

Helping to Solve Social Issues Through Technological Innovation in SiC Power Devices

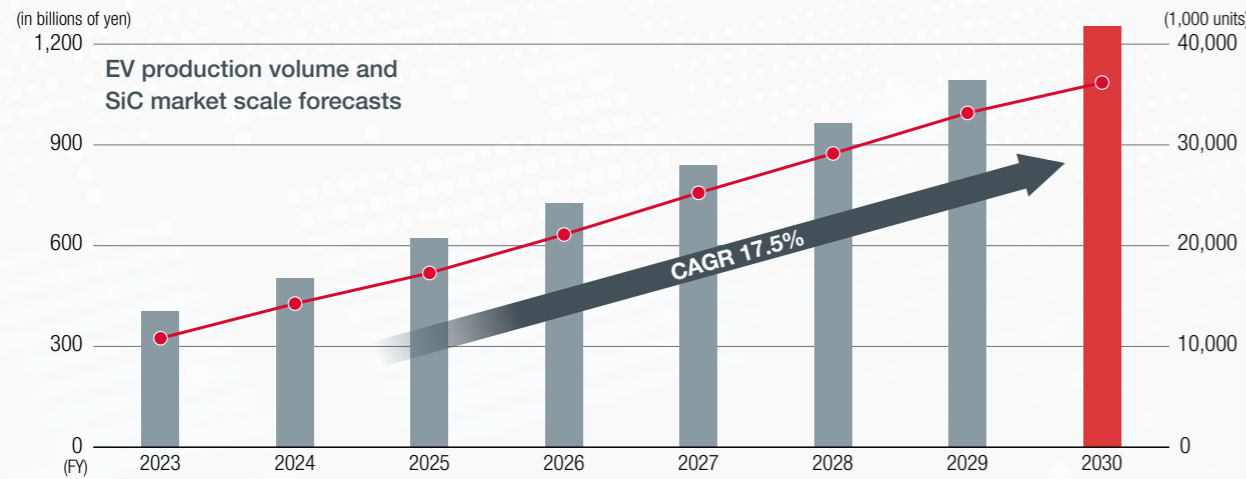
Material issues

- Evolution of Technologies to Contribute to the Advancement and Progress of Culture
- Stable Supply of High-quality Products
- Strengthening Sustainable Technologies, Developing and Supplying Innovative Products
- Mitigation of Climate Change

Contributing to the electrification of automobiles with SiC power devices

The trend of automobile electrification is accelerating to realize a decarbonized society. Most importantly, the ratio of EVs is significantly rising. In 2022, EV sales were approximately 7.74 million units, roughly 10% of global sales, and the shift to EVs is rapidly advancing. To curtail increases in EV battery capacity and extend the cruising range, the adoption of low power loss SiC power devices in inverters is essential. Because SiC power devices have

a lower specific ON resistance compared to Si devices and they demonstrate high performance even under high-temperature, high-frequency, and high-voltage environments, their adoption especially for EVs is accelerating, and it is expected that they will come into wide use. At ROHM, we are further increasing our production capacity and cost competitiveness to respond to additional increases in the demand for SiC power devices.

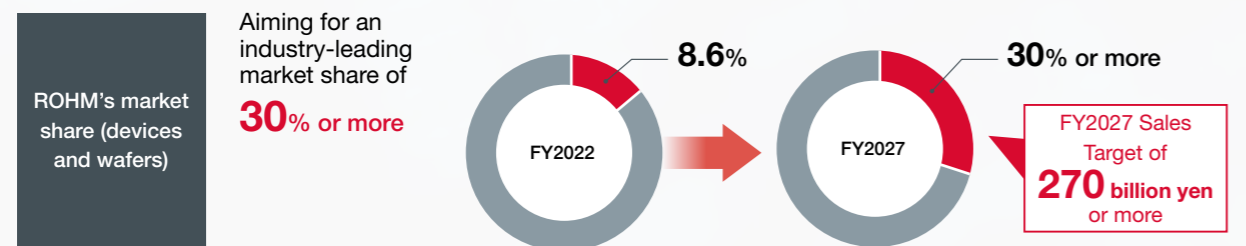


Source: SiC Market Scale Forecast Created by ROHM EV production volume forecast GlobalData Plc (forecast as of July 31, 2023) * Foreign exchange rate: \$1 = 130 yen

ROHM's position within the SiC market

Global SiC sales ranking				SiC power devices (including modules) sales ranking/market share forecast (2022)				SiC wafer sales ranking/market share forecast (2022)			
				(Millions of U.S. dollars)				(Millions of U.S. dollars)			
Sales	Company name	Sales	Share of sales	Sales	Company name	Sales	Share of sales	Sales	Company name	Sales	Share of sales
1	STMicroelectronics	700	32.5%	1	WolfSpeed	295	42.6%	1	WolfSpeed	295	42.6%
2	Infineon Technologies	360	16.7%	2	Coherent (Former II-VI)	109	15.7%	2	Coherent (Former II-VI)	109	15.7%
3	WolfSpeed	299	13.9%	3	SiCrystal (ROHM Group)	96	13.9%	3	SiCrystal (ROHM Group)	96	13.9%
4	onsemi	200	12.8%	4	TankeBlue	88	12.7%	4	TankeBlue	88	12.7%
5	ROHM	149	6.9%	5	SK siltron	56	8.1%	5	SK siltron	56	8.1%

* Tables and figures have been done thanks to Yole Group's Power SiC report, 2023 edition.



ROHM's strengths in SiC power devices

1 Construction of an integrated production system

ROHM is aiming for the top market share of 30% of the rapidly growing SiC market and aggressively investing in this area. After acquiring German SiC wafer manufacturer SiCrystal GmbH in 2009, we established a high-quality SiC substrate procurement system, which is essential for the stable manufacturing of SiC power devices, while also working to increase the diameter and production capacity. Moreover, the production building

dedicated to SiC power devices which was newly established at the ROHM Apollo Co., Ltd.'s Chikugo Plant (Fukuoka Prefecture) began operation in FY2022. It is currently producing 6-inch wafers, but equipment has been pre-installed for the switchover to 8-inch wafers. In conjunction with strengthening the BCM system, we are building a production system which can respond to medium- to long-term increases in demand.

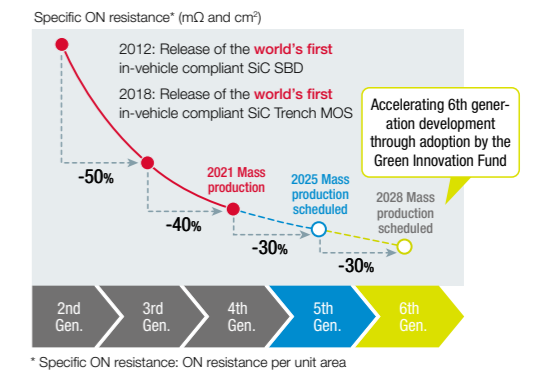
Integrated SiC power device production system



2 Industry-leading technological capabilities

In addition to Si-based transistors (MOSFET, IGBT, SJMOS, and BiP) and diodes (SBD and FRD), ROHM is developing SiC-based MOSFET and SBD products. We have realized the development of high-quality and high-performance SiC power devices which lead the industry through our in-house integrated production covering everything from SiC substrate production to power module and other packages as well as new product design, manufacturing processes, and quality control methods that support those processes in an internal system which batch manages the technologies that are essential to the evolution of SiC power devices. Our fourth generation SiC MOSFETs have evolved ROHM's original double-trench structure to reduce the specific ON resistance by approximately 40% compared to conventional products to achieve the lowest specific ON resistance in the industry. We are currently working on the development of the fifth generation which aims for further characteristic improvement.

Industry-leading SiC MOSFET low ON resistance technologies



3 Solution proposal ability

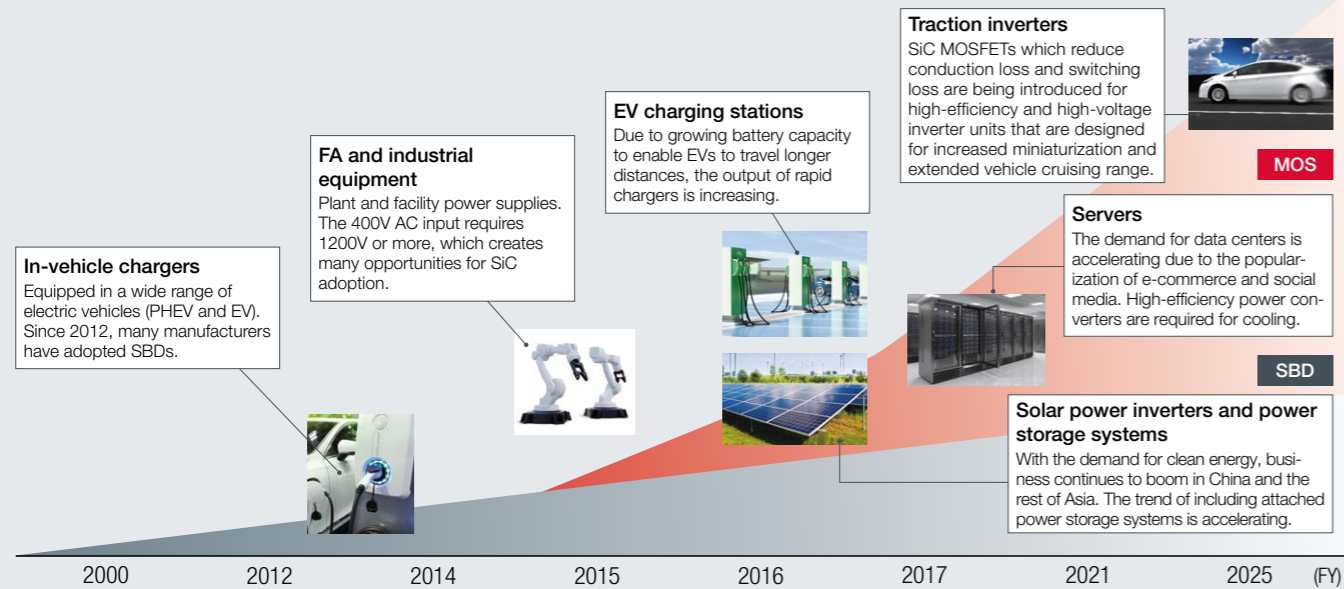
To date, ROHM has offered various solutions which help resolve issues in each customer development flow. FAEs and AEs from the System Solutions Engineering Headquarters, who understand customer systems, contribute to the realization of user functions by proposing isolated gate driver ICs, diodes, resistors, and other peripheral components which drive SiC power devices in combination. For example, products combining Insulated Gate Bipolar Transistors (IGBTs) and FRDs were previously used in power devices for EVs. However, not only replacing those with SiC MOSFETs but also proposing isolated gate driver IC solutions helps to make inverters smaller and extend the vehicle cruising range.

Solution board for easy evaluation of SiC power devices

Capable of simulating SiC power devices in an environment which is close to a real system, including the isolated gate driver ICs and peripheral components

SiC application examples

ROHM started basic research on SiC power devices in 2000 and subsequently expanded the range of products to include diodes (SiC SBD) and transistors (SiC MOSFET), etc. In 2012, we started mass production of the world's first SiC MOSFETs and full SiC modules*.



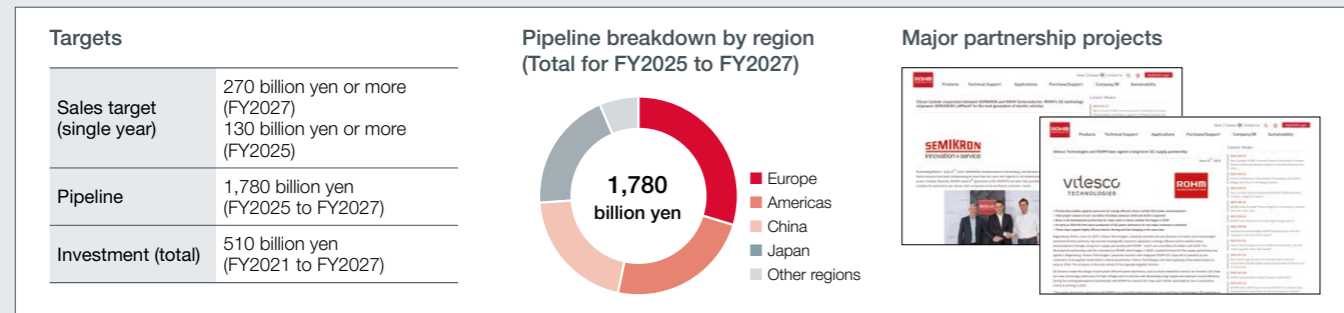
* Full SiC modules: all built-in power devices use SiCs

SiC sales targets and pipeline status

In the SiC business, we are aiming for the top market share with sales targets of 130 billion yen or more in FY2025 and 270 billion yen or more in FY2027.

Our total pipeline (business discussions with customers) for FY2025 to FY2027 is approximately 1.8 trillion yen, and

we are receiving solid inquiries without depending on a specific region such as China, Europe, the Americas, or Japan. In order to build a supply system that can effectively respond to the brisk demand, we are planning to invest a total of 510 billion yen from FY2021 to FY2027.



Signed a joint agreement to develop inverters for EVs with Mazda Motor and Imasen Electric

In November 2022, ROHM signed a joint agreement with Mazda Motor Corporation and Imasen Electric Industrial Co., Ltd. to develop inverters and SiC power modules installed in the electric drive units of EVs including e-Axle. e-Axle integrates a motor, reduction gearbox, and inverter into a single unit, which makes it an important component in determining the driving performance and power conversion efficiency of EVs. ROHM will participate in a "cooperative framework for the development and production of the electric drive units" and jointly develop inverters with a focus on the entire e-Axle through co-creation with its partner companies. Moreover, ROHM will contribute to the creation of miniature and high-efficiency electric drive units by developing and supplying the advanced SiC power modules to support those performance improvements.



Ichiro Hirose, Director, Senior Managing Executive Officer and CTO, Mazda Motor Corporation (left), Katsumi Azuma, Director and Senior Managing Executive Officer and COO, ROHM Co., Ltd. (right)

VOICE

Accurately assessing hidden customer needs and providing the optimal solution

Group Leader, Traction Inverter Group 1,
FAE Division 3, Power Device Application Department
System Solutions Engineering Headquarters

Ryo Fuchizaki



ROHM's proposal ability helps solve customer issues

To realize carbon neutrality, the demand for SiC power devices, which contribute to miniaturization and energy saving, is increasing especially among EVs. The usability of SiC power devices, which incorporate new materials, differs in some respects from conventional Si devices, and problems can occur which customers have never experienced before. We propose products based on an understanding of customer needs including the power device characteristics, how it will be used in the application, and the driving method, etc. so that even customers who are adopting an SiC power device for the first time will be able to successfully conduct an evaluation. ROHM has a lineup of many products which includes not only power devices but also ICs which drive devices and general-purpose components. We are proud of our strength which lies in the ability to combine those products and technologies to propose a solution.

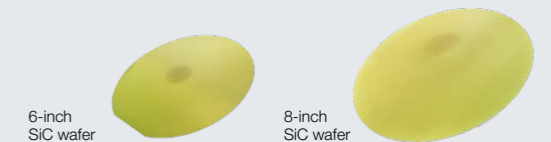
Becoming a major global player

What becoming a major global player means to FAEs such as myself is that when customers confront an issue, they will immediately think of ROHM. Our goal is to raise the awareness of ROHM in overseas markets and become the semiconductor manufacturer that is indispensable to customers. Therefore, we are focusing our efforts not only on device proposals but also proposing references and solutions which assist customers with design and evaluation. Furthermore, we aim to become a major global player as the leading SiC power device company by expanding such activities globally while planning new products based on a thorough understanding of market trends and application needs.

Initiative to increase the wafer diameter

Currently, ROHM's production is centered on using 6-inch SiC wafers, but we are developing process and manufacturing technologies using large-diameter wafers (8-inch), which can be expected to lower the cost of SiC power devices for further technological innovation. We are accelerating the development and mass production of next-generation SiC MOSFETs utilizing 8-inch wafers, and this project has been selected by the state-sponsored "Green Innovation Fund Projects." ROHM is preparing to ship devices using 8-inch

SiC wafers in FY2025. Our goal is to promote the adoption of these devices in a wide range of equipment and facilities including EVs and industrial equipment by improving the manufacturing technologies for next-generation power devices.



Column Contributing to higher efficiency in a wide range of power supplies with GaN power devices

Along with SiC, there are high hopes for gallium nitride (GaN), with its excellent high-frequency properties, as a new material for power devices that will improve efficiency in various power supplies.

ROHM envisions applications that will take advantage of the properties of GaN, such as power supplies for communication base stations and data center servers, motors for industrial equipment, and AC adapters. As such, we have expanded our lineup with the EcoGaN™ series, and in April 2023, we began mass production of the 650V GaN HEMT which has become one of the leading products in the industry in terms of device performance.

