Power Device Catalog Vol.4

ROHM SEMICONDUCTOR

The Industry's First Mass-Produced SiC"Trench" MOSFET

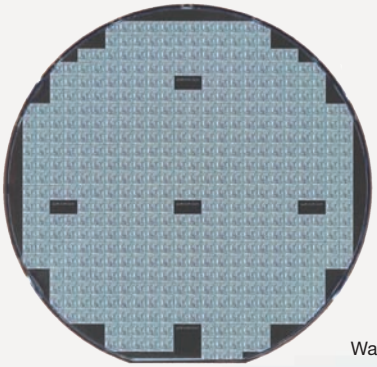
ROHM now offers SiC power devices featuring a number of characteristics,

including: high breakdown voltage, low power consumption,

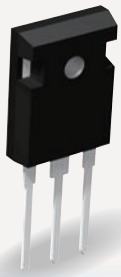
and high-speed switching operation not provided by conventional silicon devices.

ROHM, has quickly ramped up full-scale mass production of SiC products for variety of fields.

ROHM expends SiC power devices as a pioneer in the development of SiC.



Wafer



Discrete

"Full SiC" Power Modules

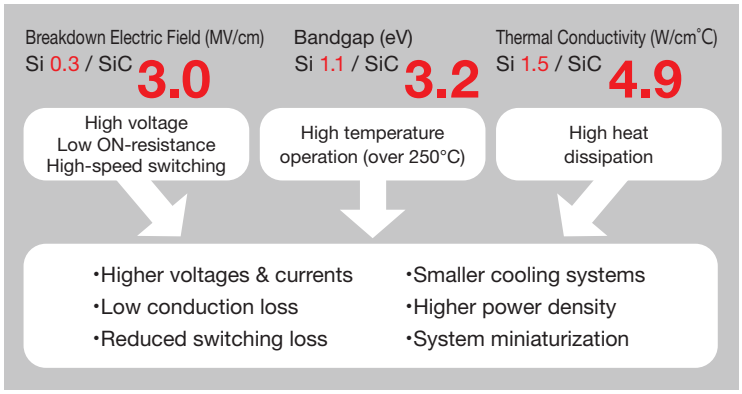
SiC - the next generation of compact, energy-saving Eco Devices

The demand for power is increasing on a global scale every year while fossil fuels continue to be depleted and global warming is growing at an alarming rate. This requires better solutions and more effective use of power and resources. ROHM provides Eco Devices designed for lower power consumption and high efficiency operation. These include highly integrated circuits utilizing sophisticated, low power ICs, passive components, opto electronics and modules that save energy and reduce CO_2 emissions. Included are next-generation SiC devices that promise even lower power consumption and higher efficiency.

Lower power loss and high temperature operation in a smaller form factor

In the power device field for power conversion and control, SiC (Silicon Carbide) is garnering increased attention as a next-generation semiconductor material due to its superior characteristics compared with silicon, including lower ON-resistance, faster switching speeds, and higher temperature operation.

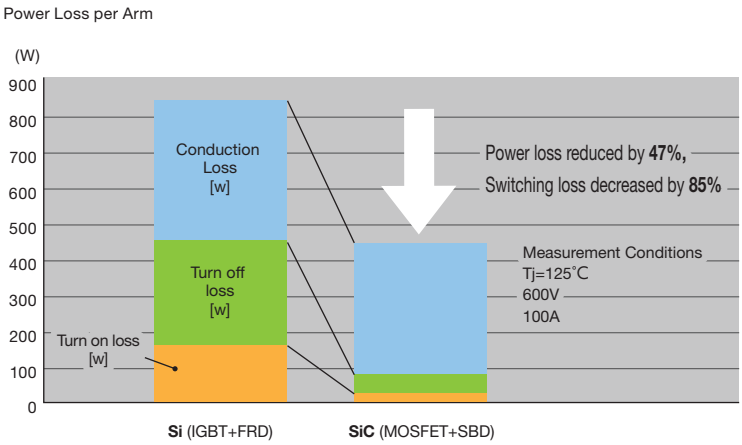
■ Performance Comparison: SiC vs. Si



Implementing SiC devices in a variety of fields, including the power, automotive, railway, industrial, and consumer sectors

SiC devices allow for smaller products with lower power consumption that make mounting possible even in tight spaces. Additional advantages include high voltage and high temperature operation, enabling stable operation under harsh conditions-impossible with silicon-based products. In hybrid vehicles and EVs SiC power solutions contribute to increased fuel economy and a larger cabin area, while in solar power generation applications they improve power loss by approximately 50%, contributing to reduced global warming.

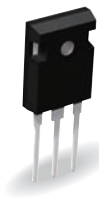
■ Power Loss Comparison



SiC Wefer

"Full SiC" Power Modules

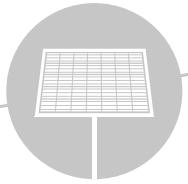
Discrete



Power transmission systems
Reduce power loss

Railway
Reduce inverter size and weight

EV
(i.e. hybrid/electric vehicles)
Reduce cooling system size, decrease weight, and increase fuel economy



Photovoltaics
Increase power conditioner efficiency

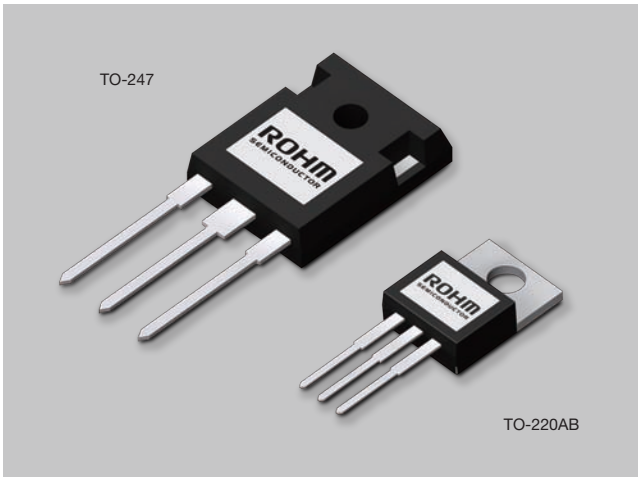
The industry's first mass-produced SiC makes the previously impossible "possible"

SiC Power Device

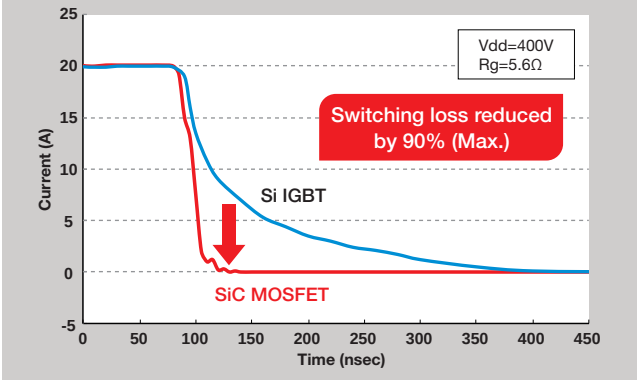
SiC MOSFET

High speed switching with low ON-resistance

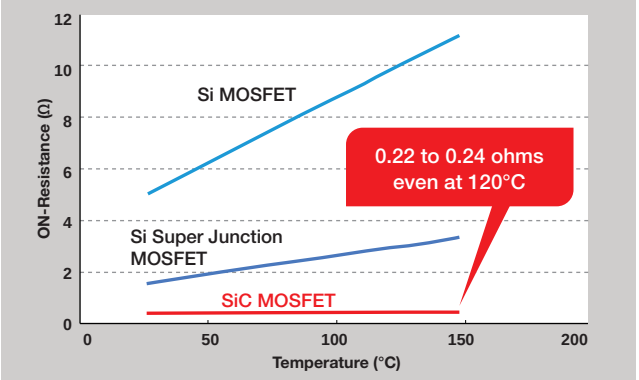
SiC enables simultaneous high speed switching with low ON-resistance - normally impossible with silicone-based products. Additional features include superior electric characteristics at high temperatures and significantly lower switching loss, allowing smaller peripheral components to be used.



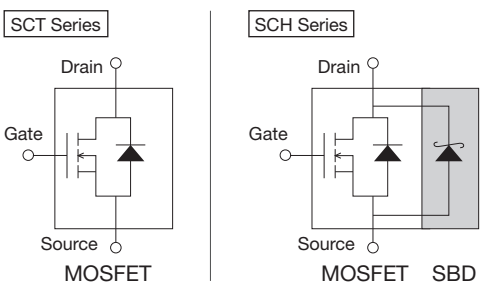
Turn OFF Characteristics (Compared with 1200V-Class Products)



ON-Resistance Temperature Characteristics (Compared with 650V-Class Products)



■ Internal Circuit Diagram



■ Lineup (2nd-Generation)

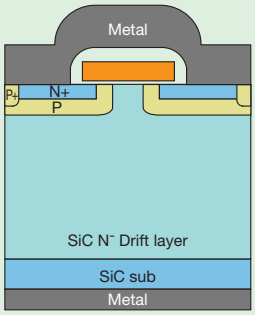
Package	V_{DSS} 650V	1200V				1700V	
	$R_{DS(on)}$ 120mΩ	80mΩ	160mΩ	280mΩ	450mΩ	750mΩ	1150mΩ
TO-220AB	SCT2120AF	—	—	—	—	—	—
TO-247	—	SCH2080KE SCT2080KE	SCT2160KE	SCT2280KE	SCT2450KE	—	—
TO-268-2L	—	—	—	—	—	☆SCT2750NY	☆SCT2H12NY
TO-3PFM	—	—	—	—	—	—	SCT2H12HZ

☆Under development

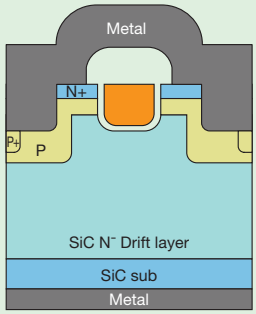
Evolution to the next generation, 3rd-Generation SiC MOSFET

ROHM's 3rd-Generation SiC MOSFET realize the reduction of loss in several kind of application by it's superior characteristics, lower on-resistans and high speed switching performance.

[Planar Structure]
(2nd-Generation)

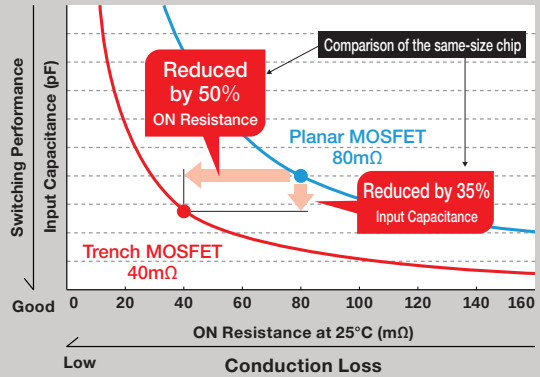


[Trench Structure]
(3rd-Generation)



Enables the development of devices featuring lower conduction loss and superior switching performance.

SiC MOSFET Performance Comparison: Planar vs. Trench

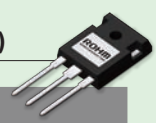


2nd-Generation SiC Planar MOSFET — 3rd-Generation SiC Trench MOSFET

■ Full SiC Power Module

Package	V_{DSS} 1200V	
	R_{DS} (on) 10mΩ	
	I_D 180A	
C type	BSM180D12P3C007	

■ Discrete Lineup (3rd-Generation)



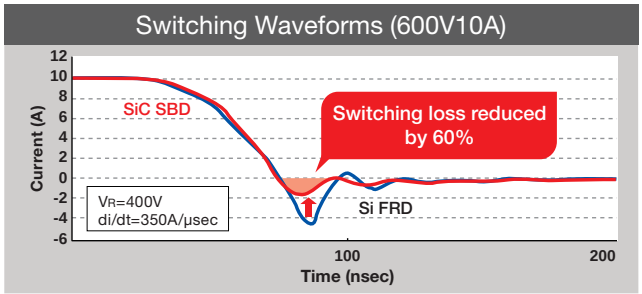
Package	V_{DSS} 650V	1200V		
	R_{DS} (on) 30mΩ	22mΩ	30mΩ	40mΩ
TO-247N	☆SCT3030AL	☆SCT3022KL	☆SCT3030KL	☆SCT3040KL

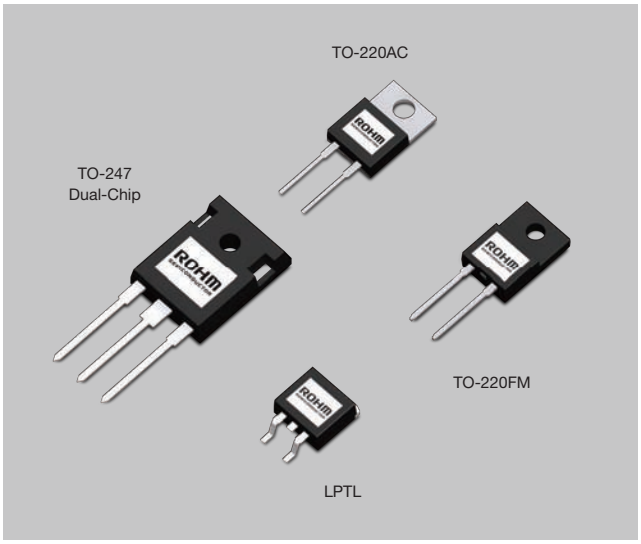
☆Under development

SiC SBD (Schottky Barrier Diodes)

Significantly lower switching loss

SBDs were developed utilizing SiC, making them ideal for PFC circuits and inverters. Ultra-small reverse recovery time (impossible to achieve with silicon FRDs) enables high-speed switching. This minimizes reverse recovery charge (Qrr), reducing switching loss considerably and contributes to end-product miniaturization.

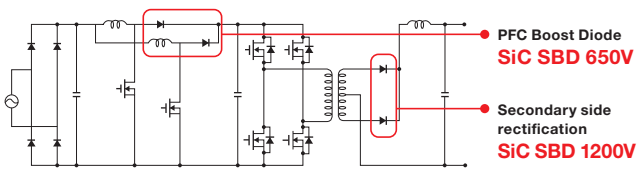




ROHM offers automotive-grade (AEC-Q101 qualified) products.

ROHM SiC SBD have been adopted in a variety of charging circuits in electric/hybrid vehicle.

■ Example: Automotive Charging Circuit



■ Lineup

Package	VRM 650V								1200V					
	IF 6A	8A	10A	12A	15A	20A	30A	40A	5A	10A	15A	20A	30A	40A
TO-220AC	SCS206AG	SCS208AG	SCS210AG	SCS212AG	SCS215AG	SCS220AG	—	—	SCS205KG	SCS210KG	SCS215KG	SCS220KG	—	—
TO-220FM	SCS206AM	SCS208AM	SCS210AM	SCS212AM	SCS215AM	SCS220AM	—	—	—	—	—	—	—	—
TO-247	—	—	—	—	SCS215AE	SCS220AE SCS220AE2	SCS230AE2	SCS240AE2	—	SCS210KE2	—	SCS220KE2	SCS230KE2	SCS240KE2
LPTL	SCS206AJ	SCS208AJ	SCS210AJ	SCS212AJ	SCS215AJ	SCS220AJ	—	—	—	—	—	—	—	—

Automotive grade (AEC-Q101)

Package	VRM 650V								1200V					
	IF 6A	8A	10A	12A	15A	20A	30A	40A	5A	10A	15A	20A	30A	40A
TO-220AC	SCS206AGHR	SCS208AGHR	SCS210AGHR	SCS212AGHR	SCS215AGHR	SCS220AGHR	—	—	SCS205KGHR	SCS210KGHR	SCS215KGHR	SCS220KGHR	—	—
TO-247	—	—	—	—	—	SCS220AE2HR	SCS230AE2HR	SCS240AE2HR	—	SCS210KE2HR	—	SCS220KE2HR	☆SCS230KE2HR	☆SCS240KE2HR
LPTL	SCS206AJHR	SCS208AJHR	SCS210AJHR	SCS212AJHR	SCS215AJHR	SCS220AJHR	—	—	—	—	—	—	—	—

☆Under development

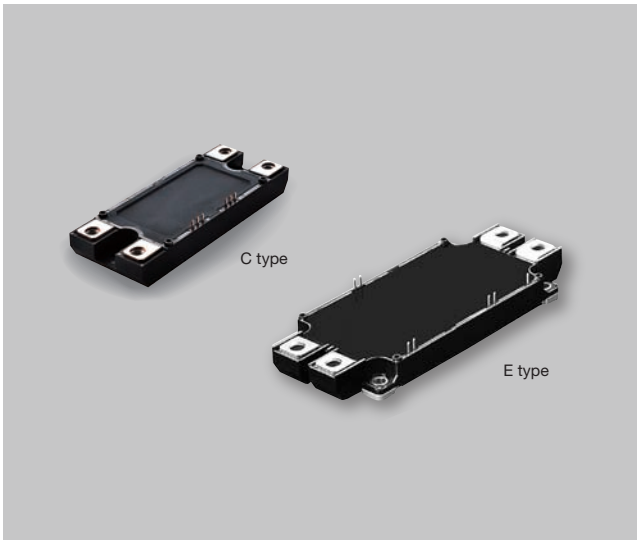
"Full SiC" Power Modules

Switching loss reduced by 85% (Max.)

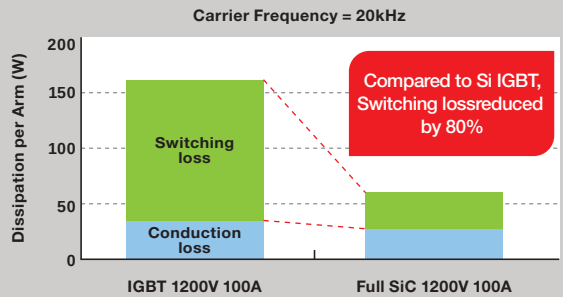
ROHM has developed low-surge-noise power modules integrating SiC devices produced in-house, maximizing high-speed performance. The result is significantly reduced switching loss compared with conventional Si IGBTs.

Features

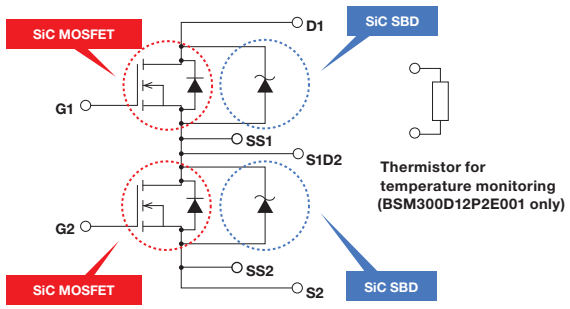
1. **High-speed switching**
2. **Low switching loss**
3. **Fast recovery**



Switching Loss Comparison



■ Internal Circuit Diagram (Half Bridge Circuit)



■ Lineup

Parameter	Symbol	Ratings				Unit
		☆BSM080D12P2C008	BSM120D12P2C005	New BSM300D12P2E001	New BSM180D12P3C007	
Switching Device	—	2nd-Generation SiC MOSFET			3rd-Generation SiC MOSFET	—
Drain-Source Voltage	V_{DSS}	1200	1200	1200	1200	V
Drain Current *1	I_D	80	120	300	180	A
Junction Temperature	Tj	-40 to +175	-40 to +150	-40 to +175	-40 to +175	°C
R_{DS} (on) typ.	—	34	20	7.3	10	mΩ
Package	—	C Type		E Type	C Type	—

☆Under development

*1 Measurement of Tc is to be done at the point just under the chip. Tc=60°C

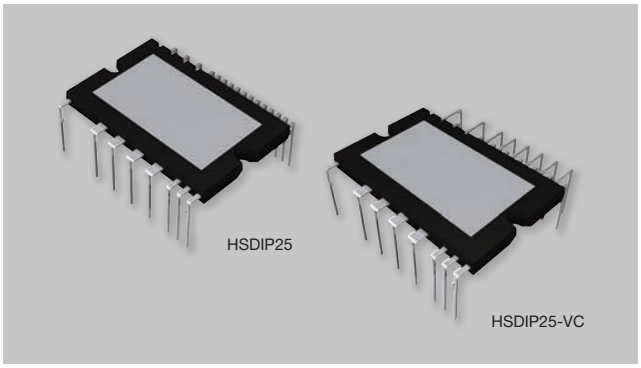
ROHM offers intelligent products ideal for motor control

IPM (Intelligent Power Module)

IGBT-IPM

Motor control is integrated into a single package

All components required for motor control, including the power device control IC and peripheral circuitry, are incorporated into a single package. ROHM utilizes an IGBT-optimized design customized for a range of applications.



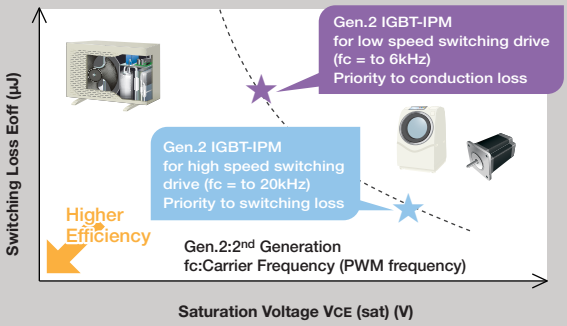
Features

1 **The lineup consists of two series (low-speed/high-speed switching) featuring an IGBT-optimized design that supports a variety or requirements**

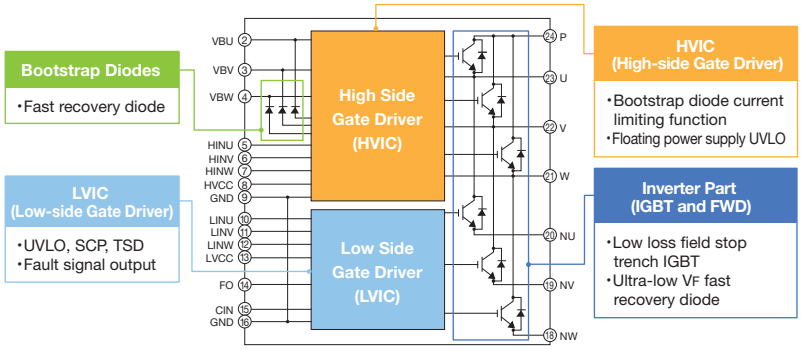
2 **An IGBT, FWD (Free Wheeling Diode), boot-strap diode, and gate driver are integrated into a single package**

3 **Multiple protection circuits (short-circuit current protection, power supply UVLO and thermal shutdown circuits) along with a FAULT signal output function that activates during protection operation**

Adopting an application-specific IGBT results in high-efficiency drive operation



■ Circuit Diagram



Protection Circuit
UVLO : Under Voltage Lock Out
SCP : Short Circuit Protection
TSD : Thermal Shut Down

■ Lineup

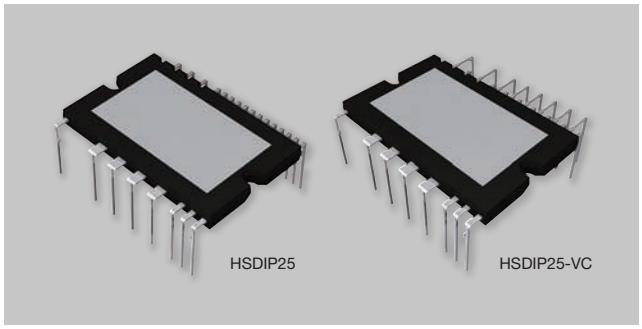
Part No.	Rating	Application
BM63363S-VA / -VC	600V / 10A	Low speed switching fc = to 6kHz
BM63364S-VA / -VC	600V / 15A	
BM63763S-VA / -VC	600V / 10A	High speed switching fc = to 20kHz
BM63764S-VA / -VC	600V / 15A	
☆BM63767A-VA / -VC	600V / 30A	

☆Under development

600V/15A IPM with built-in PrestoMOS™

Contributes to higher efficiency in motor drive devices

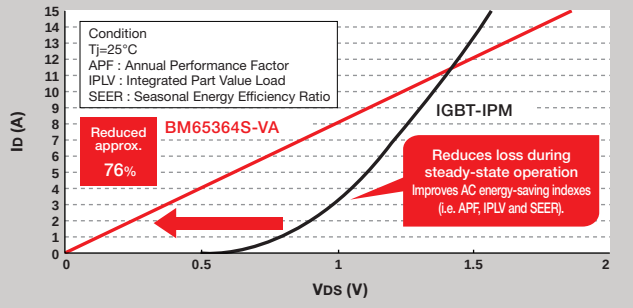
High-efficiency IPM products utilizing ROHM's PrestoMOS™. Compared to IGBT IPM, loss during normal AC operation is reduced significantly.



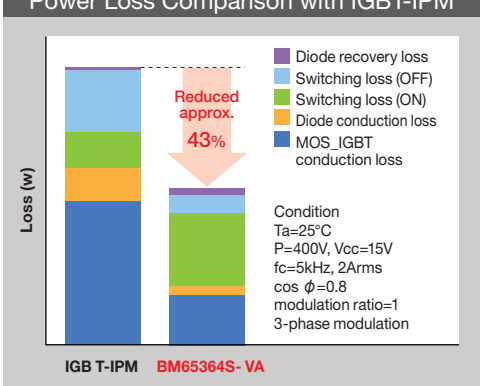
Features

1. **Using a MOSFET device helps improve efficiency during steady state operation**
2. **Integrates a bootstrap diode, Presto MOS™, and gate driver**
3. **Multiple protection circuits (short-circuit current protection, power supply UVLO and thermal shutdown circuits) along with a FAULT signal output function that activates during protection operation**

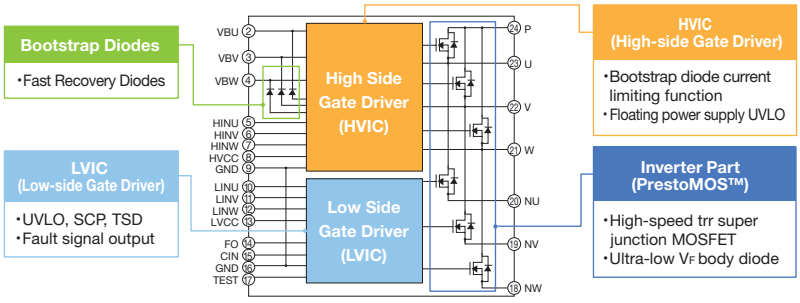
VDS-ID Features



Power Loss Comparison with IGBT-IPM



Circuit Diagram



Protection Circuits UVLO : Under Voltage Lock Out
SCP : Short Circuit Protection TSD : Thermal Shut Down

Lineup

Part No.	Power Device	Rating	Recommended switching frequency
BM65364S-VA / -VC	MOSFET	600V / 15A	fc=to20kHz

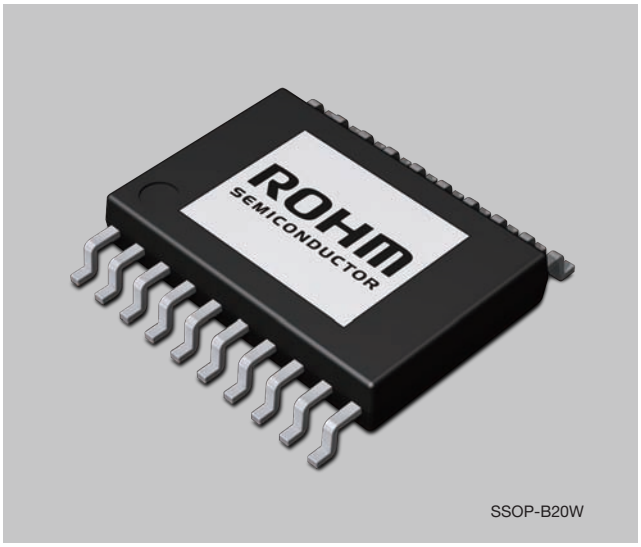
Supports SiC power semiconductors and
contributes to increased adoption

High Withstand Voltage IC

Isolated Gate Driver

High-speed operation supports SiC

- High-speed operation with a Max. I/O delay time of 150ns
- Core-less transformer utilized for 2,500Vrms isolation
- Original noise cancelling technology results in high CMR (Common Mode Rejection).
- Supporting high VGS/negative voltage power supplies* *BM6101FV-C, BM6104FV-C
- Compact package (6.5×8.1×2.01 mm)



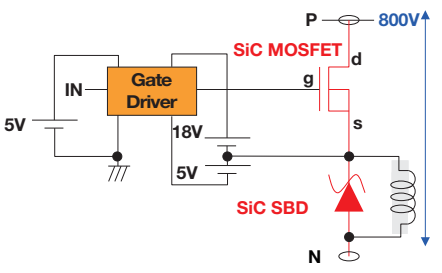
SSOP-B20W

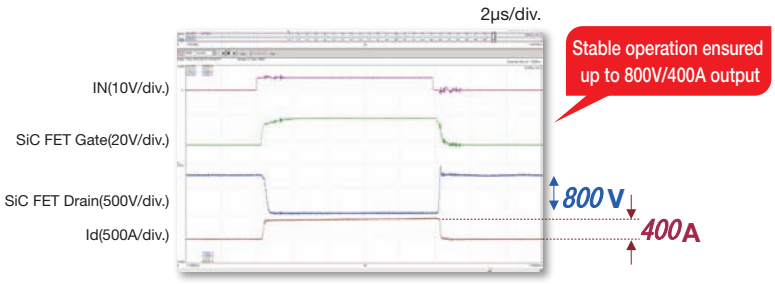
Recommended Operating Range (BM6101FV-C)

Parameter	Symbol	Min.	Max.	Unit
Input Supply Voltage	V_{CC1}	4.5	5.5	V
Output Supply Voltage	V_{CC2}	14	24	V
Output VEE Voltage	V_{EE2}	-12	0	V
Operating Temperature Range	Ta	-40	125	°C

IPM Operating Waveforms (BM6101FV-C)

<Conditions> ROHM SiC IPM V_{CC1}=5.0 V_{CC2}=18V V_{EE2}=-5V V_{PN}=800V Ta=25°C





Lineup

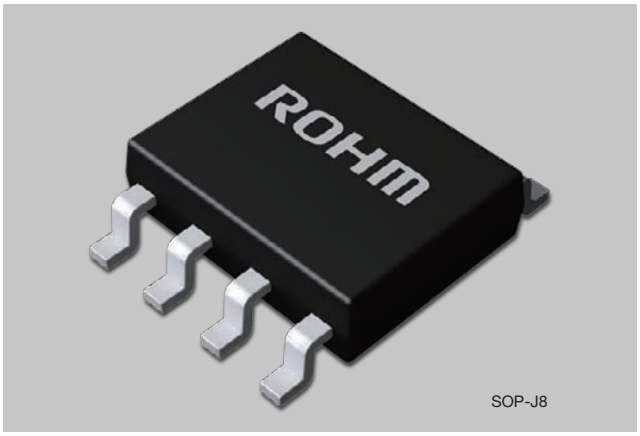
Part No.	Features								
	Rated Output Current (Peak)	Isolation Voltage	Negative Power Supply Compatibility	I/O Delay Time	Over current Detection	DESAT	Mirror Clamp Function	Soft Turn OFF Function	Error Status Output
BM6101FV-C	3.0A	2,500Vrms	✓	350ns	✓	✓	✓	✓	✓
BM6102FV-C	3.0A	2,500Vrms	—	200ns	✓	✓	✓	✓	✓
BM6104FV-C	3.0A	2,500Vrms	✓	150ns	✓	✓	✓	✓	✓

AC/DC Converter

World's first* AC/DC converter control ICs for SiC drive

These ICs make it easy to configure an AC/DC converter with built-in SiC MOSFET that up to now has only been possible using discrete configurations.
The increased proliferation of SiC power devices is expected to provide added value to the AC/DC converter market, which demands increased power savings and miniaturization.

* January 2016 ROHM study



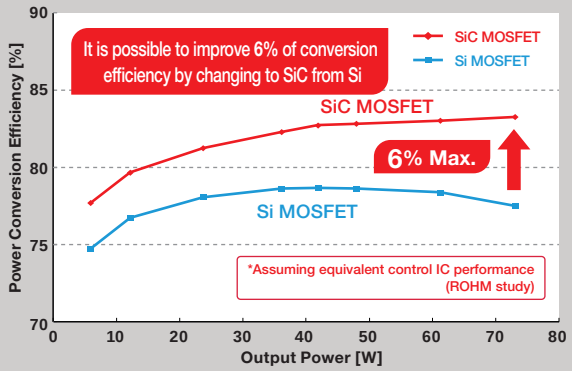
Features

1 **Maximizes SiC MOSFET performance and contributes to dramatically reduced power consumption**

2 **Enabling SiC MOSFET drive allows for greater miniaturization**

3 **Multiple protection functions enable high voltage operation up to 690V AC**

AC/DC Converter Efficiency Comparison: Si vs SiC



Lineup

Part No.	Suppry Voltage	MOSFET	Control Method	Maximum Frequency (kHz)	FBOLP	Brown Out	Vcc OVP	Package
New BD7682FJ-LB	15.0 to 27.5	External	QR	120	Self-restart	✓	Latch	SOP-J8S
New BD7683FJ-LB	15.0 to 27.5	External	QR	120	Latch	✓	Latch	SOP-J8S
New BD7684FJ-LB	15.0 to 27.5	External	QR	120	Self-restart	✓	Self-restart	SOP-J8S
New BD7685FJ-LB	15.0 to 27.5	External	QR	120	Latch	✓	Self-restart	SOP-J8S

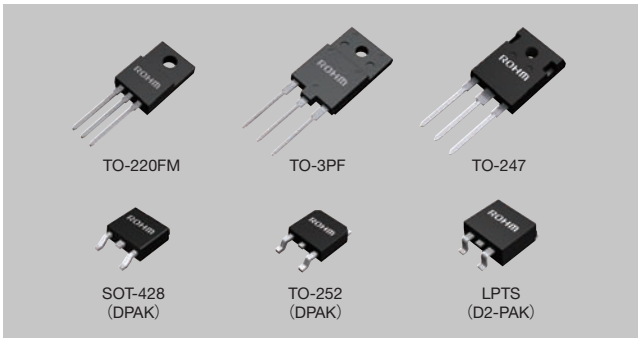
Supports high withstand voltage, high surge circuits

High withstand voltage discretes

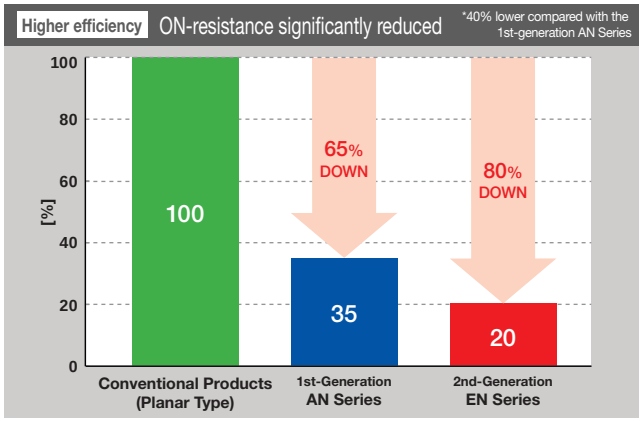
Super Junction MOSFET

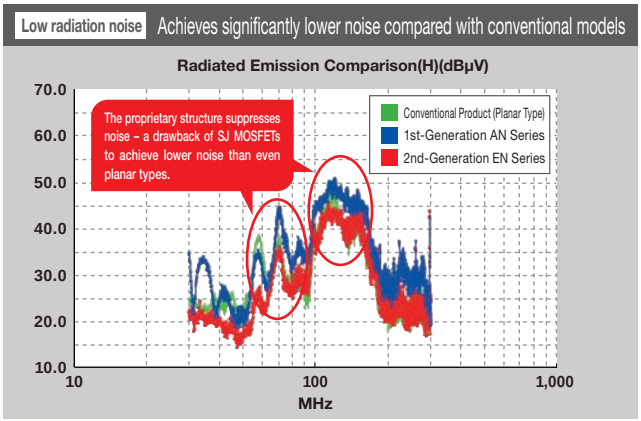
Achieves low noise with low ON resistance

- Industry-leading A·Ron
  (40% lower than conventional products)
- Lineup includes low noise types and fast switching types
- Broad package lineup, from DPAK to TO-247
- Extremely low noise reduces noise countermeasures and makes it easy to replace planar type products



■ Towards lower ON resistance and low noise





■ Lineup

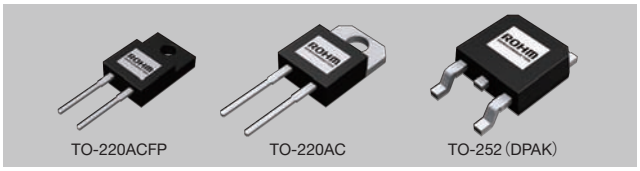
Part No.	BVDSS (V)	ID (A)	RDS(on) (Ω)	Qg (nC)		Package	
				EN Series	KN Series	EN Series	KN Series
R6002ENx/☆R6002KNx	600	1.7	2.8	6.5	4.5	TO252☆	TO252
R6004ENx/☆R6004KNx	600	4	0.9	15	10	TO252☆/LPT/TO220FM	TO252/LPT/TO220FM
R6007ENx/☆R6007KNx	600	7	0.57	20	14	TO252☆/LPT/TO220FM	TO252/LPT/TO220FM
R6009ENx/☆R6009KNx	600	9	0.5	23	16	TO252☆/LPT/TO220FM	TO252/LPT/TO220FM
R6011ENx/☆R6011KNx	600	11	0.34	32	22	TO252☆/LPT/TO220FM	TO252/LPT/TO220FM
R6015ENx/☆R6015KNx	600	15	0.26	40	27	LPT/TO220FM/TO3PF	LPT/TO220FM/TO3PF
R6020ENx/☆R6020KNx	600	20	0.17	60	39	LPT/TO220FM/TO3PF/TO247	LPT/TO220FM/TO3PF/TO247
R6024ENx/☆R6024KNx	600	24	0.15	70	47	LPT/TO220FM/TO3PF/TO247	LPT/TO220FM/TO3PF/TO247
R6030ENx/☆R6030KNx	600	30	0.115	85	57	LPT/TO220FM/TO3PF/TO247	LPT/TO220FM/TO3PF/TO247
R6035ENx/☆R6035KNx	600	35	0.095	110	74	TO3PF/TO247	TO3PF/TO247
R6047ENx/☆R6047KNx	600	47	0.07	145	97	TO247	TO247
R6076ENx/☆R6076KNx	600	76	0.04	260	174	TO247	TO247

The last (8th) character represents the package type D : CPT3(D-Pak), J : LPT(D2-Pak), X : TO220FM, Z : TO3PF, Z1 : TO247, D3 : TO252, D3 : TO252 EN:Low noise type, KN:Fast switching type
☆ : Under Development

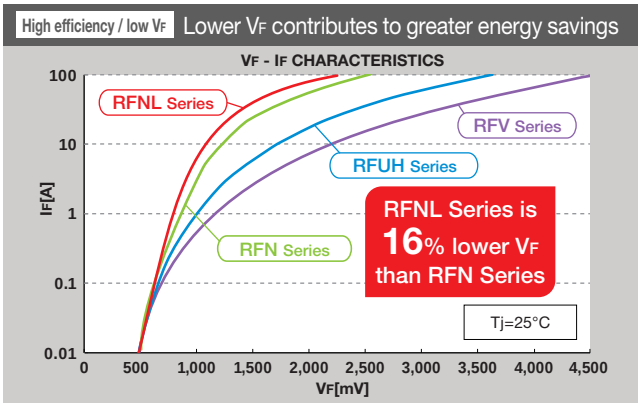
Fast Recovery Diodes

Provides optimized characteristics for each application

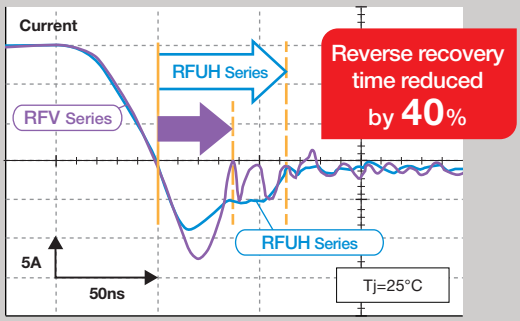
- Ideal for PFC (Power Factor Correction)
- Broad lineup
- Improved characteristics
- Ultra-low V_F units / High-speed trr models



High efficiency / low V_F Lower V_F contributes to greater energy savings



High-speed trr characteristics New processes utilized to achieve ultra-high-speed trr



■ RFNL Series Ultra-low V_F type

Part No.	Absolute Maximum Ratings(Ta=25°C)		Electrical Characteristics(Tj=25°C)			Equivalent Circuit Diagram	Package
	V_R(V)	I_O(A)	V_F(V)Max.	I_F(A)	trr(ns)Max.		
New RFNL5BM6S	600	5	1.3	5	60		TO-252(DPAK)
New RFNL5TJ6S	600	5	1.3	5	60		TO-220ACFP
New RFNL10TJ6S	600	10	1.25	8	65		
			1.3	10			
New RFNL15TJ6S	600	15	1.3	15	65		
New RFNL20TJ6S	600	20	1.3	20	70		

■ RFV Series Ultra-fast trr hard recovery type

Part No.	Absolute Maximum Ratings(Ta=25°C)		Electrical Characteristics(Tj=25°C)			Equivalent Circuit Diagram	Package
	V_R(V)	I_O(A)	V_F(V)Max.	I_F(A)	trr(ns)Max.		
New RFVS8TJ6S	600	8	3.0	8	20		TO-220ACFP
New RFV8TJ6S	600	8	2.8	8	25		
New RFV12TJ6S	600	12	2.8	12	25		
New RFV15TJ6S	600	15	2.8	15	30		
New RFVS8TG6S	600	8	3.0	8	20		TO-220AC
New RFV8TG6S	600	8	2.8	8	25		
New RFV12TG6S	600	12	2.8	12	25		
New RFV15TG6S	600	15	2.8	15	30		

Contributes to greater efficiency and energy savings in a variety of high voltage, large current applications

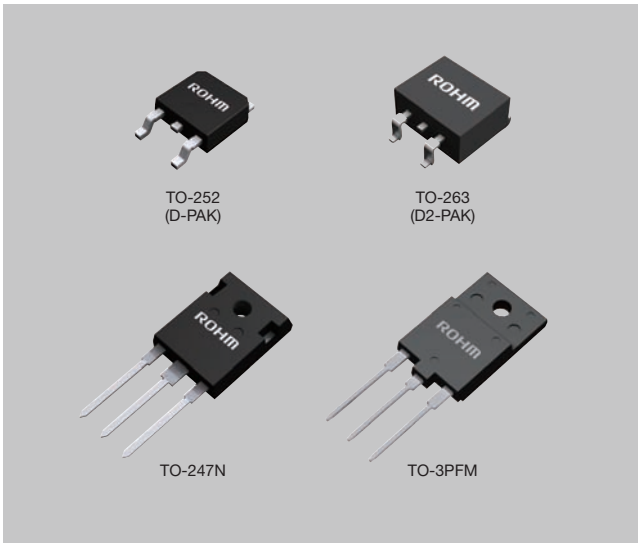
IGBT (Insulated Gate Bipolar Transistor)

Field Stop Trench IGBT

ROHM utilizes original trench gate and thin wafer technologies to achieve low V_{CE} (sat) and reduced switching loss.

Features

1. **Low V_{CE} (sat) & switching loss**
2. **A broad lineup is offered, making it possible to select the ideal solution based on set requirements**
3. **Automotive-grade (AEC-Q101 qualified) RGS Series (Under development)**



■ Application & Lineup

	Standard	V_{CE} (sat)	Switching performance	SC SOA	Lineup
SCSOA (tsc 5μs min) RGT series	–	✓	–	✓ (Recommend) 5μs	650V 4 to 50A@100°C
Low V_{CE} (sat) Series RGCL series	–	✓ (Recommend)	–	–	600V 18 to 40A@100°C
High speed switching type RGTH series	–	✓	✓	–	650V 20 to 50A@100°C
SCSOA (tsc 8μs min) ☆RGS series	AEC-Q101	✓	–	✓ (Recommend) 8μs	650V 30 to 50A@100°C

☆Under development

Ignition IGBT

High reliability products optimized for automotive ignition applications featuring both low V_{CE} (sat) and high avalanche tolerance.

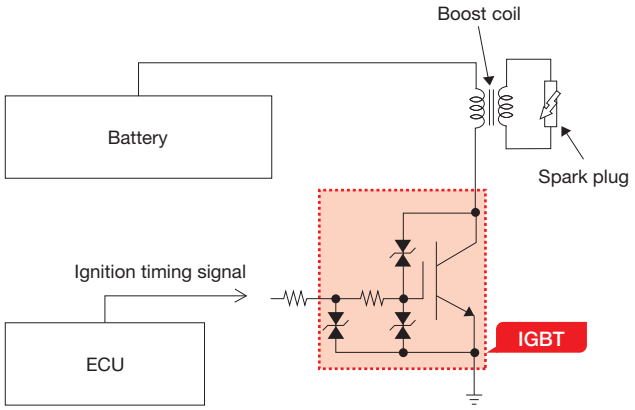
TO-252
(D-PAK)

Features

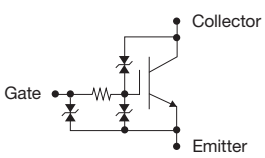
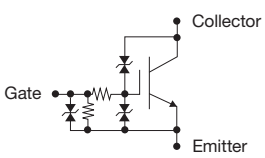
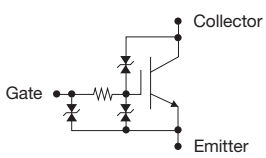
1. **Class-leading efficiency achieved through an optimized tradeoff between $V_{CE(sat)}$ and avalanche tolerance.**
2. **Built-in Gate protection diode**
3. **Gate resistance/Gate-emitter resistance (optional)**
4. **AEC-Q101 qualified**

Internal Circuit Diagram

Ex. Automotive Ignition Coil Drive



Lineup

		RGPZ10BM40FH	RGPR10BM40FH	☆RGPZ20BM56FH
Collector-Emitter Voltage (V)	V_{CES}	430 ± 30	430 ± 30	560 ± 30
Gate-Emitter Voltage (V)	V_{GE}	±10	±10	±10
Collector Current (A)	I_C	20	20	20
Junction Temperature (°C)	Tj	175	175	175
Avalanche Energy (Single Pulse) (mJ)	Eas	250	250	300
Internal Circuit				

☆Under development

A vertically integrated production system ensures high quality and stable supply

A 'Quality First' objective allows ROHM to establish a vertically integrated manufacturing system for SiC production. In addition to acquiring SiCrystal, a German wafer fabrication company in 2009, the ROHM Group continues to implement activities to improve quality throughout the entire manufacturing process, from wafers to packages. World-class manufacturing technologies and stable production capacity provide increased cost competitiveness and ensures a stable, long-term supply of new products.

State-of-the-art package

ROHM provides the latest assembling technologies such as CSP, BGA, COF and stacked package

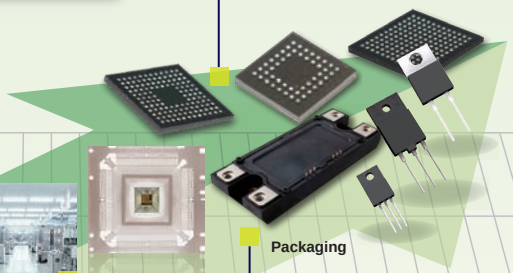
In-house production system

ROHM utilizes an integrated production system developed completely in-house to precisely meet customer needs.

All production equipment are developed in-house

In-house manufactured dies and lead frames

To enhance quality, ROHM manufactures dies to punch lead frames and molding dies within the company.



Packaging

Assembly Line

Frame & Dies

Wafer Process

Stringent material requirements

Complete wafer production, from silicon ingot pulling

Silicon ore

Photo Mask

CAD

Silicon Ingot

Wafer

Silicon
Si

Silicon carbide
SiC

Low inductance moduleA

A low inductance module utilizing SiC's high-speed characteristics was developed

In-house production equipment

High quality, high volume, and stable manufacturing are guaranteed utilizing in-house production equipment.

In-house manufactured photomask

Engineers who know well of devices and processes are in charge of quality control covering from chip design layout to photomask manufacturing consistently to pursue the highest quality products.

SiC processes

High quality lines integrating SiC's unique processes are utilized

SiCrystal AC

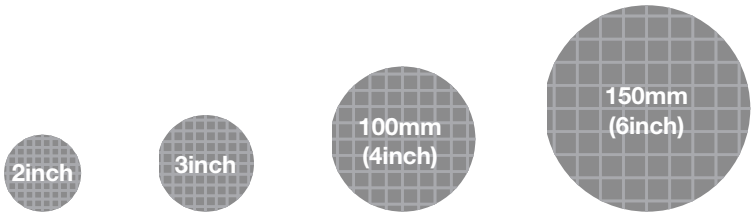
SiCrystal is a German SiC single crystal wafer manufacturer who joined the ROHM Group in 2009.

SiCrystal AG

SiCrystal AG, the largest SiC monocrystal wafer manufacturer in Europe, became a member of the ROHM Group in 2009.
SiCrystal was established in 1997 in Germany based on a SiC monocrystal growth technology development project launched in 1994.
Mass production and supply of SiC wafers began in 2001.
In 2012, SiCrystal relocated to a new plant in Nüremberg to increase production capacity.
With the corporate philosophy "Stable Quality", SiCrystal has adopted an integrated wafer production system from raw SiC material to crystal growth, wafer processing, and inspection, and in 1999 was granted ISO9001 certification.

Acquired ISO9001 Certification

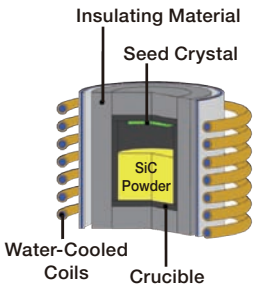
■ Manufactured Product: SiC Wafers



■ SiC Wafer Production

Advanced Crystallization Technology

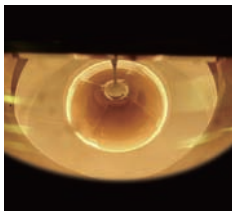
SiC ingots are produced via a crystal growth process utilizing a sublimation method called "Rayleigh's method" that sublimates SiC powder and recrystallizes it under cold temperatures. Compared with conventional Si ingots which are crystalized in the liquid phase from Si melt, the growth rate using the sublimation method is slow, making crystal defects likely to occur, and therefore requires precision technology for crystal control. SiCrystal utilizes advanced crystallization technology to produce stable quality wafers.



For SiC:

Temperature: 2,000 to 2,400°C

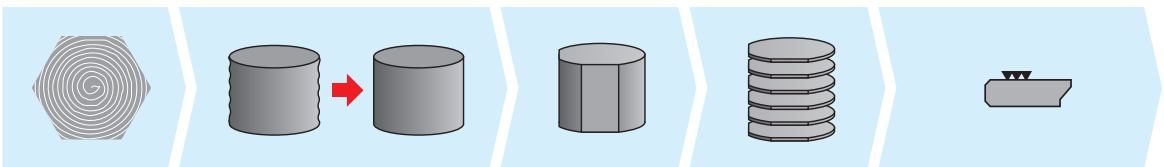
Principle: Transports sublimated gas to the surface of the seed crystal by a heat gradient in order to recrystallize it. Crystal control is difficult and the growth rate is slow compared with liquid phase growth.



For Si:

Temperature: 1,230 to 1,260°C

Principle: Liquid-phase growth during which Si melt is solidified on the seed crystal. This method is characterized by fast crystal growth.



1. Crystal growth
2. External polishing
3. Flat formation
4. Slicing
5. Sanding / Edge polishing / Cleaning

SiC Wafer

Research & Development

State-of-the-art industry-academia R&D collaboration

ROHM is actively involved in partnerships with major universities in a variety of fields in order to share expertise, cultivate new technologies, and collaborate on breakthrough R&D.

Development of mass-produced SiC epitaxialgrowth equipmentIn

Kyoto University × Tokyo Electron × ROHM

3-institution technological collaboration enables rapid development of high-quality SiC devices

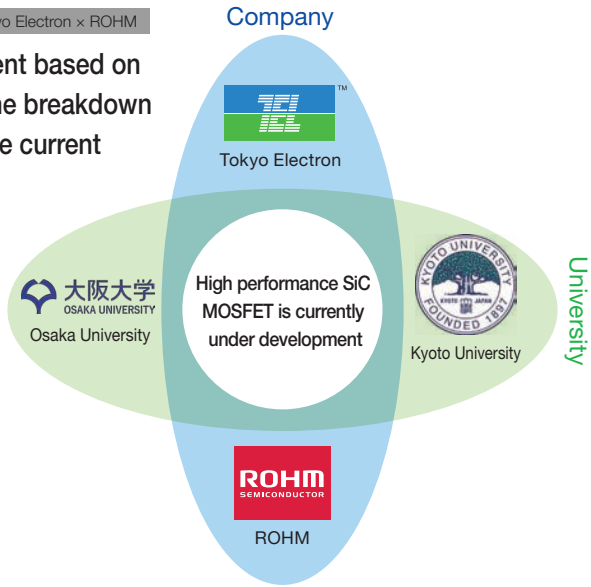
In 2007 ROHM, along with Kyoto University and Tokyo Electron, developed mass production SiC epitaxial growth equipment that can process multiple SiC wafers in a single operation. Fast development was made possible by efficiently sharing technologies. These new equipment are currently used for mass producing ROHM SiC devices.

High performance SiC MOSFET with High-k gate is currently under development

Osaka University × Kyoto University × Tokyo Electron × ROHM

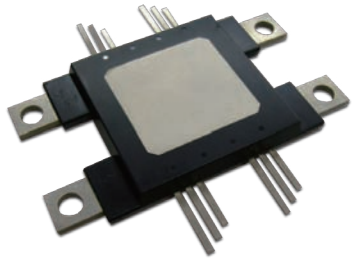
Characteristics improvement based on new materials, 1.5 times the breakdown voltage, 90% lower leakage current

Developed the industry's first SiC Trench MOSFET utilizing an aluminum oxynitride (AlON) layer on the gate insulating film. The result is 1.5x the breakdown voltage and 90% lower leakage current vs. conventional thermally oxidized films (SiO_2). These properties hold promise for higher reliability and lower loss.



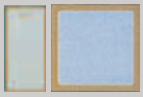
High-temperature (Tj=225°C) packaging technology for transfer-molded modules

ROHM has developed high-temperature SiC power modules for inverter driving in automotive systems and industrial devices. These transfer-molded modules are the first in the world that demonstrated the high temperature operation at 225°C. This enables the compact, low-cost packaging as commonly used in Si device modules, encouraging widely use of SiC module. Modules type is “Full Bridge” featuring 1,200V/300A with 225°C operation.

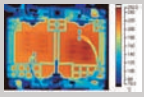


■ Future solutions for high temperature operation

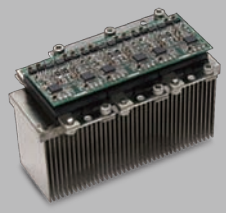
High temperature SiC gate drivers
Gate drivers using SOI wafers are currently under development. They are expected to achieve higher speeds with lower power consumption.



SiC with high temperature operation
Operation at high temperatures above 200°C has been verified. Reliability evaluation is ongoing.



High- temperature packaging technology.
ROHM’s original technology is introduced to the high-temperature packaging for SiC devices.



High-temperature, high-voltage IPM. (Intelligent Power Module)

ROHM’s high-temperature, high-breakdown-voltage SiC devices are inside with advanced high-temperature packaging technology.

Compact High temperature High power High efficiency

New TOPICS

Searching of new application using SiC power devices - High-voltage switching module for pulse generators

ROHM emphasizes search and introduction of new applications using SiC devices in order to widely spread SiC products in the society. As a part of these activities, high-voltage switching modules with SiC devices for pulse generators are proposed. By applying SiC MOSFETs with high voltage, large current and high-speed response, dramatically improvement is expected in pulse generators and end products such as medical-purpose acceleration systems in radiotherapy equipment. In September 2014, “Fukushima SiC Applied Engineering Inc.” was established to manufacturer and sell these SiC electronics products. ROHM joined the incorporation as a business partner to promote new market development.

Introduction of SiC devices to high-voltage switching module for pulse generators

32kV rating switch modules
(Voltage level can be adjusted depending on the number of modules connected in series.)

4 times faster in operation speed, 10 times larger in rating current, over 100 times higher in operation frequency

compared to the conventional switching modules

Various effects are expected for end products as follows;

- **Downsizing of medical-purpose accelerators**
- **Decreasing radiation exposure in X-ray CT**
- **Reducing process time in plasma generators**

Establishment of a joint venture for manufacturing and sales of SiC electronics products

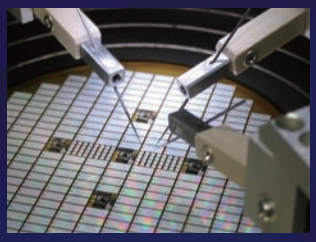
SiC 絆 福島SiC応用技研 株式会社
Fukushima SiC Applied Engineering Inc.

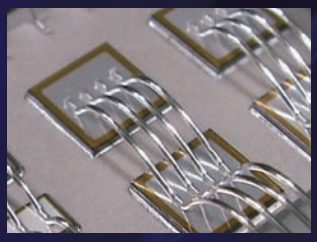
Focusing on cutting-edge SiC technology and leading the industry through innovative R&D

ROHM has been focused on developing SiC for use as a material for next-generation power devices for years, collaborating with universities and end-users in order to cultivate technological know-how and expertise. This culminated in Japan's first mass-produced Schottky barrier diodes in April 2010 and the industry's first commercially available SiC transistors (MOSFET) in December. And in March 2012 ROHM unveiled the industry's first mass production of Full SiC Power Modules.

History

SiC Technology Breakthrough





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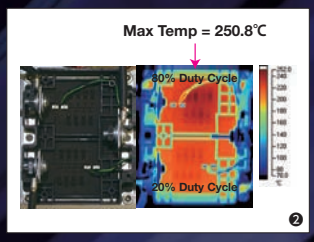

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2002

Begin preliminary experiments with SiC MOSFETs
(Jun 2002)

Develop SiC MOSFET prototypes
(Dec 2004)

2005

Ship SiC MOSFET samples
(Nov 2005)

Announce the development of SiC MOSFETs with the industry's smallest ON-resistance(3.1mΩcm²)
(Mar 2006)

2007

ROHM, along with Kyoto University and Tokyo Electron, announce the development of SiC epi film mass-production technology
(Jun 2007)

Trial manufacture of large current (300A) SiC MOSFETs and SBDs (Schottky Barrier Diodes)
(Dec 2007)

2008

Develop a new type of SiC diode with Nissan Motors
(Apr 2008)

Release trench-type MOSFETs featuring the industry's smallest ON-resistance: 1.7mΩcm²
(Sep 2008)

Nissan Motors conducts a driving experiment of a fuel-cell vehicle equipped with an inverter using ROHM's SiC diode
(Sep 2008)

Honda R&D Co., Ltd. and ROHM test prototype SiC power modules for hybrid vehicles ❶
(Sep 2008)

ROHM tests prototype high temperature operation power modules that utilize SiC elements and introduces a demo capable of operation at 250 °C ❷
(Oct 2008)

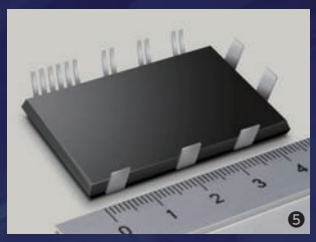
2009

The ROHM Group acquires SiCrystal, an SiC wafer manufacturer ❸
(Jul 2009)

Develop the industry's first high current low resistance SiC trench MOSFET
(Oct 2009)

❸

❹



❺

❻

2010

Establish an integrated SiC device production system. Begin mass production of SiC SBDs ❹
(Apr 2010)

Successfully develop the industry's first SiC power modules containing trench MOSFETs and SBDs that can be integrated into motors
(Oct 2010)

Begin mass production of SiC MOSFETs
(Dec 2010)

2011

Develop the industry's first transfer mold SiC power modules capable of high temperature operation (up to 225°C) ❺
(Oct 2011)

APEI Inc. (Arkansas Power Electronics International) and ROHM develop high-speed, high-current (1000A-class) SiC trench MOS modules
(Oct 2011)

2012

Launch the industry's first mass production of "Full SiC" power modules with SiC SBDs and SiC MOSFETs ❻
(Mar 2012)

Begin mass production of SiC MOS Module
(Dec 2012)History

Started mass production of automotive SiC SBD products
(In September 2012)

2013

Performed a trial production of uninterruptible power supply equipment using full SiC power modules in cooperation with Enegate and Kansai Electric Power
(In June 2013)

2015

Mass-produced SiC-MOSFET using the trench structure first in the world.
Released "Full SiC" power module products
(In June 2015)

SiC is ECO Device

Reducing environmental load

SiC power devices deliver superior energy savings. ROHM is expanding its lineup of SiC power devices with innovative new products that minimize power consumption in order to reduce greenhouse gas emissions and lessen environmental impact.

1) The information contained in this document is provided as of April 1st, 2016.
2) The information contained herein is subject to change without notice. Before you use our Products, please contact our sales representative (as listed below) and verify the latest specifications.
3) Although ROHM is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors. Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. ROHM shall have no responsibility for any damages arising out of the use of our Products beyond the rating specified by ROHM.
4) Examples of application circuits, circuit constants and any other information contained herein are provided only to illustrate the standard usage and operations of the Products.The peripheral conditions must be taken into account when designing circuits for mass production.
5) The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM does not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM or any other parties. ROHM shall have no responsibility whatsoever for any dispute arising out of the use of such technical information.
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