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SiC Schottky Barrier Diodes

SEMICONDUCTOR & STORAGE PRODUCTS

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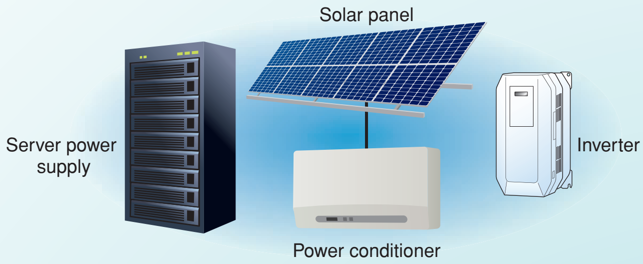
SiC Schottky barrier diodes help reduce the energy consumption and improve the power efficiency of power-hungry equipment.

Due to a major shift in customer focus to environmentally friendly, clean energy sources, market demand is increasing for power devices that will make it possible to achieve low-loss and high-efficiency power conversion. Silicon carbide (SiC), a wide-gap semiconductor, is expected to be a material for the next-generation high-voltage, low-loss power devices because its critical breakdown field is more than eight times that of silicon (Si).

While Si SBDs are available with a V_{RRM} of only up to 200 V, Toshiba's new SiC-based Schottky barrier diodes (SBDs) provide higher reverse voltage (V_{RRM}) because of low leakage current in the high-temperature region.

SiC SBDs are ideal for power conversion applications such as server power supplies and solar power conditioners. At high voltage and high current, the operation of SiC SBDs is more stable than that of the conventional Si SBDs. Therefore, SiC SBDs help to significantly reduce the loss of power through heat.



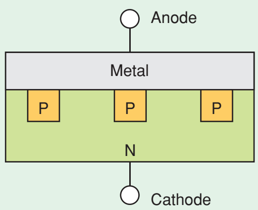
● Physical property comparisons between Si and SiC

Characteristic	Si	SiC(4H)
Band gap	1.12 eV	3.26 eV
Electron mobility μ	1400 cm²/Vs	1000 cm²/Vs
Relative dielectric constant ε	11.8	9.7
Critical breakdown field E	0.3 MV/cm	2.5 MV/cm
Transistor performance limit Ron·A (@600 V)	70 mΩ·cm²	0.14 mΩ·cm²
Features	Easily available Easy to process Inexpensive	Easy to reduce on-resistance Low leakage current at high temperatures Easy to create designs with high withstand voltage

Characteristics of SiC SBDs

Majority carrier device with a Schottky barrier structure

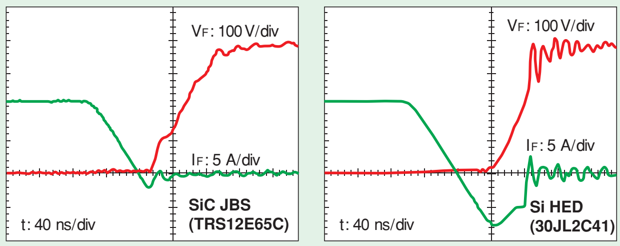
SiC SBDs are majority carrier devices and have the same structure as Si SBDs. Fabricated with a wide-gap semiconductor, SiC SBDs exhibit low leakage current even in the high-temperature region, making it possible to maintain stable operation at high voltage and high current. Toshiba's SiC SBDs have a Junction Barrier Schottky (JBS) structure to further reduce leakage current.



JBS Structure

High-speed switching

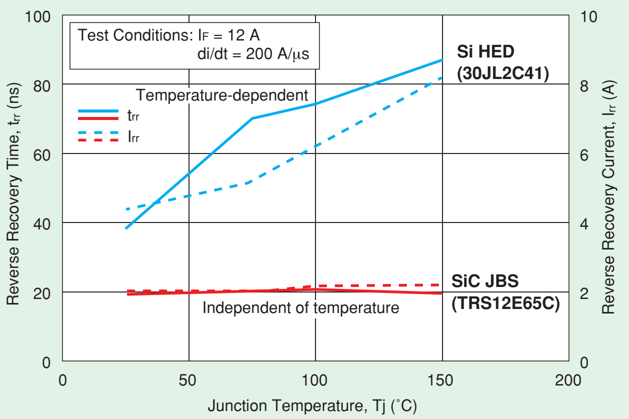
Theoretically, SiC SBDs provide zero reverse recovery time, t_{rr}, because of the Schottky structure and majority carrier operation. In practice, however, SiC SBDs also have a reverse recovery region. Its reverse recovery time, t_{rr}, is as short as 20 ns (at Ta = 25°C), compared with Si high-efficiency diodes (HEDs) with a trr of 40 ns.



Comparison of Reverse Recovery Time, t_{rr}, Between a SiC SBD and a Si HED Diode (Tj = 150˚C)

Recovery characteristics independent of temperature

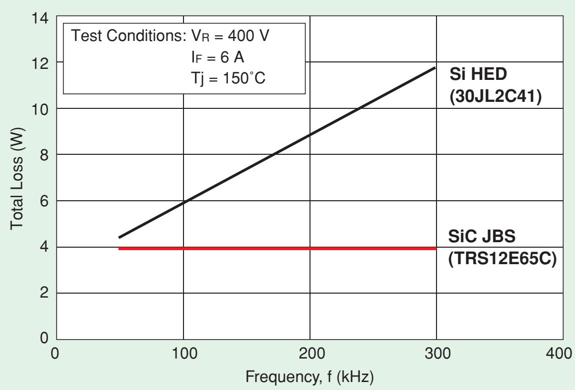
Because SiC SBDs are majority carrier devices, their electrical performance is theoretically independent of temperature. Thus, SiC SBDs exhibit excellent performance even in the high-temperature region.



Reverse Recovery Time (t_{rr})/Reverse Recovery Current (I_{rr}) vs. Temperature

Lower total loss than Si HEDs (as tested by Toshiba)

SiC SBDs offer low total loss, which consists of conduction loss and switching loss. Therefore, SiC SBDs can switch at high frequencies, making it possible to reduce the size of power supplies.



Total Loss vs. Frequency

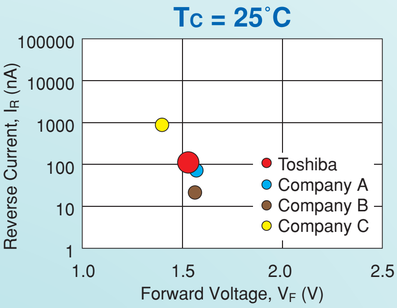
* HED: High-Efficiency Diodes

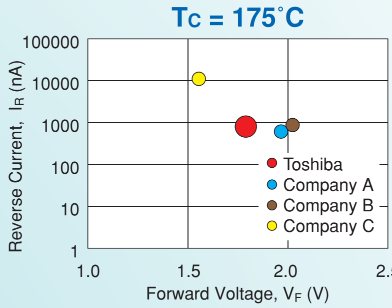
Toshiba's Schottky Barrier Diodes

Feature 1 Outstanding V_F-I_R trade-offs at high temperatures

There is a trade-off between the forward voltage (V_F) and reverse current (I_R) of an SBD.

Toshiba is endeavoring to improve the V_F-I_R trade-off by optimizing the device structure. Our SiC SBDs exhibit low loss even in the high-temperature region and thus help reduce power loss.



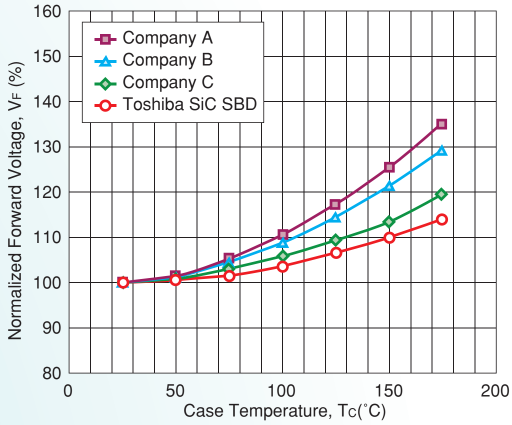


Test Conditions: V_R = 600 V
I_F = Rated current

V_F – I_R Trade-offs at Tc = 25°C and 175°C

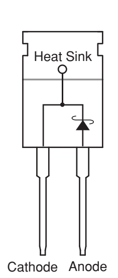
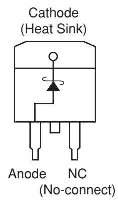
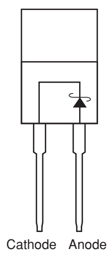
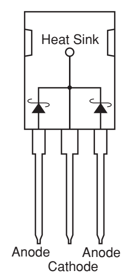
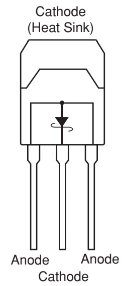
Feature 2 Low V_F temperature coefficient

Toshiba's SiC SBDs have low dependence on forward voltage, V_F, making it possible to reduce conduction loss in the high-temperature region.



Forward Voltage (V_F) vs. Temperature

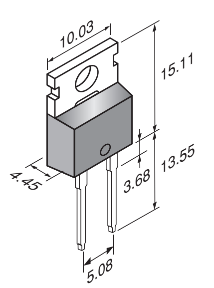
650/1200-V SiC SBD Lineup

Absolute Maximum Ratings		Electrical Characteristics (Ta=25˚C)					TO-220-2L	D2PAK	TO-220F-2L	TO-247	TO-3P(N)
V_{RRM} (V)	I_F (A)	V_F (V)			I_R (μA)						
		Typ.	Max	Test Conditions @I_F (A)	Max	Test Conditions @V_R (V)					
650	6	1.5	1.7	6	90	650	**TRS6E65C**	**TRS6G65C****	**TRS6A65C**		
	8	1.5	1.7	8	90	650	**TRS8E65C**	**TRS8G65C****	**TRS8A65C**		
	10	1.5	1.7	10	90	650	**TRS10E65C**	**TRS10G65C****	**TRS10A65C**		
	12	1.54	1.7	12	90	650	**TRS12E65C**	**TRS12G65C****	**TRS12A65C**	**TRS12N65D**	
	16	1.5	1.7	16	90	650			**TRS16A65C****	**TRS16N65D**	
	20	1.5	1.7	20	90	650				**TRS20N65D**	
	24	1.54	1.7	24	90	650				**TRS24N65D**	
1200	20	1.5	1.7	20	100	1200					**TRS20J120C**

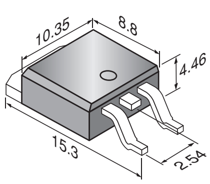
**: Under Development

Packaging

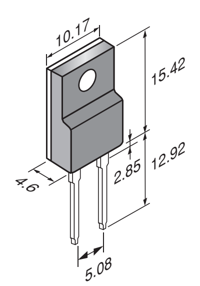
TO-220-2L



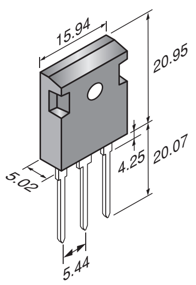
D2PAK



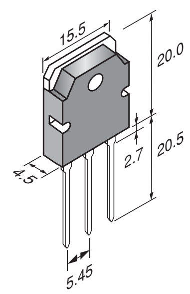
TO-220F-2L



TO-247



TO-3P(N)



Sep. 2014

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