickness and production complexity compared to conventional multi-layer solutions. This advancement positions silicon carbide SRG waveguides as the optimal choice for next-generation AR displays requiring compact form factors and immersive visual experiences. As AI glasses evolve into mainstream wearable computing platforms, it is estimated that by 2030, the potential market size of silicon-carbide-based SRG waveguides in the global AI glasses market will reach over 60 million pieces.

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Source: Frost & Sullivan

Applications of SiC in AI Glasses

Comparison of Main Optical Solutions for AI Glasses

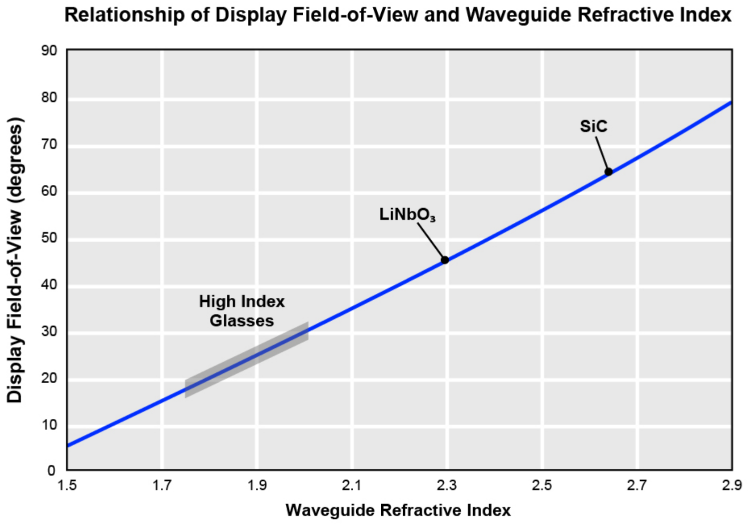
	SRG Waveguide	VHG Waveguide	Array Waveguide
Advantages	- Mature manufacturing process with low mass production difficulty: The production and manufacturing of SRG waveguides adopt mature semiconductor manufacturing processes such as nanoimprinting.	- Excellent display effect: High diffraction efficiency, capable of achieving a larger field of view angle, avoiding light leakage problems, and reducing the rainbow effect.	- Excellent display effect: Uniform color, large field of view angle, high resolution and high light efficiency.
Current Main Limitations	- The refractive index of traditional waveguide materials (such as glass) is relatively low, resulting in a smaller FOV and lower light efficiency. - There is a rainbow effect.	- The final display effect depends on the selection and preparation of holographic materials, which will directly affect optical properties such as the uniformity of the holographic coating and the FOV. - Has very strict requirements on the stability of the production environment.	- High mass production difficulty and cost: The manufacturing process of array waveguides is complex, and the manufacturing complexity of the array mirror film layer is high, resulting in low yield; if two-dimensional pupil expansion technology is used, the mass production difficulty and cost are several times that of one-dimensional pupil expansion.

- The optical system is one of the essential hardware components of AI glasses with display functions. The optical system transmits the images displayed on the screen to the user's eyes while not interfering with the user's view of the real world. Currently, the main optical solutions for AI glasses include Birdbath and optical waveguides. Among them, optical waveguides have advantages in terms of volume, light transmittance, clarity, and field-of-view (FOV), and will become the mainstream optical solution for AI glasses in the future. Optical waveguides can be divided into geometric optical waveguides and diffractive optical waveguides. Geometric optical waveguides are mainly dominated by array optical waveguides, and diffractive optical waveguides are further divided into surface relief grating (SRG) waveguides and volumetric holographic grating (VHG) waveguides. Benefiting from the use of mature semiconductor manufacturing processes, SRG waveguides have a stronger mass-production capacity. However, how to address current issues such as the small FOV and rainbow effect of SRG waveguides has become a key factor affecting the penetration rate of SRG waveguides.

Source: Frost & Sullivan

Applications of SiC in AI Glasses

Theoretical Relationship between Waveguide Refractive Index and Display FOV



Comparison of Silicon Carbide and Some Traditional Materials

	SiC	High Index Glasses	$LiNbO_3$
Refractive Index	2.6-2.7	<2.1	2.3
FOV	60-70°	<30°	40-50°
Full-color Display Solution	It can combine the red, yellow, and blue color channels into a single waveguide, reducing the size, weight, manufacturing cost, and complexity of AI glasses.	Adopts a two-layer or multi-layer waveguide solution, resulting in higher weight and cost.	Adopts a two-layer or multi-layer waveguide solution, resulting in higher weight and cost.

- In SRG waveguides, the refractive index of the material used to make the optical waveguide is a key factor determining the size of the FOV. The higher the refractive index of the material, the larger the FOV of the AI glasses. The refractive index of silicon carbide is significantly higher than that of competing materials such as high-refractive-index glass and lithium niobate. When applied in AI glasses, it can achieve a larger FOV, significantly enhancing the user experience. In addition, the high refractive index of silicon carbide makes it possible to combine the red, yellow, and blue color channels into a single waveguide. This can replace the multi-layer optical waveguide solution used to alleviate the rainbow-stripe effect and achieve full-color display, reducing the size, weight, manufacturing cost, and complexity of AI glasses.

- Benefiting from the above-mentioned advantages of silicon carbide materials, the silicon-carbide-based SRG waveguide solution has huge potential for growth in the display field of AI glasses. It is estimated that by 2030, the potential market size of silicon-carbide-based SRG waveguides in the global AI glasses market will reach 659.3 million pieces.

SiC RF Semiconductor Devices – TF-SAW High-end Filters

Applications of SiC in TF-SAW High-end Filters

Definition

- TF-SAW (Thin-film surface acoustic wave) high-end filters are a type of acoustic filter. Acoustic filters are used to process acoustic wave signals. They can selectively pass or suppress acoustic waves of specific frequencies, thus achieving a filtering effect. They are widely applied in fields such as consumer electronics (smartphones, personal computers, etc.), Internet of Things devices, and vehicle-to-everything (V2X). Acoustic filters include surface acoustic wave (SAW) filters and bulk acoustic wave (BAW) filters. SAW filters are the filter components most commonly used in consumer electronics on a large scale. They have a relatively low cost and complexity and are mainly suitable for low-frequency communication. BAW filters, on the other hand, are slightly more expensive and are mainly used in high-frequency communication. As wireless communication technology evolves towards higher communication frequency bands, the market for filters that support these higher frequency bands has great potential. However, due to the high cost, process complexity, and high manufacturer concentration of BAW filters, more and more filter manufacturers are seeking technological innovation in the SAW filter field to enable SAW filters to support higher communication frequency bands.
- TF-SAW filters are currently the most important technological innovation direction in the SAW filter field. TF-SAW filters are based on the Piezoelectric on Insulator (POI) substrate. By adding a carrier substrate under the piezoelectric layer, energy dissipation is reduced. They possess excellent properties such as high frequency, high selectivity, high temperature stability, low insertion loss, small size, high reliability, and durability. The production process of TF-SAW filters is similar to that of ordinary SAW filters, and their process complexity and manufacturing cost are lower than those of BAW filters. However, the POI substrate has become the core factor determining the competitiveness of TF-SAW filters.

SiC Application

Benefiting from its excellent physical properties, TF-SAW filters based on silicon carbide substrates perform even more outstandingly in terms of high frequency, high Q-value, high power, and high-temperature stability. Specifically:

(1) The high sound-velocity property of silicon carbide helps optimize the acoustic wave propagation mode in TF-SAW filters, thereby improving the frequency selectivity and pass-band performance of the filters;

(2) The low-loss property of silicon carbide effectively reduces the acoustic wave propagation loss and enhances the filtering efficiency;

(3) The high thermal conductivity and low coefficient of thermal expansion of silicon carbide materials enable better low-temperature bonding with other heterogeneous materials and meet the requirements of temperature compensation and heat dissipation.

Silicon-carbide-based TF-SAW filters can support frequency bands above 3.3GHz and can be used in high-end smartphones (5G and above), 5G routers, base stations, optical communication, AIoT, intelligent connected vehicles, and other fields. They are expected to replace BAW filters in high-frequency bands. With the development of wireless communication technology towards more advanced communication technologies (such as 5G-Advanced, 6G), the demand in the communication field for silicon-carbide-based TF-SAW filters with high frequency, large bandwidth, high-power handling capabilities, high-temperature stability, miniaturization, and integration has increased significantly. The global market for silicon-carbide-based TF-SAW filters is expected to continue growing. As wireless communication technology advances, the demand for these filters is expected to grow substantially, with the potential market size for silicon-carbide-based TF-SAW filters projected to reach USD5.2 billion by 2030.

Source: Frost & Sullivan

SiC RF Semiconductor Devices – Heat Dissipation Components

Overview of Global Silicon Carbide Materials and Applications Market
Applications of SiC in Heat Dissipation Components

SiC Application

Due to its high thermal conductivity, low coefficient of thermal expansion, high hardness, chemical stability, and lightweight characteristics, SiC has a wide range of applications in the fields of heat dissipation and heat sinks, including semiconductors, thermal management systems, 5G communication, high-power LED lighting, electric vehicles, and renewable energy systems. This improves the operating efficiency and reliability of equipment, reduces the weight of the thermal management system, and extends the service life of the equipment. Compared with traditional heat-dissipation materials such as copper and aluminum nitride, the thermal conductivity of SiC is 1.2 times that of copper and more than 2 times that of aluminum nitride. Therefore, SiC is more suitable for scenarios where rapid heat dissipation is required to protect sensitive electronic components or to maintain stable operation in high-power-density devices.

TAM Estimation

For example, in high-power laser applications, silicon carbide could be used in the fabrication of heat sinks, which are designed to transfer heat away from a heat-generating object, to replace other conventional materials. It is estimated that in 2030 the total potential demands for heat sinks made of silicon carbide in high-power laser applications could reach more than 35 million pieces.

Source: Frost & Sullivan

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Introduction of Silicon Carbide Substrates and Manufacturing Processes

Definition

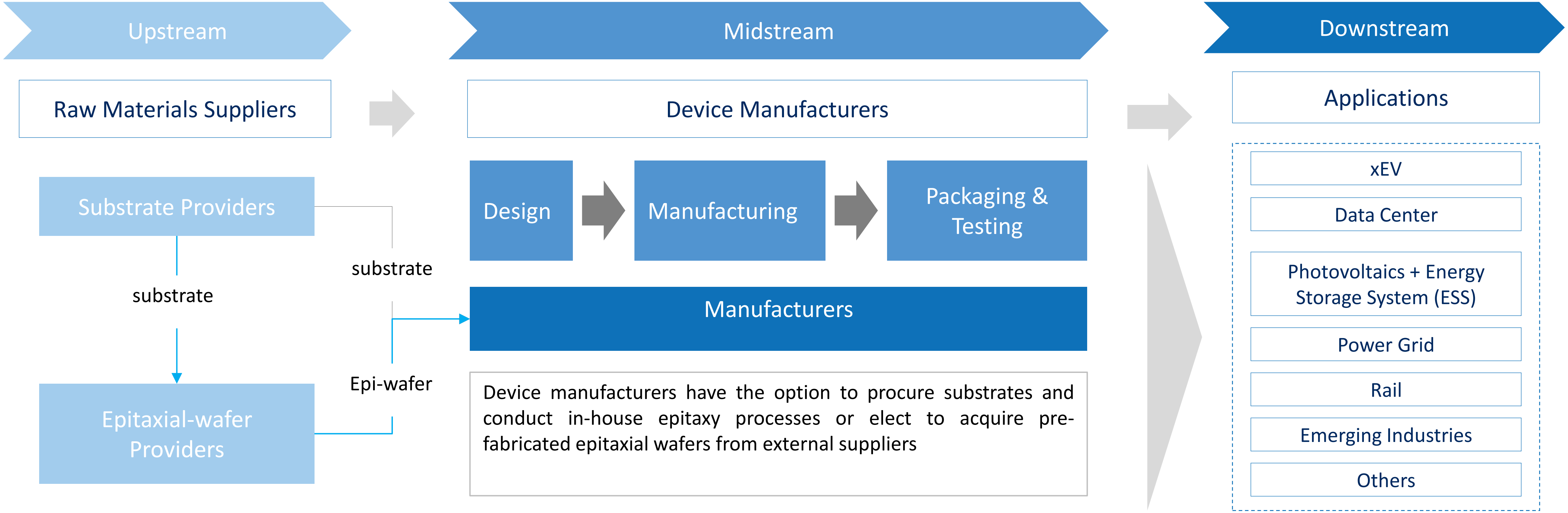
- A silicon carbide substrate refers to a single-piece material formed through manufacturing processes such as crystal growth, ingot processing, cutting, grinding, polishing, and cleaning, with silicon carbide powder as the main raw material. It is the basic material for fabricating wide-bandgap semiconductors and other silicon-carbide-based devices. The research, development, and manufacturing processes of silicon carbide substrates are highly complex, involving the application of interdisciplinary knowledge from materials science, thermodynamics, semiconductor physics, chemistry, computer simulation, and mechanics. The manufacturing process of silicon carbide substrates is much more difficult than that of silicon wafers. Moreover, the growth rate of silicon carbide ingots is slow, resulting in high technical barriers, low product yields, long manufacturing cycles, and high costs for silicon carbide substrates.

- Based on differences in electrical properties, silicon carbide substrates are divided into conductive substrates and semi-insulating substrates. Conductive substrates, through the homo-epitaxy process, grow an epitaxial layer with characteristics consistent with those of the substrate material, and are mainly applied to the manufacturing of silicon carbide power semiconductor devices. Silicon carbide power semiconductor devices, with their excellent performance in terms of high efficiency, high power density, and high-temperature resistance, play a key role in multiple fields such as new energy vehicles, photovoltaic energy storage, rail transit, industry, and data centers. Semi-insulating substrates, on the one hand, can use hetero-epitaxy technology to grow a gallium nitride epitaxial layer with different characteristics from the substrate material, mainly for the production of radio-frequency (RF) devices. These RF devices demonstrate their unique value in high-frequency communication applications. On the other hand, semi-insulating substrates can be used in other types of devices such as optical waveguides, high-end filters, and heat dissipation components, leveraging the unique advantages of silicon carbide in acoustics, optics, and heat dissipation.

- When classified by substrate diameter, silicon carbide substrates can be divided into products with diameters of 2-inch,3-inch, 4-inch, 6-inch, 8-inch, and 12-inch. The research, development, and commercialization progress of different-sized silicon carbide substrates under different technical routes vary.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Silicon Carbide Substrate Industry Chain



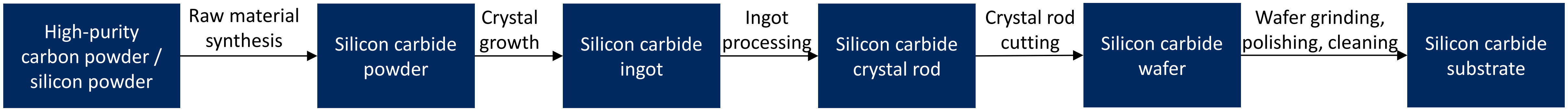
- Substrate manufacturers are upstream participants in the entire silicon carbide industry chain. They are responsible for processing raw materials into silicon carbide substrates through a series of technological processes. These substrate manufacturers are a crucial link in the industry chain, transforming raw materials into substrate products that can be used by downstream players.

- The mid-and downstream segments include device manufacturers, foundry manufacturers, and end-customers. After epitaxial growth, the substrates are used to manufacture various power devices, radio-frequency devices, etc. These devices are widely applied in fields such as new energy vehicles, photovoltaics and energy storage, power supply, rail transit, and emerging industries.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Introduction of Silicon Carbide Substrates and Manufacturing Processes

The technological process of silicon carbide substrates includes steps such as raw material synthesis, crystal growth, ingot processing, crystal bar cutting, wafer grinding, polishing, and cleaning. The specific technological process is shown in the following figure:



- **Raw Material Synthesis:** High-purity silicon powder and high-purity carbon powder are uniformly mixed according to the process formula. Under high-temperature conditions above 2000°C, in the reaction chamber, high-purity silicon carbide powder raw materials meeting the requirements of crystal growth are prepared through specific reaction processes and treatment procedures. Silicon carbide substrate manufacturers without the ability of raw material synthesis usually need to purchase finished silicon carbide powder raw materials from outside.
- **Crystal Growth:** The Physical Vapor Transport (PVT) method is commonly used in the industry to prepare silicon carbide single crystals. The PVT method realizes the growth of ingots through sublimation and vapor deposition, including three main processes: high-temperature sublimation, vapor transport, and crystal growth, ultimately forming high-quality SiC ingots.
- **Ingot Processing:** The silicon carbide ingot is ground and rounded through precision machining to be processed into a silicon carbide crystal rod with a standard diameter size and angle.
- **Crystal Rod Cutting:** In the industry, multi-wire cutting (such as diamond wire cutting) is often used to cut the silicon carbide crystal rod into cutting slices of different thicknesses to meet customer requirements. Automatic testing equipment is used to detect surface shapes such as warpage, bow, and thickness variation.
- **Wafer Grinding, Polishing and Cleaning:** During the grinding process, the cutting slices are thinned to the appropriate thickness using a grinding fluid, while also removing surface wire marks and damage. For polishing, the ground slices undergo mechanical and chemical polishing with a polishing fluid. This serves to eliminate surface scratches, reduce surface roughness, relieve processing stress, and ultimately achieve a nanoscale level of flatness on the surface of the ground slices. Finally, in the cleaning stage, the polished slices inside the cleaning machine are washed with chemical reagents and deionized water. This removes fine dust particles, metal ions, and organic contaminants from the surface of the polished slices. After that, the slices are spin-dried and packaged in clean wafer boxes, resulting in silicon carbide substrates that are ready-to-use for customers upon opening the box.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Difficulties in Manufacturing Processes

The preparation of silicon carbide substrates is highly complex, with the following difficulties:

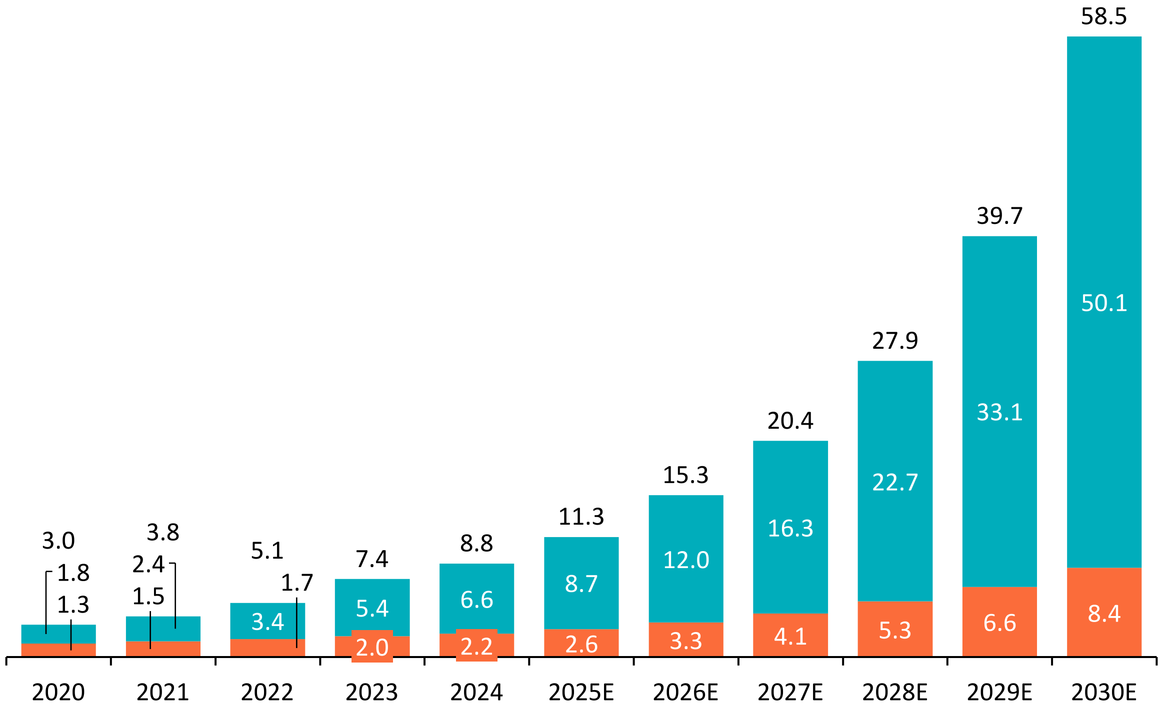
- **High difficulty in growth process**: Defect control during the growth of SiC single crystals is extremely challenging and constitutes a significant production difficulty. First, there are diverse and intractable defect types. Second, SiC has a complex crystal form, covering more than 200 structures. Many of these crystal forms are prone to transformation due to similar formation energies in a high-temperature growth environment, resulting in polytype inclusion, which disrupts the crystal structure and seriously interferes with electrical and optical properties. Third, thermal field factors lead to many problems. The temperature gradient in the thermal field can generate thermal stress. Coupled with frequent fluctuations in temperature and components during the growth process, defects such as dislocations are likely to occur, laying hidden dangers for subsequent epitaxial growth and device manufacturing, and greatly affecting product quality and performance. Overall, these difficulties are intertwined, and producers must adopt precise measures in complex technological processes to achieve the stable production of high-quality SiC single crystals.
- **Powder synthesis difficulty:** The preparation of SiC powder faces several challenges. The synthesis environment exerts an influence, and the raw and auxiliary materials contain inherent and unremovable impurities. As a result, the synthesized SiC powder unavoidably has a large number of impurities introduced. These impurities directly impact the purity and electrical performance of the crystals, posing significant difficulties in the preparation of high-quality SiC powder.
- **High processing difficulty:** Silicon carbide substrates, as a high-hardness brittle material, face challenges such as cracking during processing and issues like warping post-processing. To meet the high standards of “ready-to-use” requirements for downstream epitaxial processes, ultra-precision surface processing is essential to significantly reduce surface roughness and improve flatness, while strictly controlling metal impurities and particle contamination. Additionally, the high hardness and brittleness of SiC substrates make cutting, grinding, and polishing processes time-consuming and prone to chipping, further increasing processing difficulty. These factors collectively highlight the high technical barriers and complexity involved in the processing of SiC substrates.
- **High difficulty in diameter expansion**: Large-sized crystals require a more uniform temperature distribution to avoid stress and defects. Thermal stress management becomes more complex. Internal stress caused by temperature gradients and growth rate differences may lead to crystal cracking. Raw material consumption and costs increase accordingly, as diameter expansion means more high-purity raw materials are needed. The crystal growth rate slows down, increasing the production cycle and costs. Due to the combined effects of the above factors, the growth yield of expanded-diameter crystals is usually low, affecting the product’s economic efficiency and market competitiveness. These challenges need to be overcome through technological innovation and process optimization to achieve the stable production of large-sized, high-quality SiC substrates. Currently, 6-inch silicon carbide substrates have become the mainstream in the market, while 8-inch substrates are in a phase of rapid scaling. With swift technological advancements, they are expected to further drive industry upgrades in the future.
- **Difficulty in maintain production consistency**: The highly complex preparation process of SiC substrates makes it difficult to maintain production quality consistency during large-scale mass production. The quality of the final SiC substrate is jointly affected by key links such as material purity, process control capabilities, equipment accuracy, and inspection capabilities. The instability of any link will affect the consistency of the final product quality. Substrate manufacturers usually need to have a profound understanding of process technology, and by establishing a fine-grained production process system, introducing automated and intelligent equipment, and implementing a complete quality inspection system, they can ultimately achieve consistency in product production quality during large-scale mass production.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Global Silicon Carbide Substrate Market Size

Global Silicon Carbide Substrate Market, by Sales Revenue
billion RMB, 2020-2030E

CAGR	2020-2024	2024-2030E
Total	**29.9%**	**37.1%**
Conductive silicon carbide substrate	38.5%	40.1%
Semi-insulating silicon carbide substrate	14.1%	25.0%



Note: The market size only includes products for external sales, and data of self-produced and self-used products are not included.)

Key Takeaways

- In terms of sales revenue, the global silicon carbide substrate market has grown from 3.0 billion RMB in 2020 to 8.8 billion RMB in 2024, with a compound annual growth rate of 29.9%. It is expected that by 2030, the market size is likely to increase to 58.5 billion RMB, with a compound annual growth rate of 37.1%.
- The market size of conductive silicon carbide substrates is expected to grow from 1.8 billion RMB in 2020 to 6.6 billion RMB in 2024, with a compound annual growth rate of 38.5%. It is projected that by 2030, the market size of conductive silicon carbide substrates will reach 50.1 billion RMB, with a CAGR of 40.1%.
- The market size of semi-insulating silicon carbide substrates will increase from 1.3 billion RMB in 2020 to 2.2 billion RMB in 2024, with a CAGR of 14.1%. It is estimated that by 2030, the market size of semi-insulating silicon carbide substrates will grow to 8.4 billion RMB, with a CAGR of 25.0%.

Source: Yole, Frost & Sullivan

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Overview of Global Silicon Carbide Substrate Market
Key Drivers

Global Energy Transition Propels the Development of the Silicon Carbide Industry

For energy supply, energy transition emphasizes reducing reliance on fossil fuels and developing clean and renewable energy sources like solar and wind energy. In 2024, renewable energy accounted for over 40% of the global total electricity generation, and this proportion is expected to rise further in the future. For energy consumption, the trend of electrification is driving the growth of electricity consumption demand and changing the energy consumption structure. From 2020 to 2024, the proportion of global electricity consumption in total global energy consumption increased from 19.8% to over 20% and is expected to further increase to 23% in 2028. The increase in the total amount of electricity consumption makes the conversion efficiency of electricity particularly crucial. Thanks to the advantages of silicon carbide materials, such as high frequency, low loss, high-voltage resistance, and high-temperature resistance, silicon carbide power semiconductor devices can enhance the conversion efficiency of electricity in the generation and consumption, achieve a smaller system size and higher power density, and also less demand for cooling systems. They have become the "energy efficiency multipliers" in fields such as new energy vehicles, photovoltaic and energy storage system, power supply, and data centers, driving the energy system to transition towards low-carbonization. The global market size of the silicon carbide power semiconductor device industry is expected to reach $19.7 billion in 2030, with a compound annual growth rate of 35.2% from 2024 to 2030.

Growth and Innovation of AI Industries Create More Incremental Opportunities for Silicon Carbide

Currently, AI is being integrated into various aspects of industries and people's daily lives, exerting a profound impact on human development. With the advancement of large language model technology, generative AI has stronger reasoning and intelligent capabilities, further accelerating the rapid penetration of AI. As an important infrastructure supporting the development of AI, data centers are expected to account for 10% of global power consumption by 2030. Compared with traditional silicon-based power semiconductor devices, silicon carbide-based power semiconductor devices can provide higher power conversion efficiency and higher power density. The application of silicon carbide-based power semiconductor devices in data centers is an inevitable choice to alleviate the global power supply challenges for AI and achieve the low-carbonization of data centers. Moreover, the development of AI technology continuously gives rise to innovations in AI-enabled smart products, which in turn create application opportunities for new materials represented by silicon carbide. For example, the application of silicon-carbide-based optical waveguides in AI glasses can achieve a larger field of view and a simpler structured full-color display. This can reduce the size, weight, manufacturing cost, and complexity of AI glasses, and significantly enhance the user experience.

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Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Key Drivers

Higher Requirements for Performance, Efficiency, and Stability Drive the Growth of the Silicon Carbide Power Device Market

From 2020 to 2024, the global market size of the SiC power semiconductor device industry increased significantly, from $644 million to $3.2 billion, with a CAGR of 49.8%. This growth trend not only reflects the strong demand in the SiC power semiconductor device market but also directly drives the growth of the demand for SiC substrates. With the widespread application of SiC power semiconductor devices in strategic emerging industries such as xEVs, photovoltaic and wind energy, and 5G communication, the substrate, as a key material for producing SiC devices, has seen an expansion in market demand. It is expected that from 2024 to 2030, the market size of the SiC power device industry will continue to grow, with a compound annual growth rate of 35.2%. By 2030, the market size is expected to reach approximately $19.7 billion. The global penetration rate of SiC in the entire power semiconductor device market has also increased significantly, from 1.4% in 2020 to 6.5% in 2024, and is expected to increase to 22.6% by 2030.

Technological Advancements Improve Production Efficiency, Reduce Production Costs, and Enhance Economy and Penetration Rate

Technological progress in crystal growth, slicing, and grinding and polishing processes has significantly improved the production efficiency of SiC substrates and reduced production costs. For example, advancements in crystal growth technology have enabled the mass production of 8-inch conductive substrates. The larger available substrate area has reduced the unit comprehensive cost by 50% and increased the substrate production yield, further driving down the unit cost of substrates. With continuous technological progress and capacity expansion, the cost of SiC substrates is expected to decline further, and their economy and market penetration rate will continue to increase.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Key Trends

Accelerated Penetration in Existing Fields and Expansion into Emerging Application Areas

SiC substrates have witnessed rapid development in recent years, with their application scope continuously expanding. The penetration rate of SiC power semiconductor devices in the xEVs field was 19.2% in 2024 and is expected to reach 53.6% by 2030. In the photovoltaic energy storage field, the market penetration rate of SiC is expected to increase from 9.7% in 2024 to 20.4% in 2030. In the optical waveguide field, SiC can be used in AI glasses to achieve a lower refractive index and lighter weight. It is expected that in the future, with the increase in the shipment volume of AI glasses, the shipment volume of SiC in this field will also rise. With the vigorous development of 5G, the demand for SiC in the filter field has increased sharply. The high-frequency and high-speed characteristics of 5G require filters to have low loss and high stability, which SiC substrates can precisely meet. Therefore, in the construction of advanced communication base stations in the future, its penetration rate will climb year by year. Its penetration rate in advanced communication base stations increased from 36% in 2019 to 50% in 2024 and is expected to increase to 66% by 2030. At the same time, the improvement of electronic device performance brings heat dissipation pressure. SiC, with its high thermal conductivity and high-temperature resistance, stands out in the high-end heat-dissipation material market, and its market share will continue to grow. Evidently, SiC substrate materials have great potential in both existing and emerging fields. In the future, they will play a key role in the transformation of the technology industry, helping multiple industries break through technical bottlenecks and promoting the global technology industry to a new height.

The substrates are evolving towards larger sizes. Currently, 6-inch conductive substrates remain the mainstream, while the 8-inch conductive substrates are starting to gain momentum, and there are already R & D samples of 12-inch conductive substrates

At present, the SiC substrate industry is at a crucial development stage of size upgrading. Although 6-inch conductive substrates are still dominant in the market, the market demand for 8-inch conductive substrates is gradually rising. The output of single-chip chips on an 8-inch substrate is approximately twice that of a 6-inch substrate and four times that of a 4-inch substrate. Moreover, 8-inch substrates can make partial use of the production line equipment of silicon-based power chips, which can effectively reduce costs and improve production efficiency. Enterprises that take the lead in achieving R&D breakthroughs in 8-inch SiC substrates will enter the verification process of downstream device manufacturers earlier. The verification period for their electrical performance generally lasts 6 to 12 months. Once the verification is successful, downstream device manufacturers will not easily change substrate suppliers. Based on these advantages, global substrate manufacturers are vigorously investing in the construction of 8-inch conductive substrate production lines. Statistics show that the total investment of global SiC power semiconductor device manufacturers in 8-inch projects has exceeded 175.4 billion RMB. Among them, the total investment of the top five SiC power device manufacturers has exceeded 126.9 billion RMB, accounting for more than 72%. At the same time, manufacturers in the industry are constantly exploring substrates of larger sizes. Currently, there are R & D samples of 12-inch conductive SiC substrates. The 12-inch substrates can further enhance economic benefits, create more possibilities for the large-scale application of SiC materials, and represent the future development direction and industrialization trend of SiC substrate technology.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Key Trends

Decrease in Unit Production Costs and Emergence of Economies of Scale, Promoting the Adoption of Silicon Carbide Substrates in More Downstream Scenarios

The price of SiC substrates will continue to decline in the future, mainly driven by two factors. First, the reduction in unit die cost brought about by ongoing improvements and advancements in both technology and processes. As the yield in links such as SiC crystal growth improves and the substrate size expands, the unit cost of each device will continue to decrease. Second, economies of scale. With the capacity expansion of leading SiC substrate manufacturers globally, especially in China, these leading manufacturers demonstrate significant economies of scale in aspects such as cost-sharing, production automation and process optimization, supply chain procurement, and technology accumulation, thus driving down the price of substrates. The decline in substrate prices will promote the adoption of SiC substrates in more downstream scenarios.

Continuous Capacity Expansion of Manufacturers with Obvious Head-effect

With technological progress and capacity expansion, especially the R&D and production of 8-inch substrates, industry manufacturers will witness more capacity release, promoting cost reduction and quality improvement of silicon carbide and accelerating its application. At the same time, market competition is becoming increasingly fierce. Manufacturers without technological and scale advantages will face significant limitations in technological upgrading, product yield improvement, production cost reduction, and continuous R&D investment. Some manufacturers may withdraw from the market due to a lack of competitive advantages. However, leading enterprises with technological and scale advantages will win in the competition and continue to maintain their leading positions.

Source: Frost & Sullivan

Overview of Global Silicon Carbide Substrate Market
Price and Cost Analysis

Analysis of the Unit Price of Global SiC Substrates

The market price of global SiC substrates has experienced decline between 2019 and 2024, mainly driven by factors such as increased market competition, cost optimization due to technological maturity, and gradual expansion in production capacity. In the future, with the accelerated iteration of SiC substrate products and the continuous rise in demand due to the fast development of downstream applications, the price decline for substrates of the same size is expected to gradually narrow.

SiC Substrate Price 000' RMB/Piece	2020	2021	2022	2023	2024	2025E	2026E	2027E	2028E	2029E	2030E
Price Range	4.4-6.4	4.0-6.0	3.6-5.6	3.3-5.3	2.7-4.7	2.4-4.4	2.3-4.3	2.3-4.3	2.3-4.3	2.3-4.3	2.3-4.3

Analysis of Price Changes of Major Upstream Raw Materials for Global SiC Substrates

The major upstream raw materials for SiC substrates include silicon powder, carbon powder, graphite parts, graphite felts used for substrate preparation, as well as diamond powder, polishing fluid, polishing pads, etc. used for post-processing procedures. In the total cost composition of SiC substrates, carbon powder and silicon powder, which directly form the substrate, usually account for a relatively low proportion as raw materials. The prices of carbon powder and silicon powder are highly positively correlated with their purity. Higher purity means more complex preparation processes and cost inputs, resulting in higher prices. Fluctuations in the prices of these raw materials have a relatively limited impact on the overall cost of SiC substrates. Graphite parts and graphite felts account for a relatively large proportion in the cost of SiC substrates. However, graphite parts and graphite felts are mostly customized products, and their prices depend on various factors.

000' RMB/Piece	2020	2021	2022	2023	2024	2025E	2026E	2027E	2028E	2029E	2030E
Graphite Parts	2.7-3.7	5.0-6.0	6.5-7.6	5.0-6.0	5.2-6.2	5.4-6.4	5.6-6.6	5.8-6.8	6.0-7.0	6.2-7.2	6.4-7.4
Graphite Felts	7.3-8.3	10.6-11.6	17.5-18.5	13.1-14.1	14.1-15.1	15.1-16.1	16.1-17.1	17.1-18.1	18.1-19.1	19.1-20.1	20.1-21.1

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Source: Frost & Sullivan

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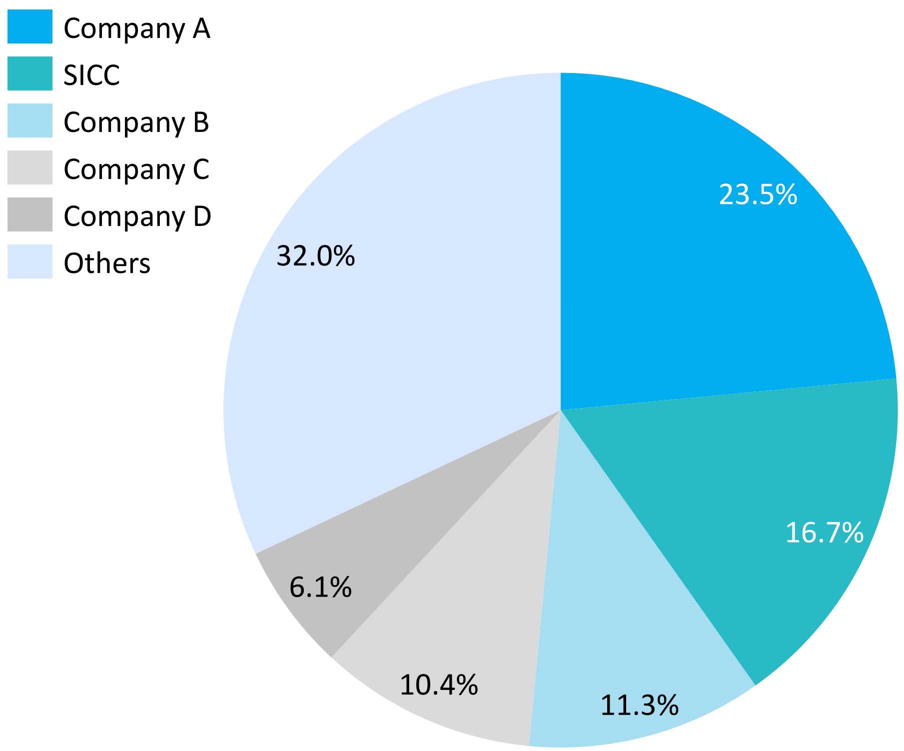
Competitive Landscape of Global Silicon Carbide Substrate Market
Overview of the Competitive Landscape

There are numerous participants in the global silicon carbide substrate market. However, the competition landscape is dominated by a few leading enterprises, which have significant advantages in terms of technological strength, production scale, brand awareness, and recognition. In terms of the sales revenue of silicon carbide substrates, the total market share of the top five market participants in 2024 was 68.0%. The market concentration is relatively high, with leading enterprises taking a dominant position.

The Top Five Global Silicon Carbide Substrate Manufacturers, in terms of Sales Revenue (2024)

Ranking	Manufacturers	Revenue of SiC Substrates (RMB Billion)	Market Share (%)
1	Company A	2.07	23.5%
2	SICC	1.5	16.7%
3	Company B	1.0	11.3%
4	Company C	0.9	10.4%
5	Company D	0.5	6.1%
CR5		6.0	68.0%

The Top Five Global Silicon Carbide Substrate Manufacturers, in terms of Sales Revenue (2024)



Source: Frost & Sullivan

Competitive Landscape of Global Silicon Carbide Substrate Market
Key Success Factors and Entry Barriers of the Global Silicon Carbide Substrate Market

Technical Know-how

The preparation of SiC substrates is a technology-intensive process, involving multiple technical challenges. Firstly, the growth of SiC crystals must be carried out in a high-temperature and airtight environment exceeding 2000°C, which requires extremely high precision in temperature control. Secondly, during the growth process, parameters such as the silicon-carbon ratio, temperature gradient, crystal growth rate, and gas flow pressure need to be precisely controlled to avoid crystal form transformation and polytype inclusion defects. In addition, the processing of SiC substrates is difficult. Reducing the micropipe density is a key technical direction for improving device performance and reliability. With the increase in substrate size, the challenges of diameter-expansion technology also increase, which requires comprehensive technical control in aspects such as thermal field design, structural design, and crystal preparation process design. These technical difficulties jointly form the high-tech barriers of the SiC substrate industry.

Adequate Resources (Customers, Capital, Suppliers, etc.)

The SiC substrate industry poses severe challenges to new entrants due to its high resource barriers. These challenges include investment in equipment such as crystal growth furnaces and processing machinery, as well as the continuous R&D capital investment required to maintain technological leadership and ensure product quality. In addition, the high entry threshold for forming professional management and R&D teams, and the technical barriers in precisely controlling multiple parameters during the crystal-growth process to ensure crystal quality and stability, all increase the difficulty of entering the industry. The long-term verification process of downstream customers leads to long-term cooperation between customers and existing suppliers. This high customer stickiness makes it difficult for new entrants to compete for market share. At the same time, the intensification of market competition and the diversification of demand require enterprises to have strong R&D capabilities and production flexibility to meet the needs of different customers. These factors jointly form the difficult-to-enter threshold of the SiC substrate industry.

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Source: Frost & Sullivan

Competitive Landscape of Global Silicon Carbide Substrate Market
Key Success Factors and Entry Barriers of the Global Silicon Carbide Substrate Market

Cost-control Capability

Cost-control capability is a key competitive barrier in the SiC substrate industry because it involves multiple aspects such as technological accumulation, equipment investment, R & D investment, production efficiency, material processing difficulty, market acceptance, economies of scale, and supply chain management. New entrants, due to their lack of experience and resources in these areas, find it difficult to achieve cost optimization quickly. Early entrants, through long-term technological accumulation, large-scale production, and mature supply chain management, have already established cost advantages, putting new entrants under higher cost pressure in market competition and making it difficult for them to reach the same cost-control level as early-stage enterprises in the short term.

High-quality Mass-production Capability

In the SiC substrate industry, achieving high-quality mass production is of great significance. Its production and processing are extremely difficult and require long-term industry-specific efforts and profound process experience accumulation. On the one hand, large-scale production of large-sized substrates faces challenges. It is necessary to design compatible equipment in advance according to the processes of different-sized products based on a forward-looking strategy to achieve rapid production switching, and at the same time, keep up with downstream demand and iterate the process. On the other hand, there are many difficulties in increasing the effective crystal-growth thickness. It is necessary to overcome the impact of thickness and source-powder consumption on the thermal field during the crystal-growth process, and also ensure the consistency of output from a large number of production equipment. Furthermore, achieving low-defect production is not easy. Product-related measurement indicators need to break through the existing industry level, and it is quite difficult to achieve zero-defect delivery. Finally, the investment in intelligent construction is large, and the threshold is high. High-performance intelligent equipment, professional personnel, and multiple systems are required to achieve real-time control of production quality and optimization of multiple links, so as to achieve a high automation rate, high production-efficiency improvement, and high overall equipment efficiency. For new entrants, it is difficult to take into account all aspects and achieve high-quality mass production in the short term. Especially for the mass production of automotive-grade silicon carbide substrates, as they require breakthroughs in multiple technical barriers such as low-defect control, thermal field stability, intelligent production, and automotive-grade certification, while meeting stringent reliability and consistency requirements.

Source: Frost & Sullivan

Thanks!

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