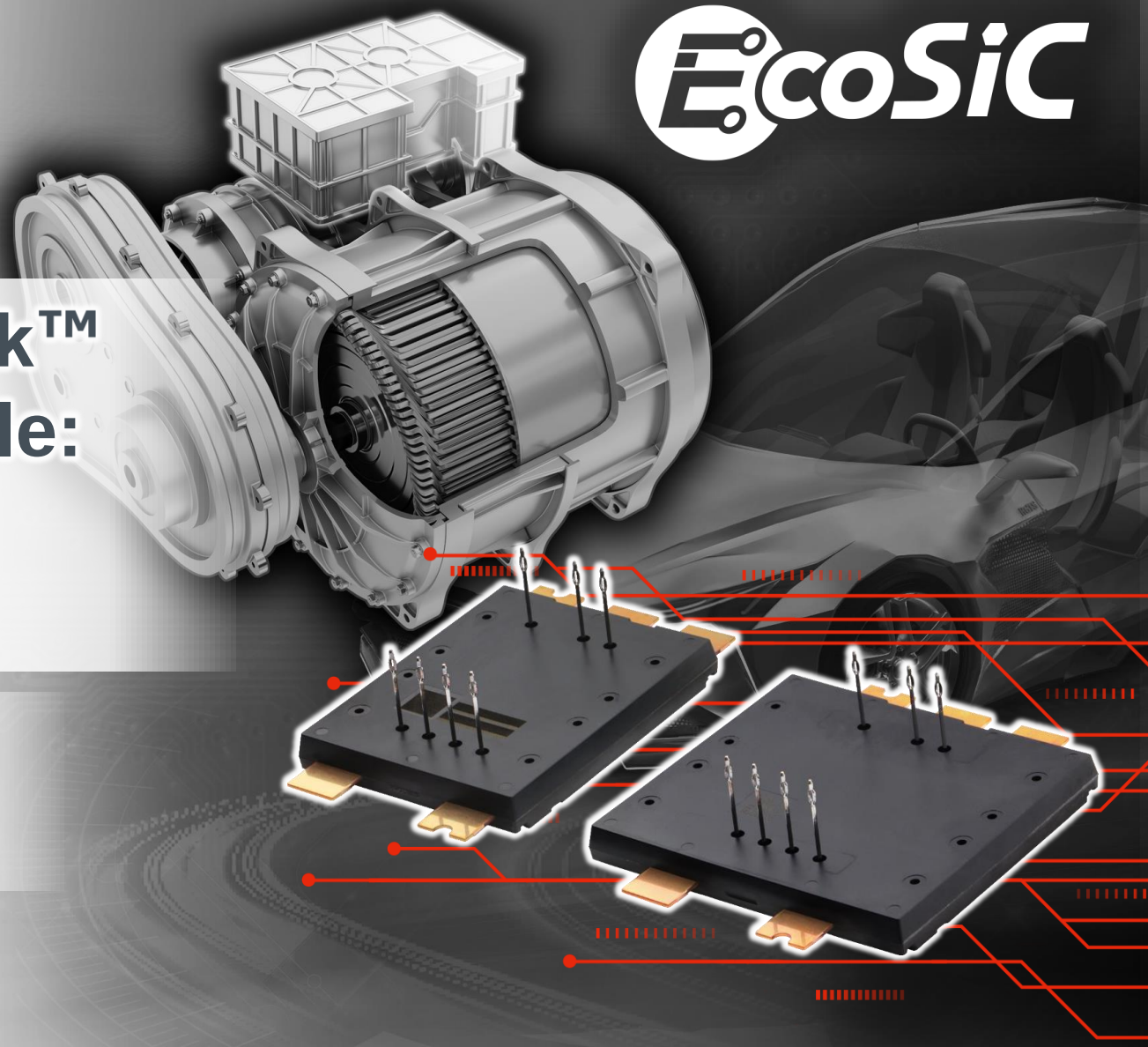
ROHM SEMICONDUCTOR

Electronics for the Future

EcoSiC

ROHM's New TRCDRIVE pack™ with 2-in-1 SiC Molded Module: Significantly Reduces the Size of xEV Inverters



Achieves industry-leading* power density by integrating 4th Generation SiC MOSFETs in a compact package

June 11, 2024
ROHM Co., Ltd.
Marketing Communications Dept.

* ROHM Tuesday, June 11, 2024 study

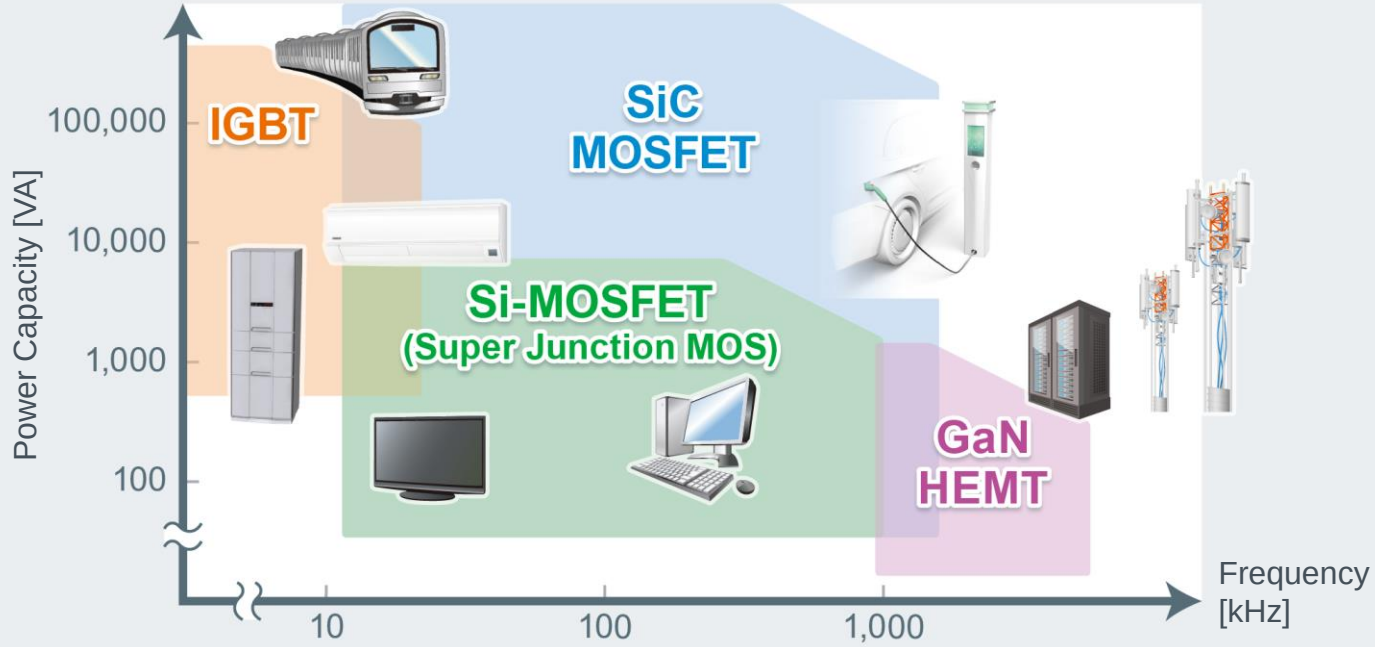
What is SiC?

SiC Silicon Carbide Features

	Si	4H-SiC
Bandgap (eV)	1.12	3.2
Dielectric Constant	11.7	9.66
Dielectric Breakdown Electric Field (MV/cm)	0.3	3
Electron Saturation Velocity (10^7 cm/s)	1	2
Bulk Electron Mobility (cm^2/Vs)	1350	720
Thermal Conductivity (W/cm·K)	1.5	4.5

- Wide Bandgap
- High electron saturation velocity
- High dielectric breakdown electric field

Power Device Application Scope



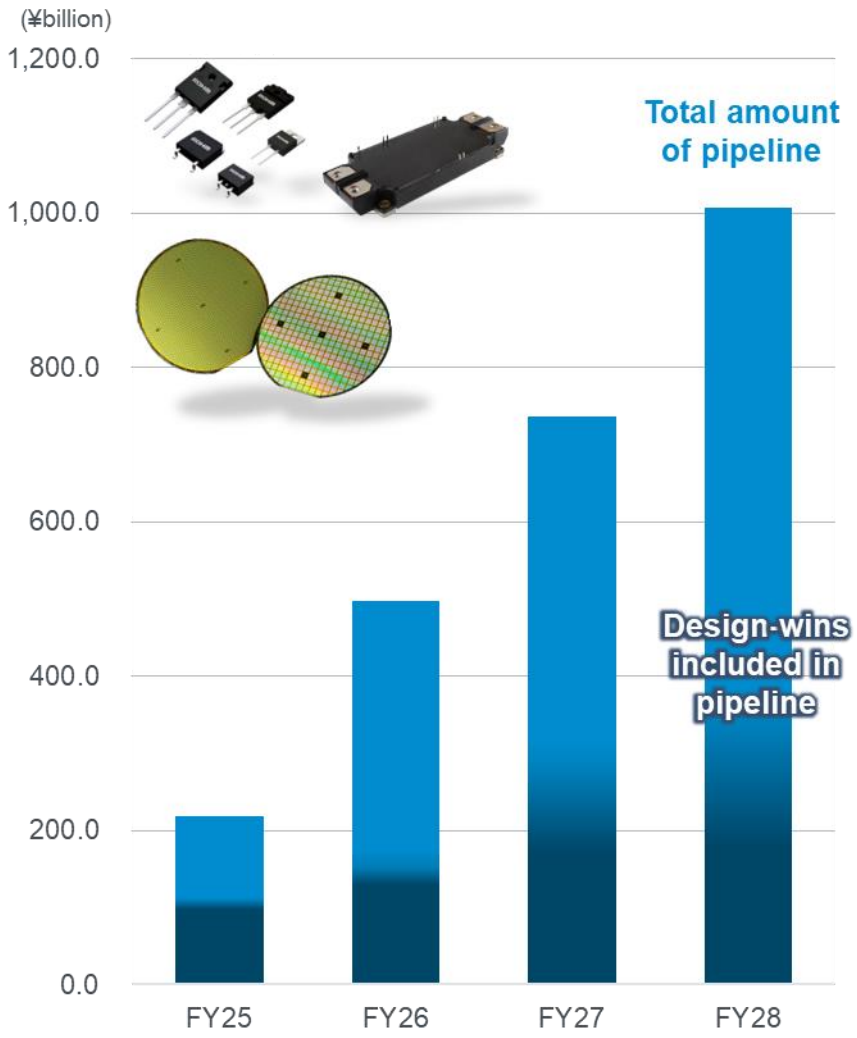
SiC
- High power
- High voltage (>600V)
- High frequency (20 to 200kHz)

GaN
- Medium power
- Medium voltage (100 to 600V)
- High frequency (over 200kHz)

SiC features high breakdown voltage, low ON resistance (low loss) under high power, and high frequency operation, making it ideal for high power applications

SiC Pipeline and Sales Target

Pipeline of the SiC Business

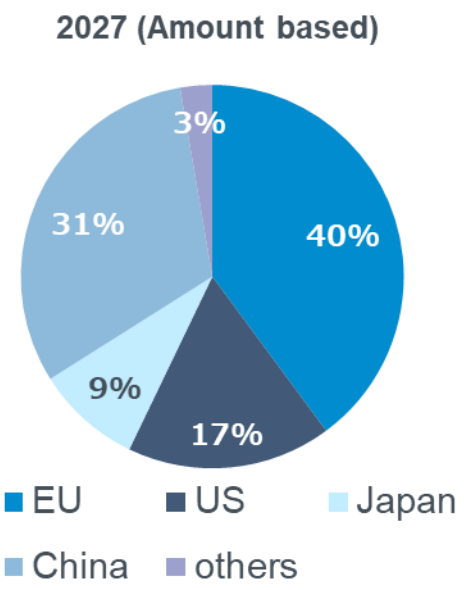


Target for the SiC Business

Sales Target	> ¥**110**billion (FY2025)	> ¥**220**billion (FY2027)
	> $**0.76**billion (FY2025)	> $**1.52**billion (FY2027)

*Converted at ¥145

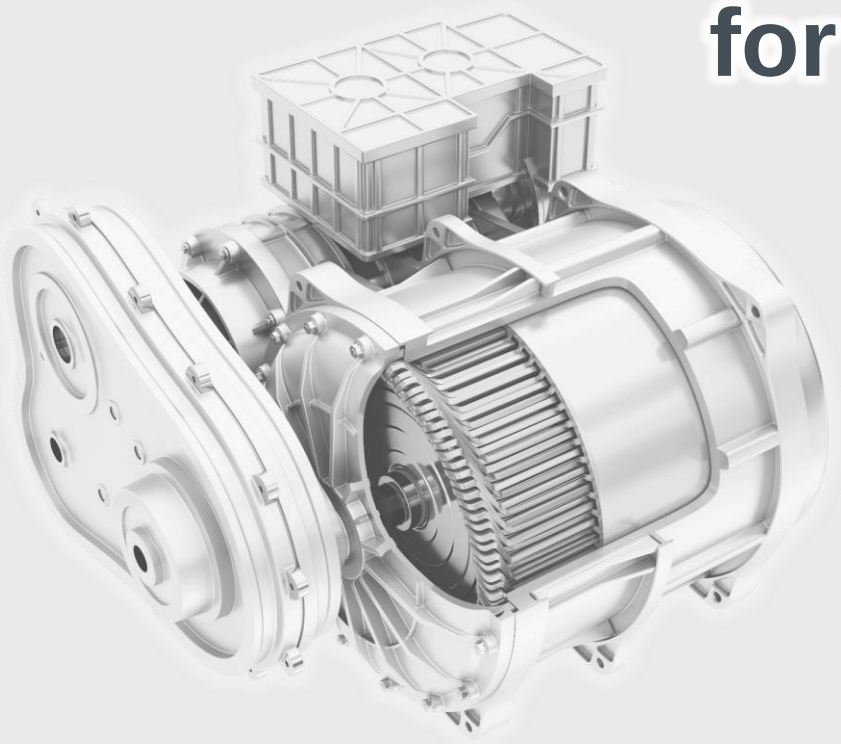
A good balance of design-wins achieved worldwide. Confirmed design-wins with over 130 companies.

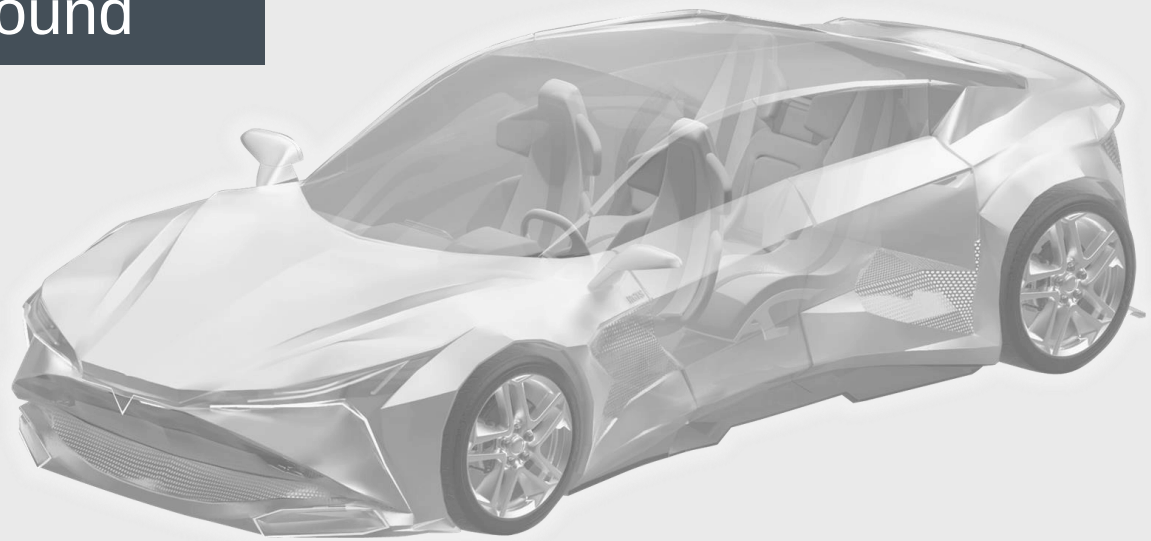


		Number of design-win companies
Europe	SEMIKRON DANFOSS, BMW, SMA, TRUMPF, vitesco TECHNOLOGIES, Vincotech, ABB, SIEMENS, KOSTAL, ALSTOM	24
Americas	GENERAC, LUCID	14
Japan	mazda, GS YUASA, Astemo	43
China	HAIMOSIC, LEADRIVE TECHNOLOGY, SUNGROW, GEELY, UAES, GOODWE, BASiC Semiconductor	39
Others		18

Full SiC Modules for Traction Inverters

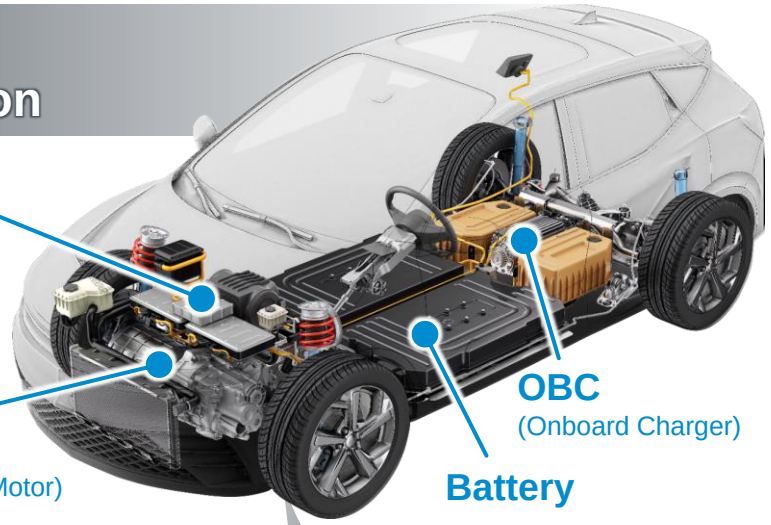
Development Background





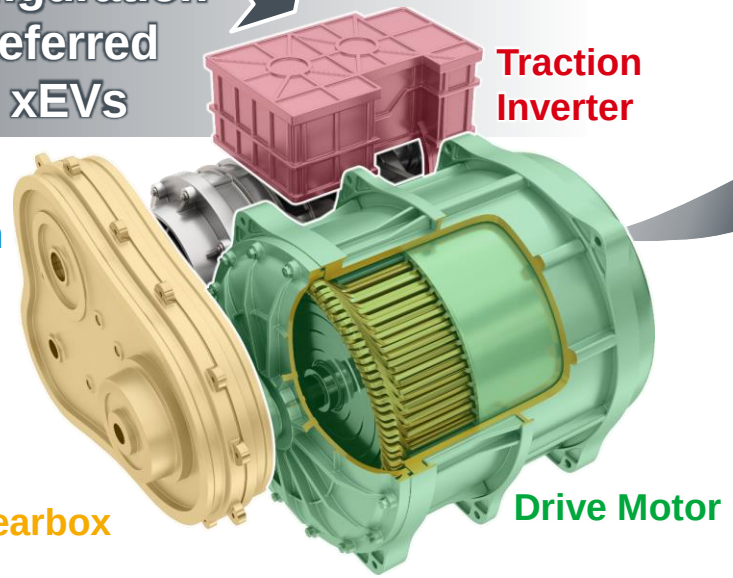
xEV Applications

Typical xEV Configuration

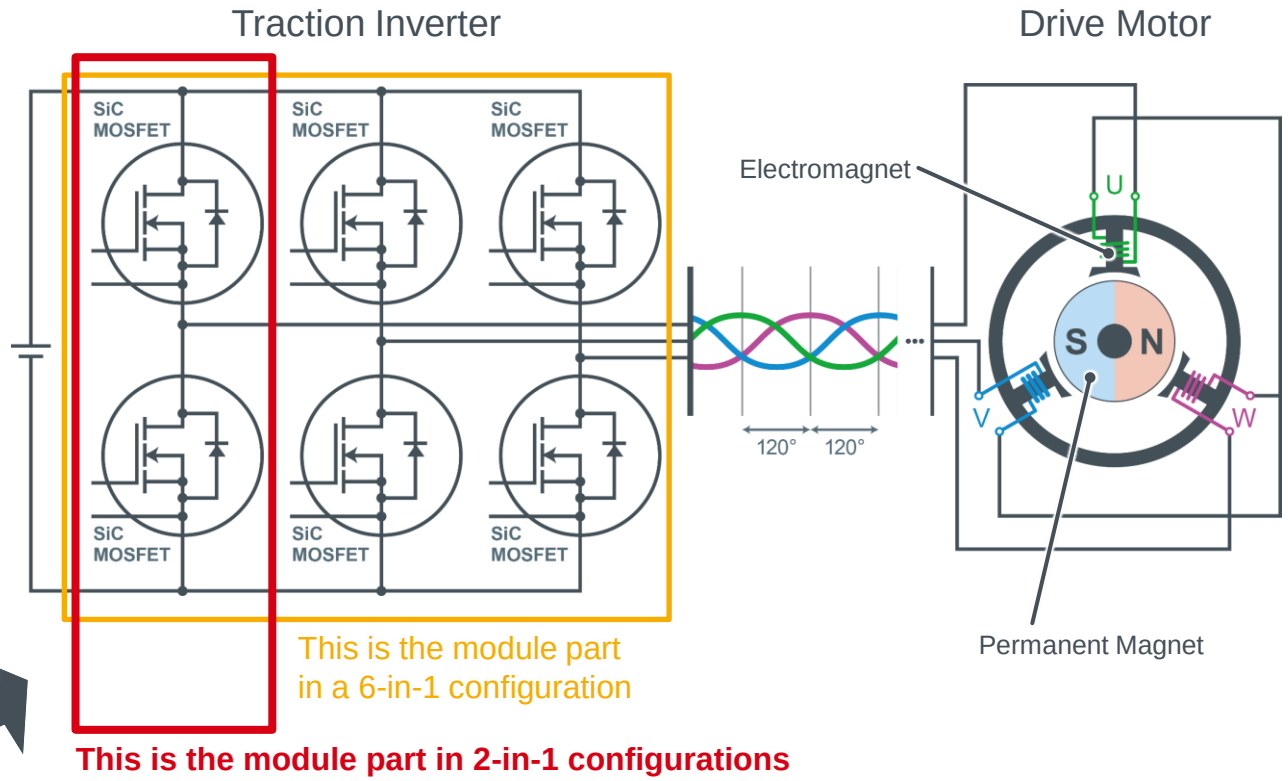


This Drive Configuration is Commonly Referred to as a 3-in-1 in xEVs

Integrated unit combines a traction inverter, gearbox, and drive motor



Operating Principle of a Drive Motor



Key Point

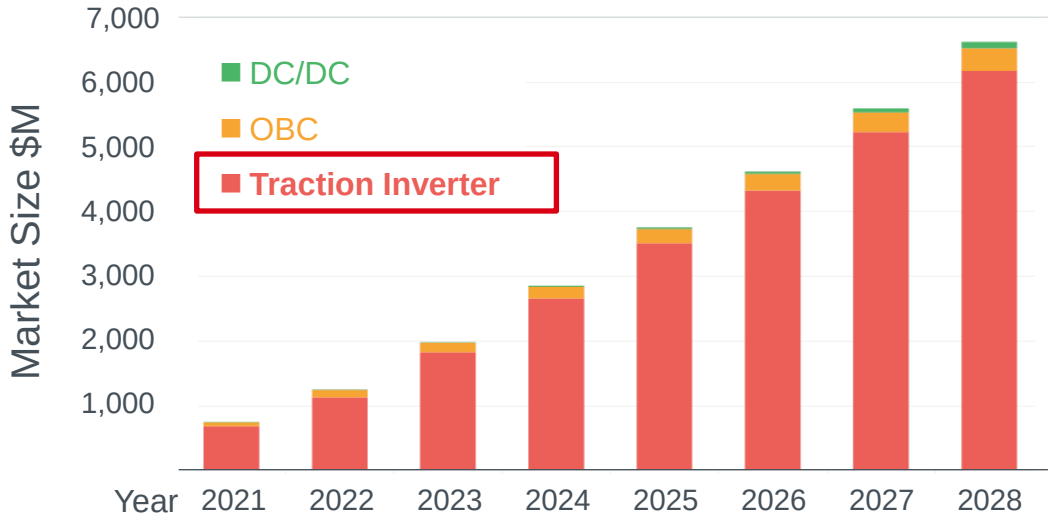
The x-in-1 configuration of the drive unit in the main body of the xEV differs from the x-in-1 configuration in the traction inverter

Market for SiC in xEV Applications

Market for SiC Devices in xEV Applications (from Yole Group report)

Source: Power SiC report, Yole Intelligence, 2023. Graphs extracted from the report..

Market Size for Applications in xEVs

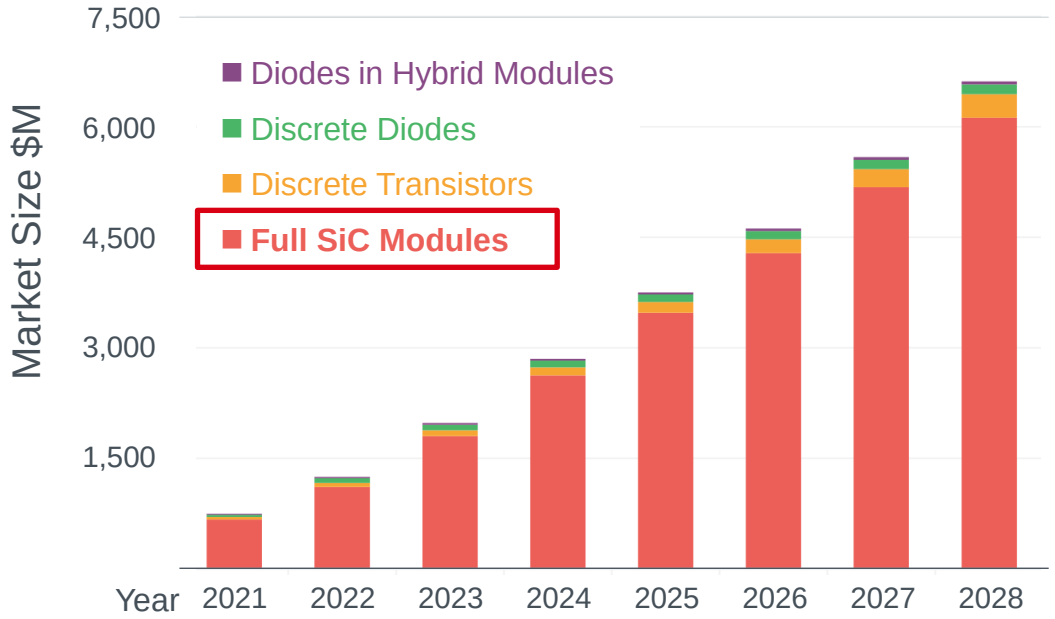


The main battleground for automotive SiC is traction inverters

However, until now ROHM has not had a competitive module

Develop full SiC modules that resonate with the market

Market Size for SiC Devices in xEVs

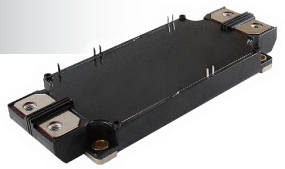


There is a demand for full SiC modules that can reduce both size and labor costs

Main Types of Full SiC Modules

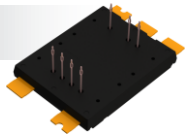
Case Type

Elements are enclosed with a resin case and lid



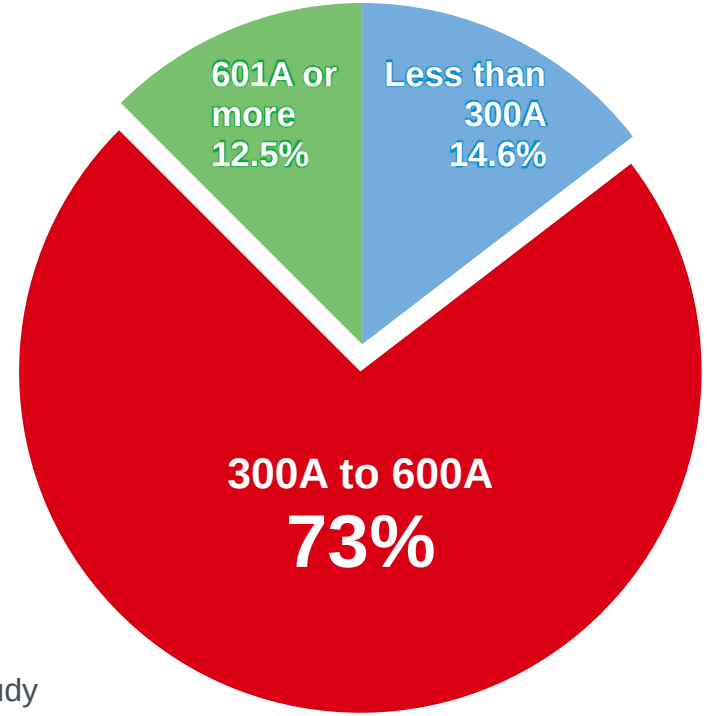
Molded Type

Elements are encapsulated with mold resin



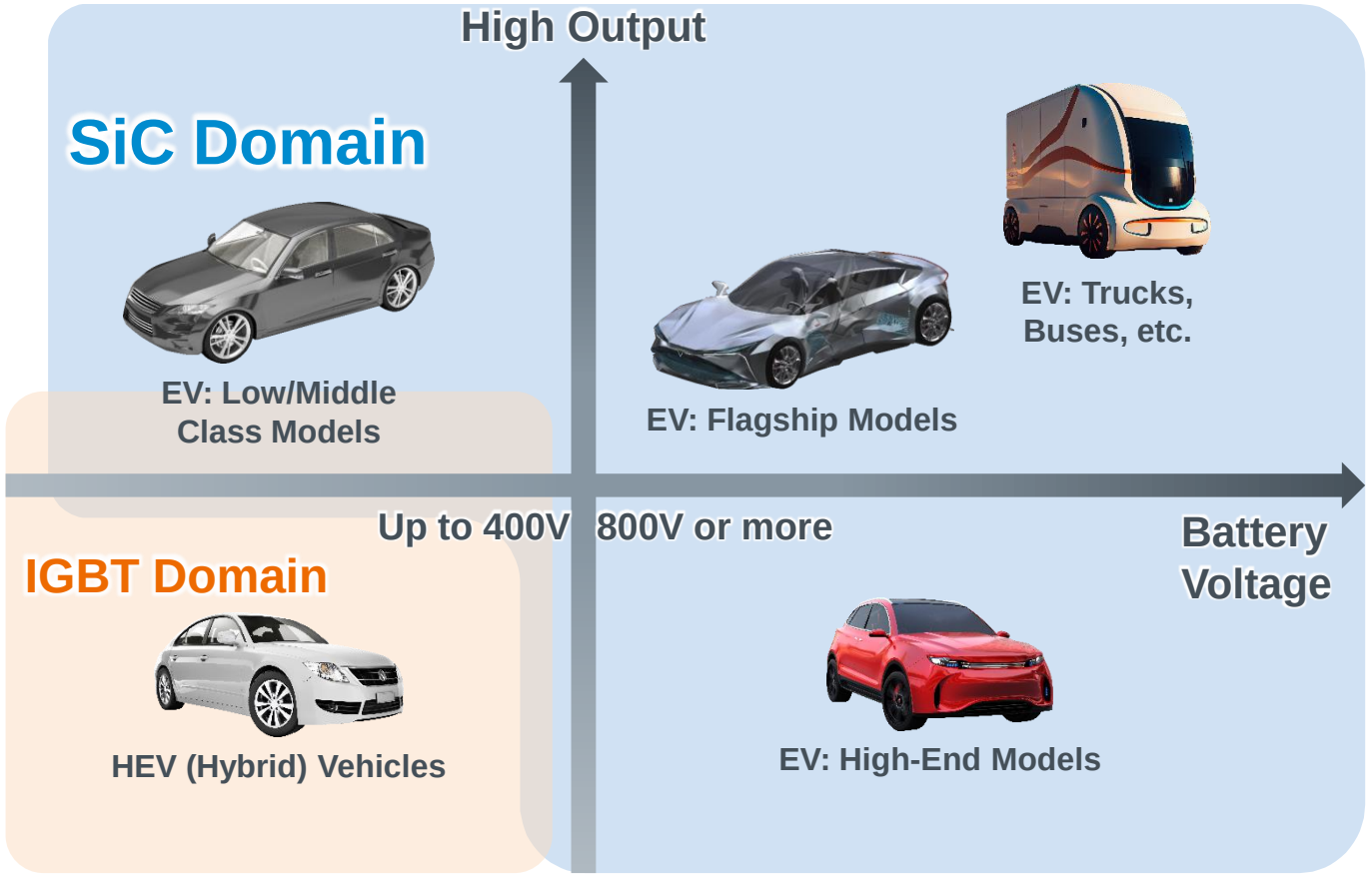
What Type of Full SiC Module will Impact the Market?

Currents Used by Traction Inverters in BEVs (Battery EVs) Released Since 2021



*ROHM study

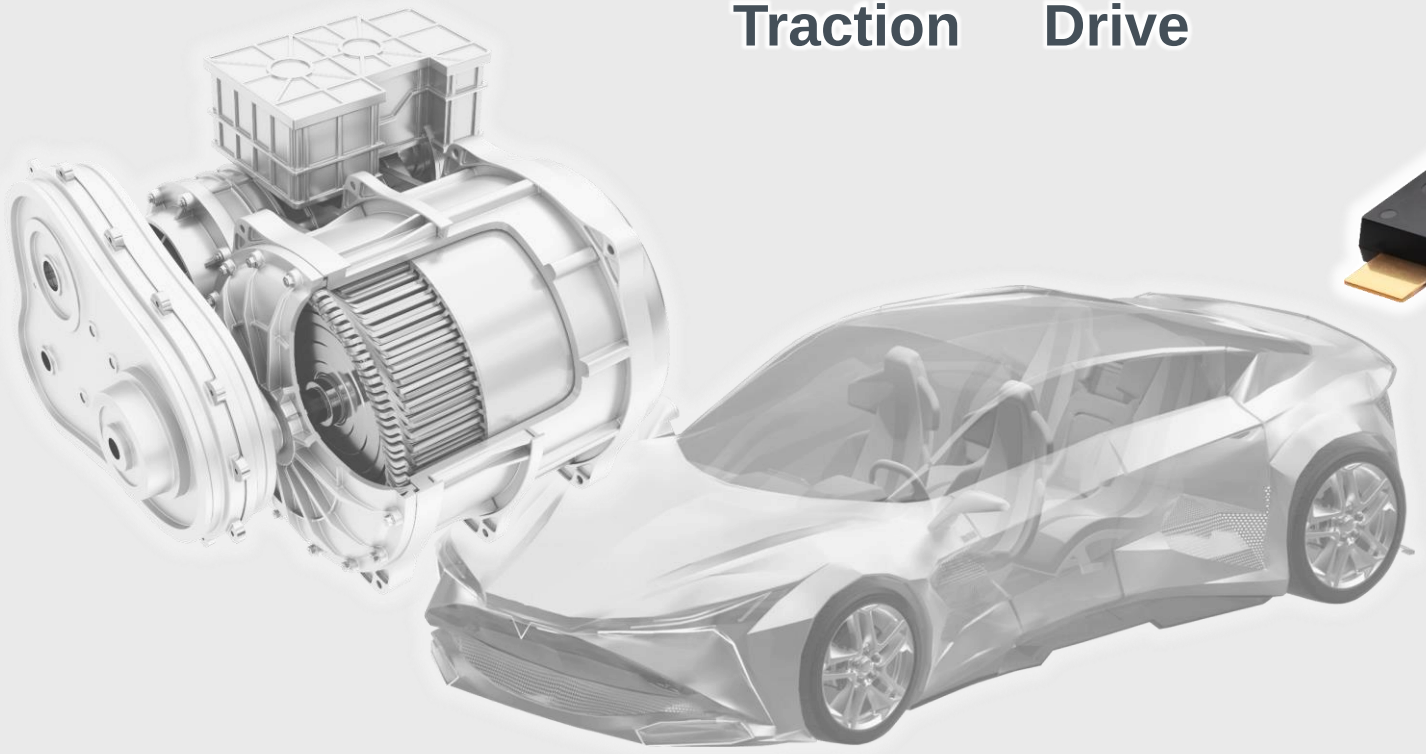
Diagram of Semiconductor Devices by xEV Type

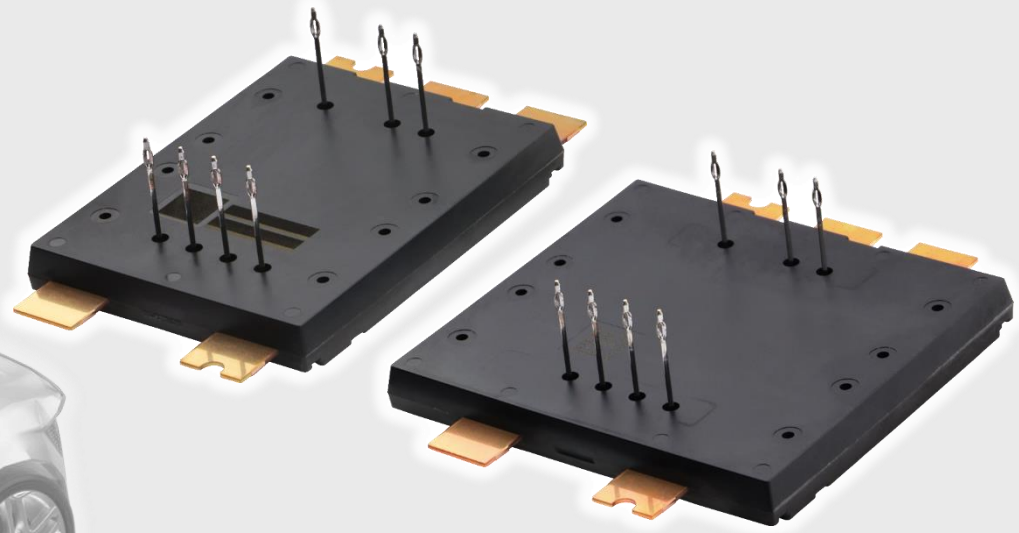


Full SiC modules are needed for volume zones requiring high currents of 300A or more and breakdown voltages over 400V

TRCDRIVE pack™

Traction Drive





New Product

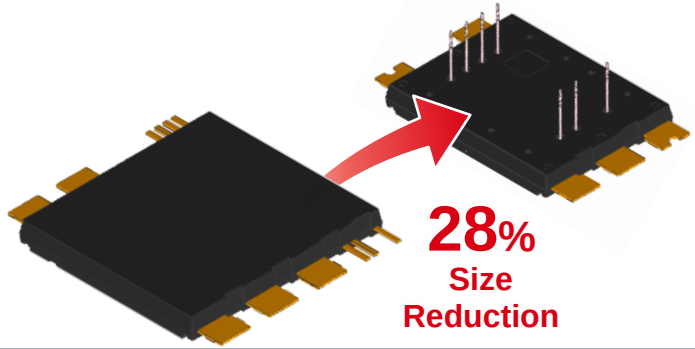
TRCDRIVE pack™ Overview

Features

1. Smaller	Combining press-fit pins and molding technology
2. High Power Density	Higher heat dissipation & Lower stray inductance
3. Ease of use for customer	No soldering for signal terminals
4. High productivity	By Introducing “discrete” packaging production system

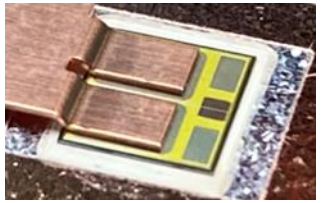
Smaller

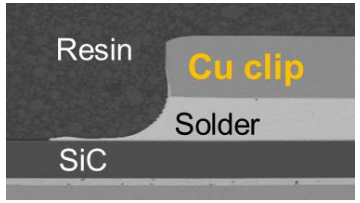
Combining press-fit pins and molding technology



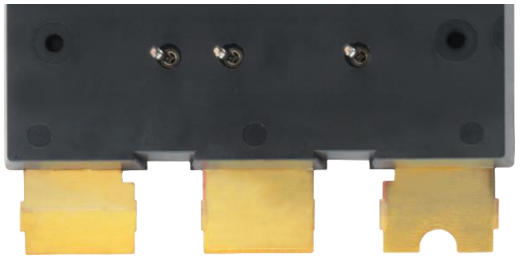
High Power Density Lower Inductance

Cu Clip Circuit



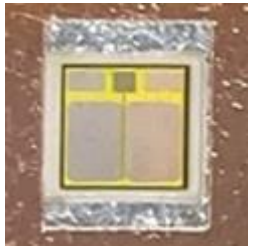


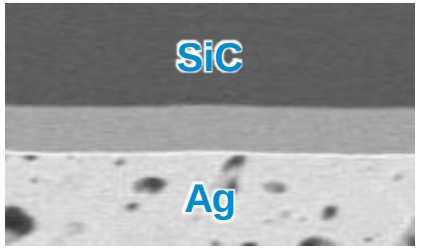
Optimization of Power terminal



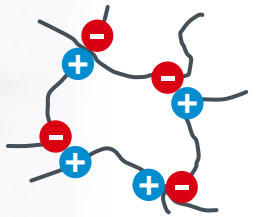
High Power Density Higher Heat Dissipation

Ag sinter Bonding





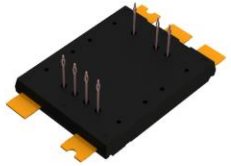
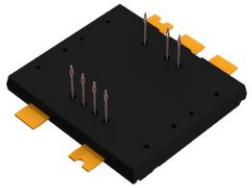
High Performance Resin Tg>230°C



New Product

Lineup of TRCDRIVE pack™

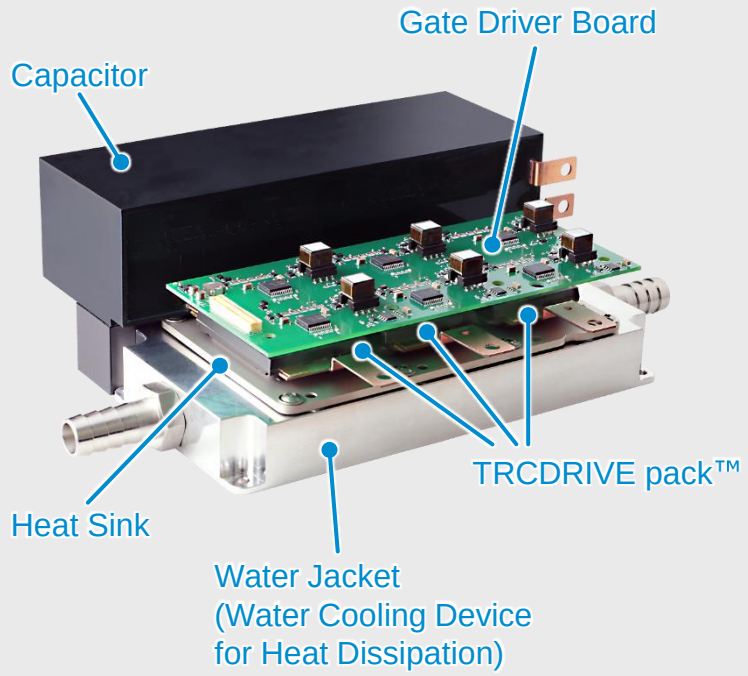
TRCDRIVE pack™ is a trademark or registered trademark of ROHM Co., Ltd.

Part No.	Absolute Max. Ratings (Tj=25°C)				Heat Sink Assembly	Module Type		AQG 324 Qualified
	V_{DSS} [V]	$R_{DS(on)}$ [mΩ]	DC Current [A]*1	AC Current [A]*2				
New BST500D08P4A104	750	2.0	506	417	TIM: heat dissipation sheet	Small	Type A (Small)  (41.6mm × 52.5mm)	YES
☆ BST500D08P4A114				429	Ag Sinter			
New BST400D12P4A101	1,200	2.8	394	326	TIM: heat dissipation sheet			
☆ BST400D12P4A111				336	Ag Sinter			
New BST740D08P4A154	750	1.4	738	634	TIM: heat dissipation sheet	Large	Type A (Large)  (58.6mm × 52.5mm)	
☆ BST1040D08P4A156		1.0	1,039	736				
☆ BST740D08P4A164		1.4	738	659	Ag Sinter			
☆ BST1040D08P4A166		1.0	1,039	771				
New BST580D12P4A151	1,200	1.9	575	475	TIM: heat dissipation sheet			
☆ BST780D12P4A153		1.2	778	571				
☆ BST580D12P4A161		1.9	575	494	Ag Sinter			
☆ BST780D12P4A163		1.2	778	593				

☆ : Under Development

*1: Tc=60°C, V_{GS}=18V *2: Tf=65°C, V_{DC}=800V/500V, fsw=10kHz, Modulation=0.9, Power factor=0.9

AQG 324 is a qualification standard for automotive power modules established by ECPE (European Center for Power Electronics).
European automakers are required to comply with this standard when considering adoption.

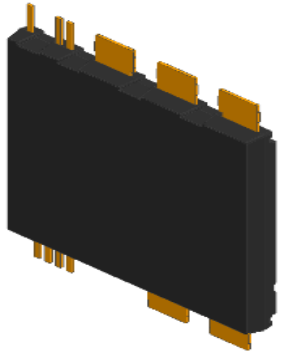


Evaluation kits are enabling evaluation in similar conditions as practical inverter circuits

*For details, please contact a sales representative or visit the contact page on ROHM's website.

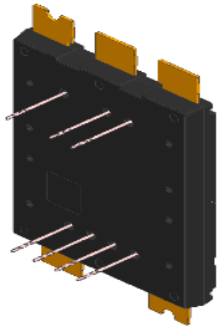
1. Compact

Conventional Packaging Technology



28% smaller

TRCDRIVE pack™



Unique layout ensures even current flow between internal chips

+

Separate paths for the main current and control signals (press fit pins)

+

Built-in low ON resistance 4th Generation SiC MOSFETs deliver high efficiency

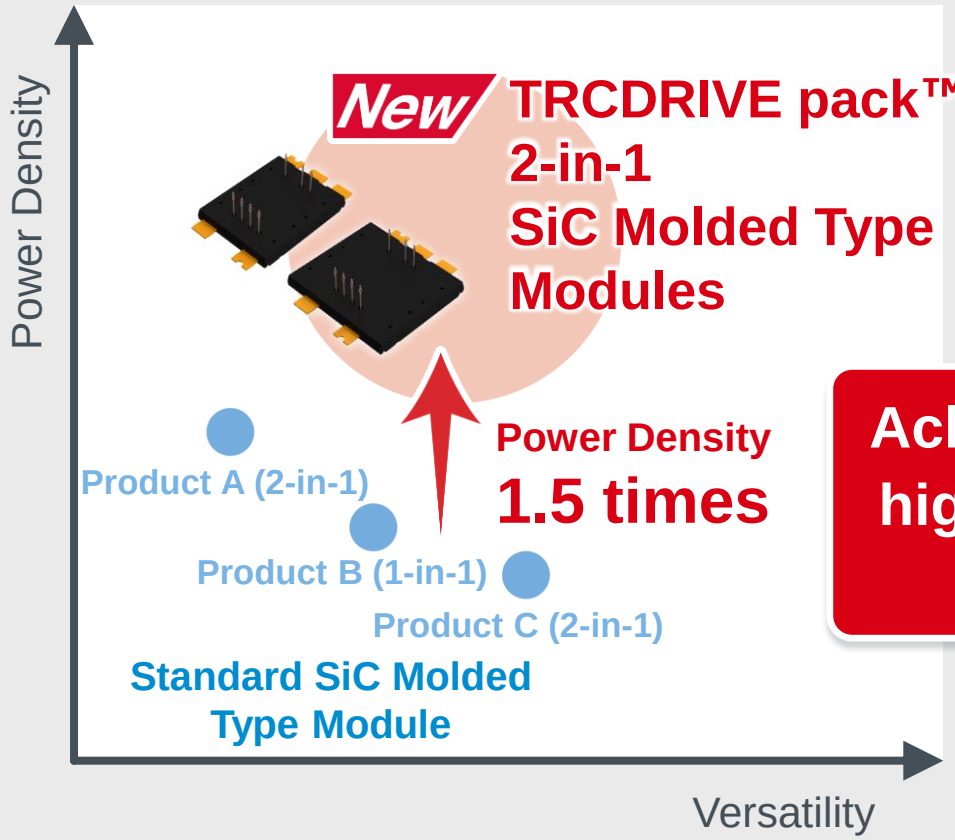
High efficiency 4th Generation SiC MOSFETs integrated into a compact high heat dissipation package

New Product

2. High Power Density

*1: ROHM June 11, 2024 study
TRCDRIVE pack™ is a trademark or registered trademark of ROHM Co., Ltd.

Comparison of TRCDRIVE pack™ vs Standard SiC Modules



Method for Calculating Power Density

$$= \frac{\text{Effective Chip Mounting Area}^{*2}}{\text{Module Component Area}}$$

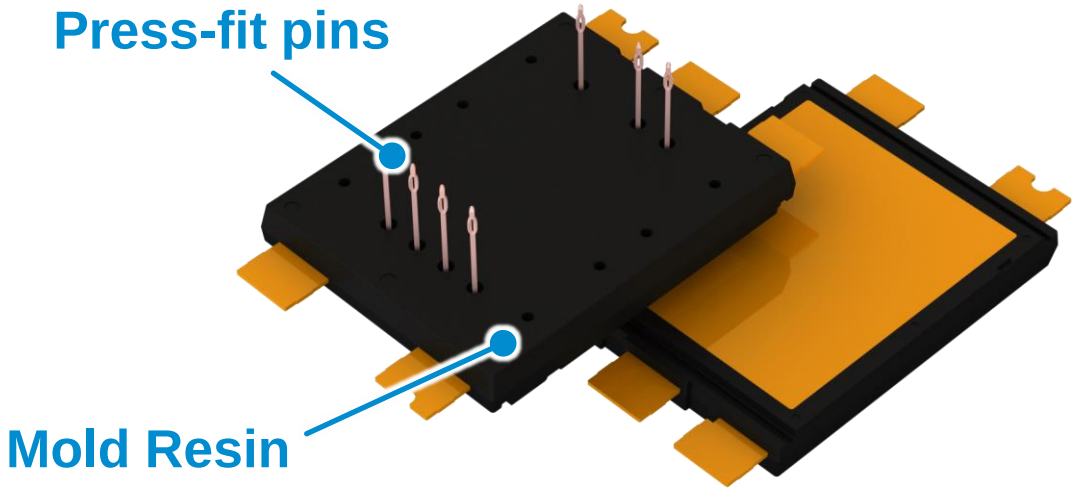
*2: Area available for mounting chips after considering factors such as heat dissipation

Achieves industry-leading*1 power density 1.5 times higher than standard products, greatly contributing to the miniaturization of inverters for xEVs

New Product

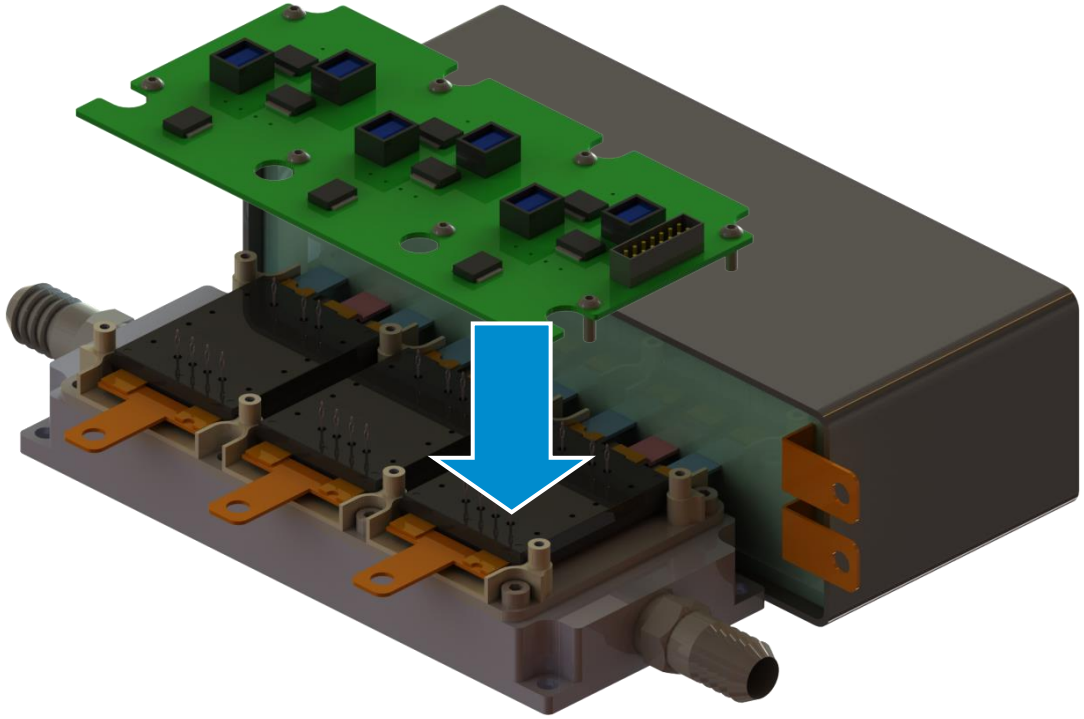
3. Reduced Mounting Time

TRCDRIVE pack™ Features



When attempting to implement press fit pins into a molded type module, it is difficult to ensure clearance between pins as they are encapsulated with resin while mounted on the lead frame

TRCDRIVE pack™ realizes press fit pin with its internal layout design and proprietary molding technology



Enables connection by simply pressing the gate driver board from the top, facilitating mounting considerably

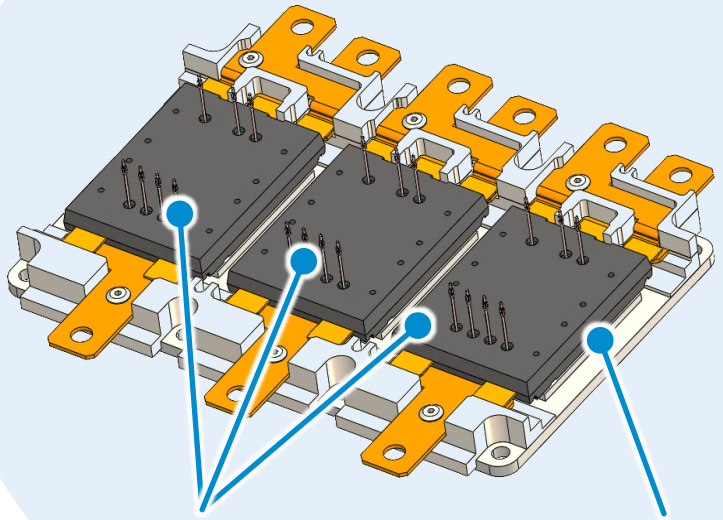
Future Development Plans

Sales Targets for ROHM's SiC Power Module Business

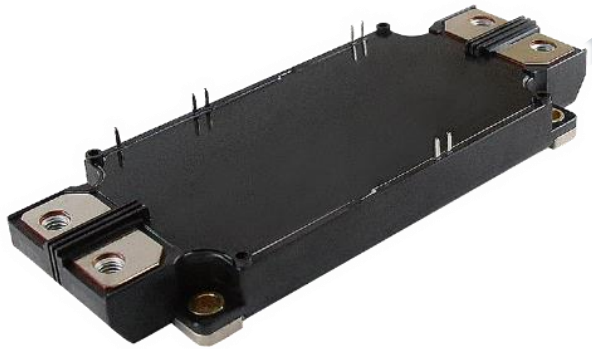
FY2027: Over 60 billion yen
413.7 million USD

*Converted at ¥145

6-in-1 SiC molded-type module consisting of 3 modules mounted on a heat sink
(under development)



Conventional SiC Case-Type Module



Power Density 1.3 times

Samples will be available in 2Q 2024

The 6-in-1 design will further contribute to the miniaturization of traction inverters

Electronics for the Future

ROHM Co.,Ltd.

Notes

- The contents specified herein are for the purpose of introducing ROHM products (hereinafter “Products”).
- When using any such Products, please be sure to refer to the specifications, which can be obtained from ROHM upon request.
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