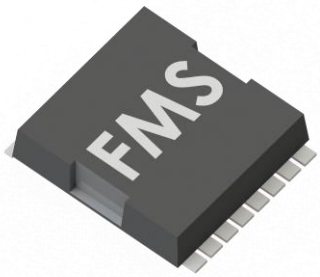
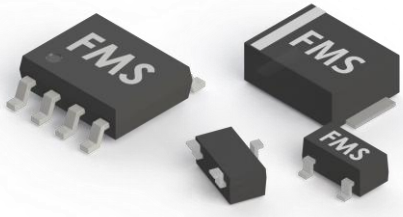
2024

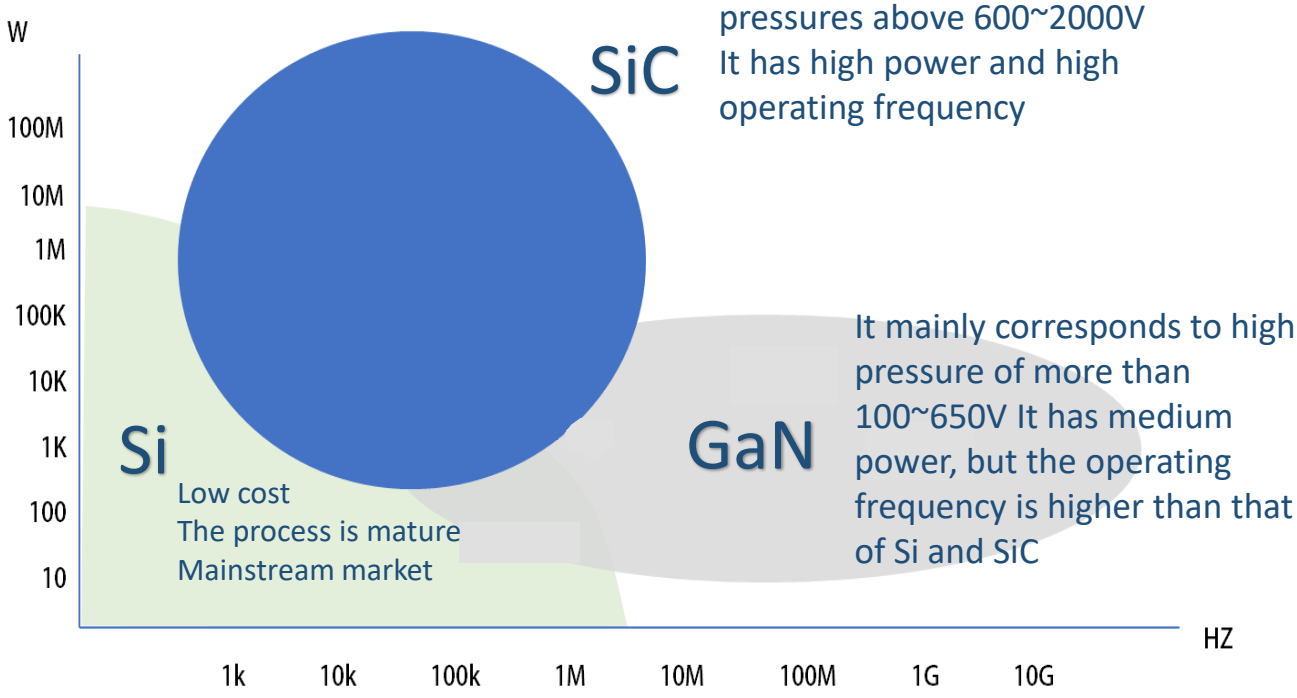
Introduction to SiC components

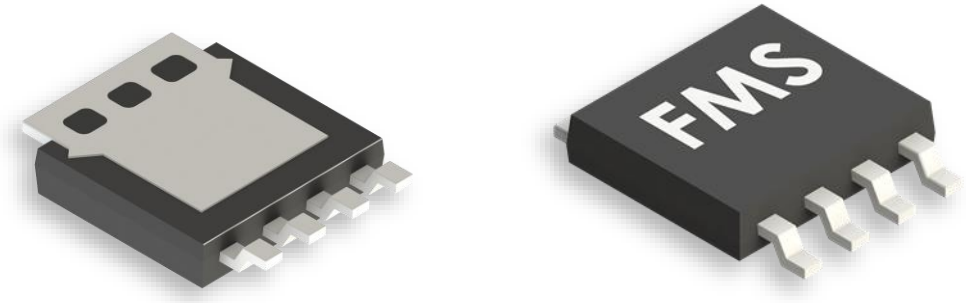
1. SiC Diode
2. SiC MOSFET





Features of SiC MOSFETs





SiC diodes

The reasons for choosing SiC Diode

1. Suitable for high voltage applications
2. Suitable for high temperature applications
3. Extremely fast switching speeds
4. Total power consumption is lower than Si Diode
5. Smaller EMI
6. Avoid thermal run away
7. Reduced substrate usage in high-speed applications
8. Reduced size of peripheral parts for high-speed applications

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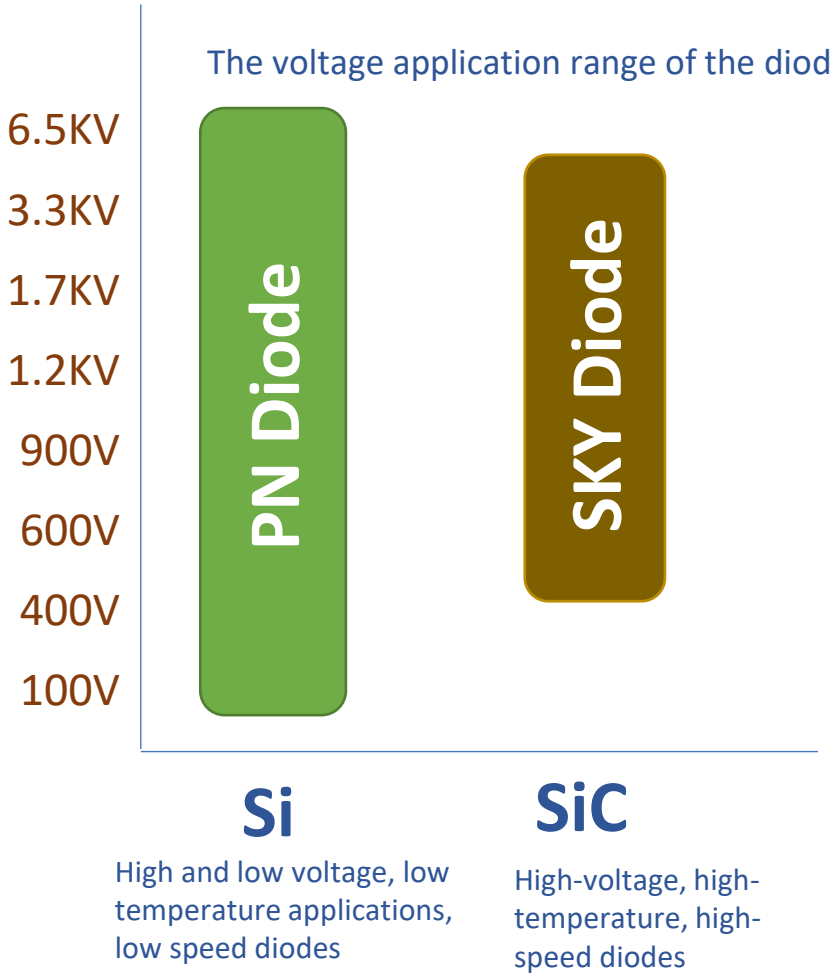
1. Suitable for high voltage applications
2. Suitable for high temperature applications

Sic and Si material properties

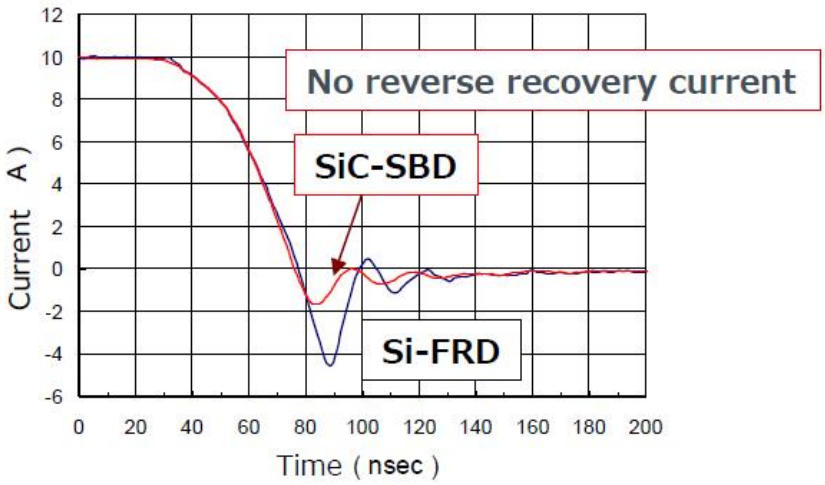
Parameter	Si	SiC	Component characteristics
Energy Gap : EG (eV)	1.12	3.26	high temp. operation Voltage
Breakdown Field : EB (V/cm) x106	0.3	3	Power devices
Thermal Conductivity (W/cmK)	1.5	4.9	High heat dissipation
Saturation Drift Velocity : vS (cm/s)x107	1	2.7	High frequency devices

Due to the differences in the above materials, the parameters between the components are different
Because of the high energy gap of SiC components, it is not easy for atoms to be pulled out by external forces at high pressure.
It is not easy to rise atoms at high temperatures, so it is very suitable for high-voltage power supplies
The operation of automotive electronic circuits at high temperatures.

SiC diodes

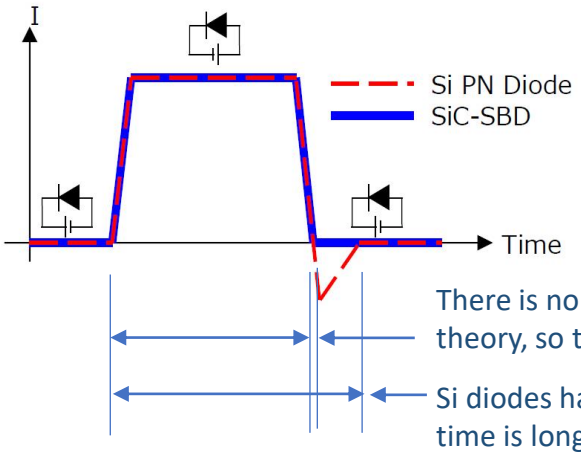


3. SiC has extremely fast switching speeds, mainly because of Trr



SiC diodes

4. The total power consumption of SiC diodes is lower than that of Si diodes

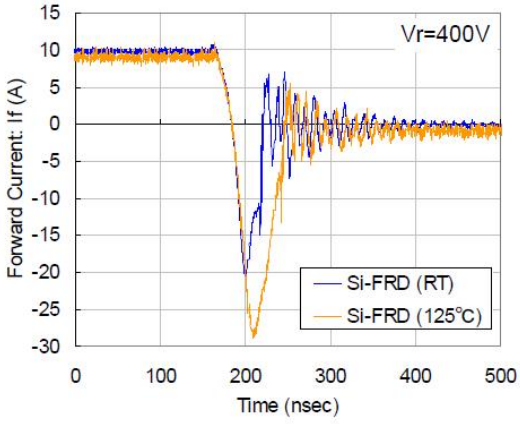


There is no trr in SiC diode management theory, so the switching speed is faster

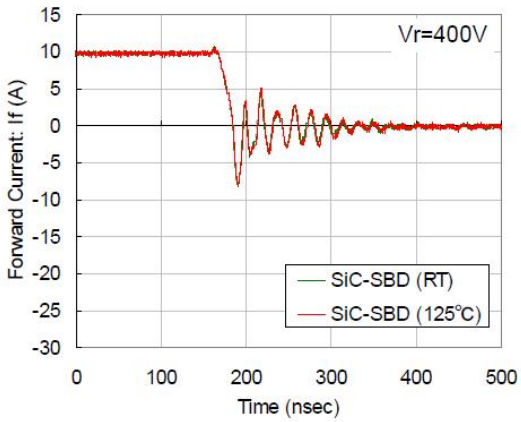
Si diodes have trr, so the switching speed time is longer

Si diodes have a slower switching speed due to the large trr, and the overall power is caused during the trr It is not conducive to the power consumption of the power supply line. On the contrary, SiC diodes because The TRR is very small, so it stands out in terms of power performance. And in different conditions (voltage & temperature), the trr of the SiC diode has stable performance, which is in the stability design of the power supply circuit is very important

Si diodes

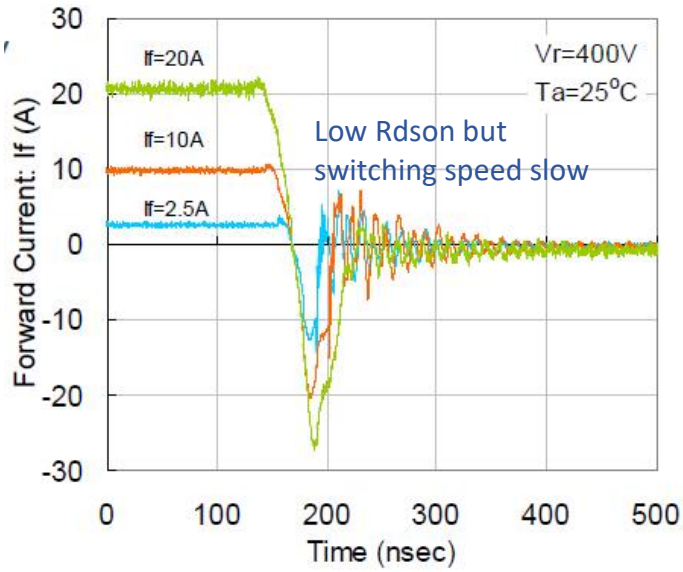


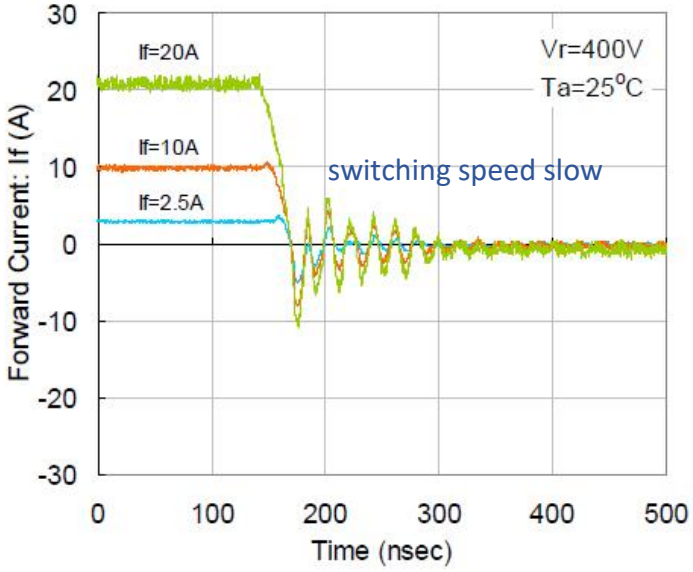
SiC diodes



The Trr of SiC diodes is almost unchanged at different temperatures, which isThe operation of components under high temperature and high speed has stable performance and excellent reliability.

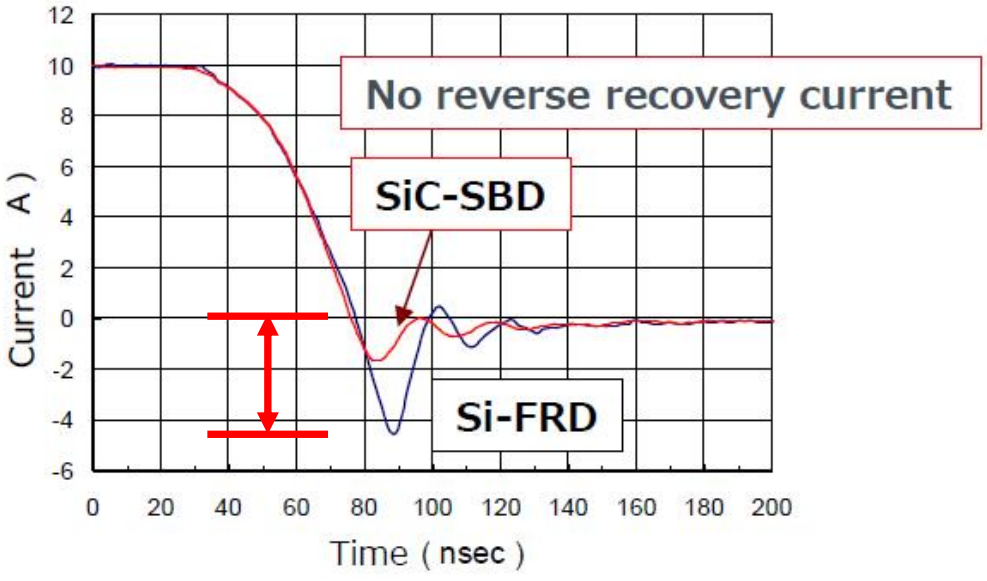
SiC diodes





The Trr of SiC diodes is almost unchanged under different operating currents, which is suitable for large load changes.products can reduce switching losses and total power losses

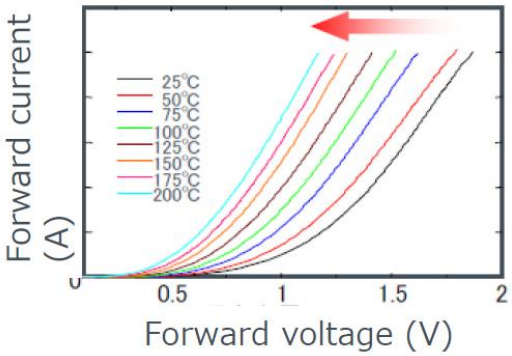
5. SiC has a smaller EMI



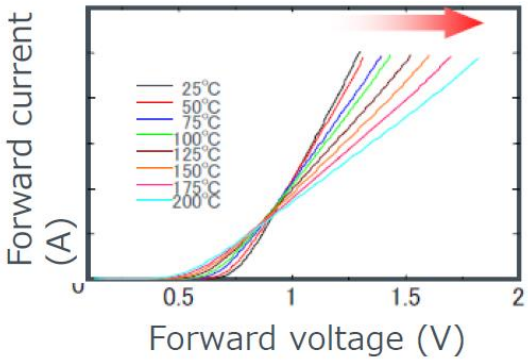
SiC diodes have a smaller Trr value and a smaller depth of reverse current during Trr, resulting in lower noise and easier EMI certification testing

SiC diodes

6. Avoid thermal run away



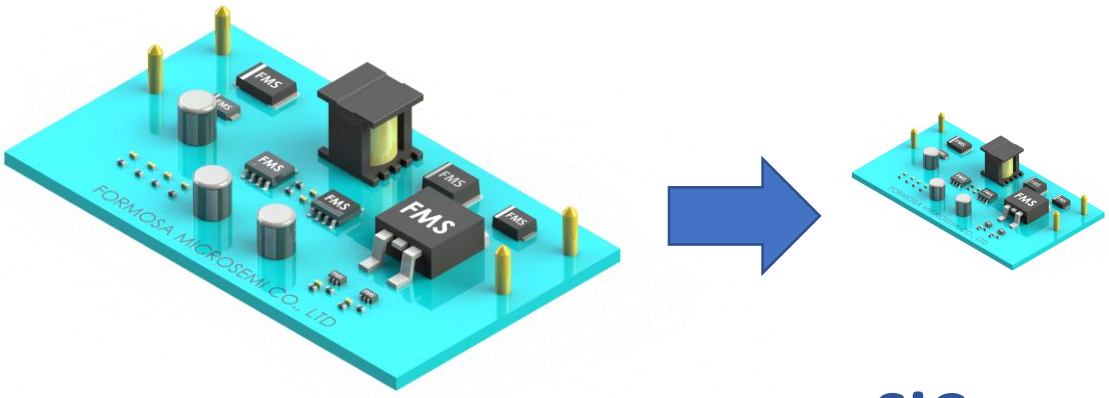
The higher the temperature of the Si diode, the VF value will decrease, which is easy to cause the diode to enter the hot rabbit phenomenon, resulting in the diode burning



The higher the temperature of the SiC diode, the VF value will increase. This will eliminate the phenomenon of thermal degeneration of the diode, thus causing SiCDiodes are well suited to operating at high temperatures

7. SiC reduces substrate usage in high-speed applications

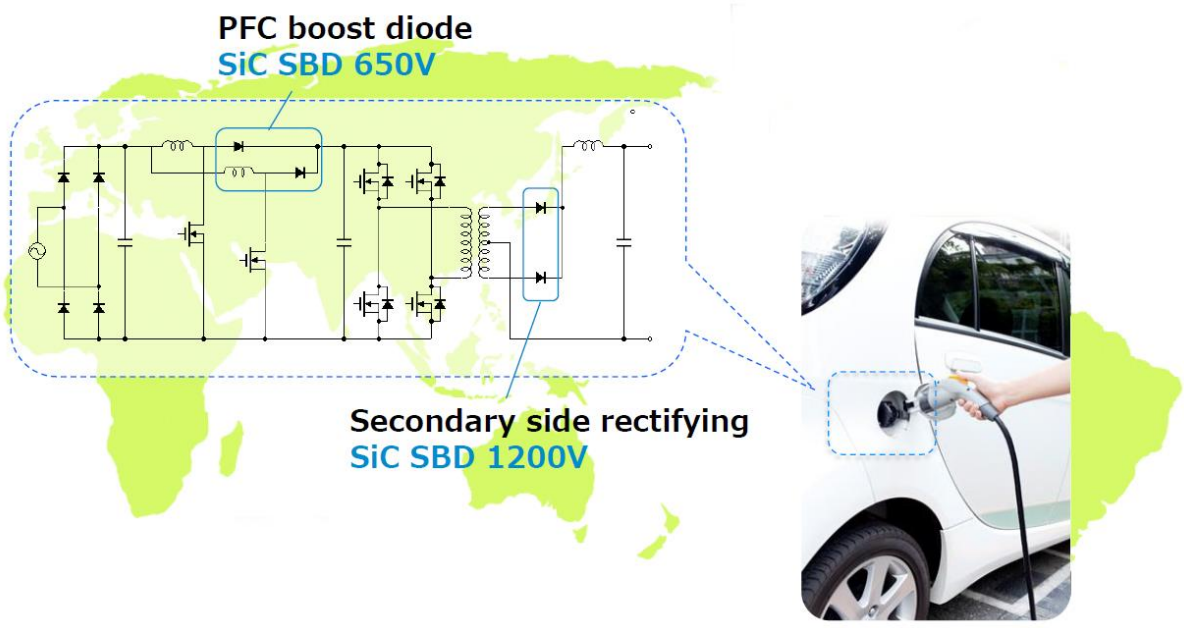
8. SiC reduces the size of peripheral parts in high-speed applications



Si **SiC**

With the same output power, the size of both the substrate and the parts is reduced due to the use of high-speed conversion SiC diodes

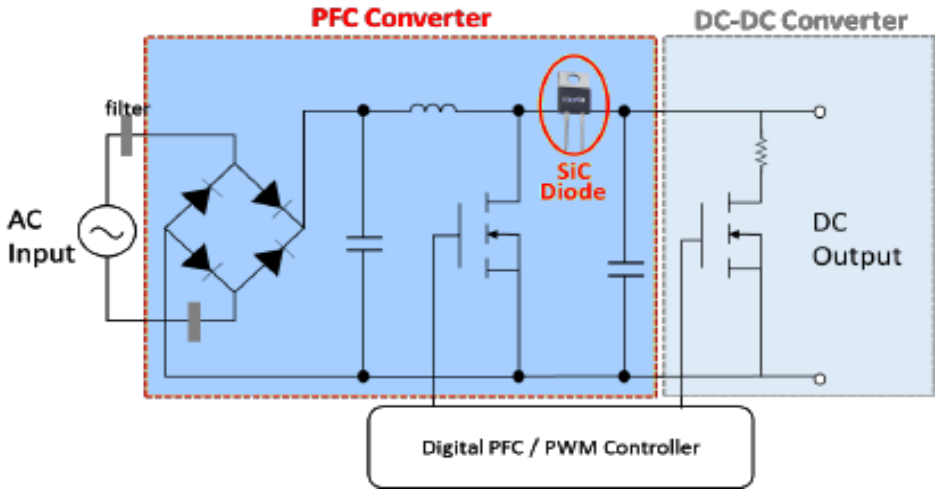
SiC diodes



SiC diodes are used in high-voltage and high-temperature automotive environments

SiC Schottky diodes are used in PFC circuits:

- Improve system efficiency
  - Replacing silicon-based diodes with SiC diodes can immediately improve system efficiency
- Reduce system size
  - The use of SiC diode designs can increase the system frequency, thereby increasing the system power density and decreasing the correlation
  For example, the volume of capacitance and inductance
- Improve EMI
  - SiC diodes have virtually no reverse recovery current, reducing electromagnetic interference.



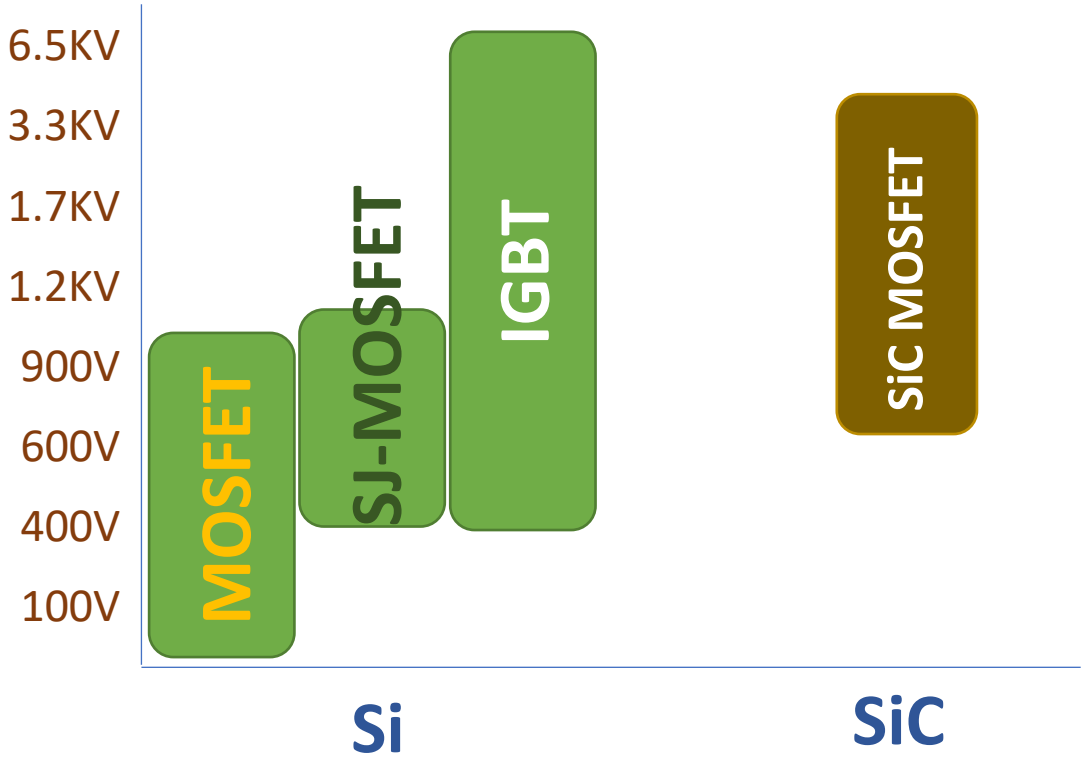
List of SiC diodes

Part Number	Package	IF1 (A)	IF1@TC1(℃)	IF2 (A)	IF2@TC2(℃)	IF3 (A)	IF3@TC3(℃)	VR (V)	IFSM (A)	VR(V)	RθJC Typ.(℃/W)
SCSB10A650A	TO-220AC	38	25	19	135	10	158	650	86	650	1
SCSB10A650D	TO-247AC	-	25	15	135	10	155	650	90	650	0.9
SCSB10A650E	TO-252	29	25	14.5	135	10	153	650	85	650	1.16
SCSB10A650J	TO-263	29	25	14.5	135	10	153	650	85	650	1.16
SCSB2A650E	TO-252	8	25	4	135	2	161	650	20	650	3.8
SCSB3A650A	TO-220AC	11	25	5	135	3	158	650	30	650	3.2
SCSB3A650E	TO-252	11	25	5	135	3	158	650	30	650	3.2
SCSB3A650J	TO-263	11	25	5	135	3	158	650	30	650	3.2
SCSB4A650A	TO-220AC	13	25	6	135	4	158	650	40	650	2.9
SCSB4A650E	TO-252	-	25	8	135	4	160	650	32	650	2.5
SCSB4A650F	ITO-220AC	11	25	4.9	135	4	141	650	36	650	4.9
SCSB4A650J	TO-263	13	25	6	135	4	155	650	40	650	2.7
SCSB501200WT	TO-247	-	-	50	112	-	-	1200	275	1200	0.36
SCSB6A650A	TO-220AC	19	25	9	135	6	158	650	60	650	1.6
SCSB6A650E	TO-252	19	25	9	135	6	155	650	60	650	1.6
SCSB6A650F	ITO-220AC	13	25	6	135	-	-	650	54	650	3.6
SCSB6A650J	TO-263	19	25	9	135	6	155	650	60	650	1.6
SCSB8A650	TO-220AC	24	25	11	135	8	152	650	71	650	1.4
SCSB8A650A	TO-220AC	24	25	11	135	8	158	650	72	650	1.4
SCSB8A650E	TO-252	24	25	11	135	8	153	650	72	650	1.4
SCSB8A650F	ITO-220AC	20	25	8	128	-	-	650	70	650	3.3
SCSB8A650J	TO-263	24	25	11	135	8	153	650	72	650	1.4
SCSB9A650F	ITO-220AC	18	25	10	123	9	135	650	86	650	3

SiC MOSFET

Reasons to choose a SiC MOSFET

1. Suitable for high voltage applications
2. Suitable for high temperature applications
3. Extremely fast switching speeds
4. Total power consumption is lower than Si MOSFET
5. Smaller EMI
6. Avoid thermal run away
7. Reduced substrate usage in high-speed applications
8. Reduced size of peripheral parts for high-speed applications

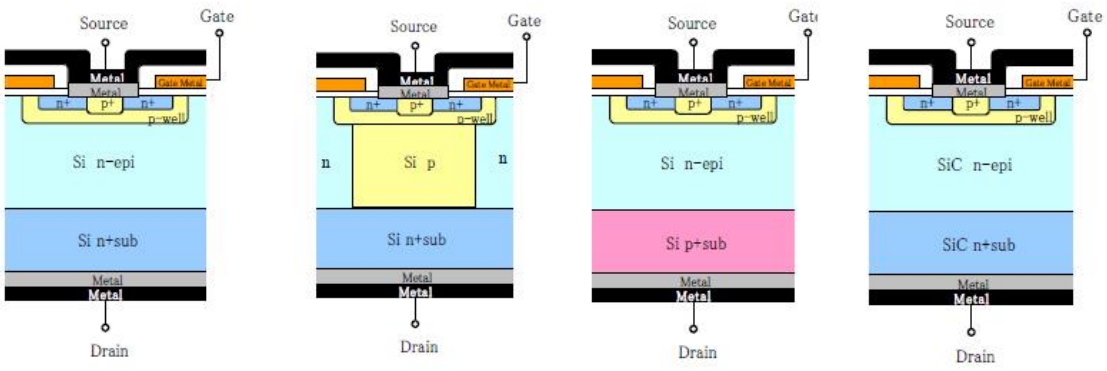


1.Si MOSFET has a low on-resistance but the withstand voltage is not high, and the speed is slow.
2. Si MOSFET has a high withstand voltage but high on-resistance and slow speed.

SiC MOSFET On-resistance, withstand voltage and speed Excellent performance, but no low-voltage products.

SiC MOSFET

1. **SiC is suitable for high voltage applications**
2. **SiC is suitable for high-temperature applications**
3. **SiC extremely fast switching speed**



Si-DMOS	SJ-MOS	IGBT	SiC-MOS
Bvdss	Bvdss	Bvdss	Bvdss
RDSON SPEED	RDSON SPEED	RDSON SPEED	RDSON SPEED

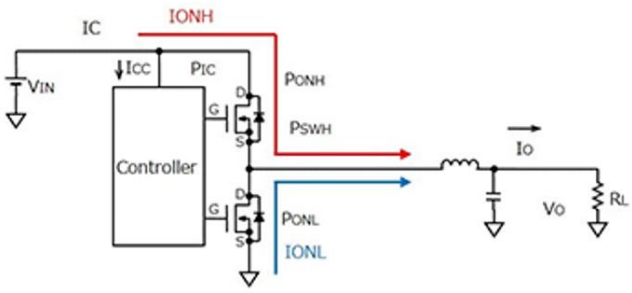
Comparison of the characteristics of various MOSFETs

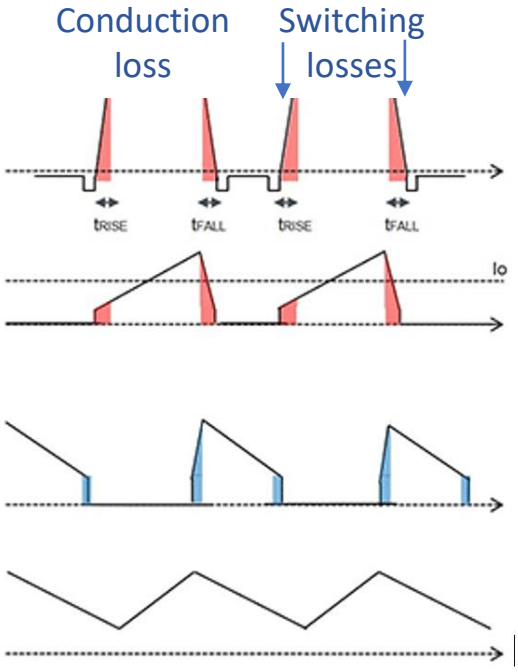
SiC MOSFET

4. SiC total power consumption is lower than Si MOSFET

Total power loss = conduction loss power + switching loss power
Conduction loss power=I_O^2 X R_{DSON}
Please refer to the following example for switching loss.

Switching loss calculations





$$P_{SWH} = 0.5 \times V_{IN} \times I_O \times (t_{RISE} + t_{FALL}) \times f_{SW} \text{ (W)}$$

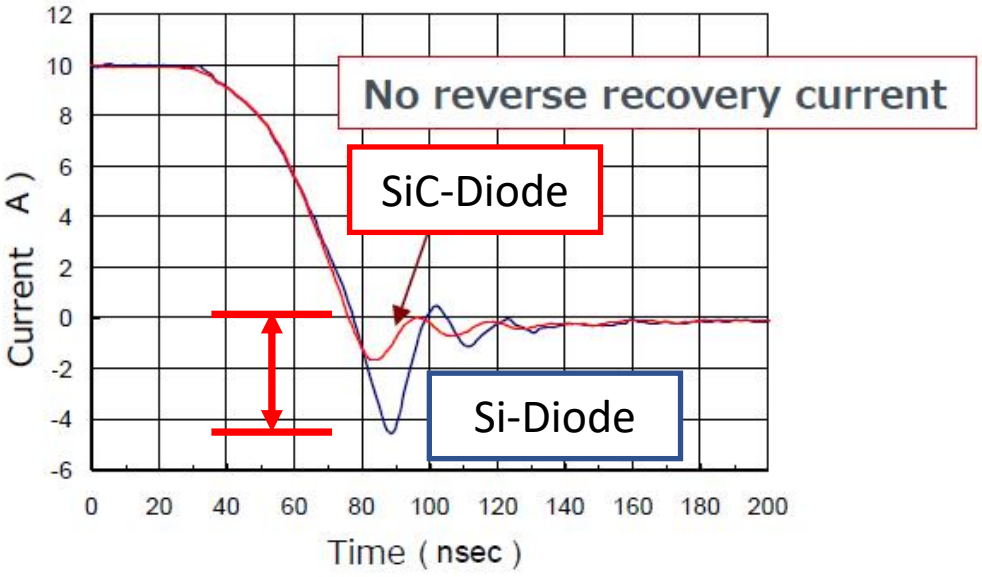
TRISE: rise time of switching voltage
TFALL: the falling time of the switching voltage
Io: load current
VIN:Input voltage
Vo:Output Voltage
fsw:Operating frequency

	VDS(V)	ID	Td(on)nS	Tr(on)nS	Td(off)nS	Tr(off)nS	f kHZ	dissipation power(W)
SiC-MOSFET	650	6A	5.3	5.3	7.3	13	100	6.0255
MOSFET	650	6A	9	8	40	10	100	13.065

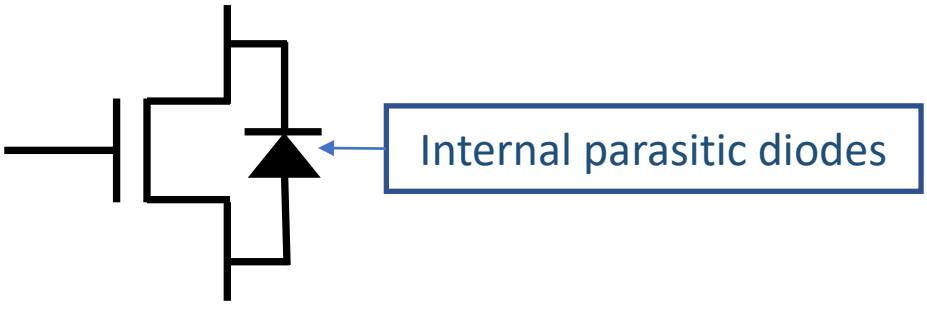
Important parameters for switching loss are tRISE and tFALL
tRISE=Td(on) + Tr(on)
tFALL=Td(oFF) + Tr(oFF)
Td(on)&Tr(on)➔Ciss relevancy
Td(oFF)➔Coss relevancy
Operating frequency➔Cdg relevancy

SiC saves 7W of power

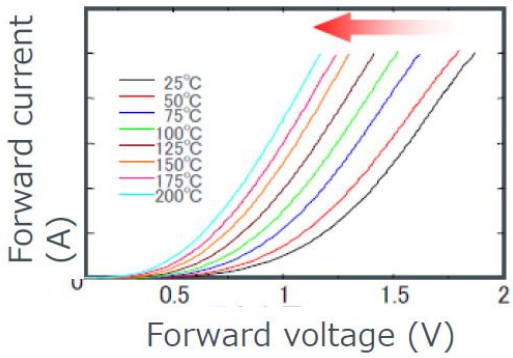
5. SiC MOSFET has smaller EMI than Si MOSFET



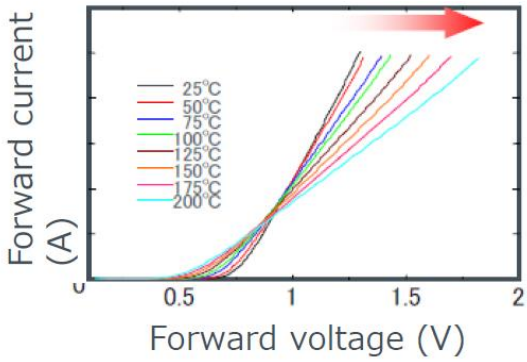
The internal parasitic diode of SiC MOSFET has a smaller Trr value, so it causes lower noise and is easier to pass EMI certification testing.



6. SiC MOSFET Avoid thermal run away

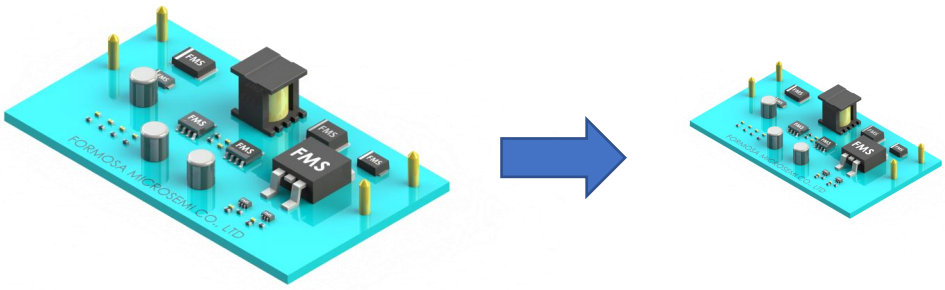


The higher the temperature of Si MOSFET parasitic diode, the VF value will decrease, which may easily cause the diode to enter thermal run away and cause the Si mosfet to burn out.



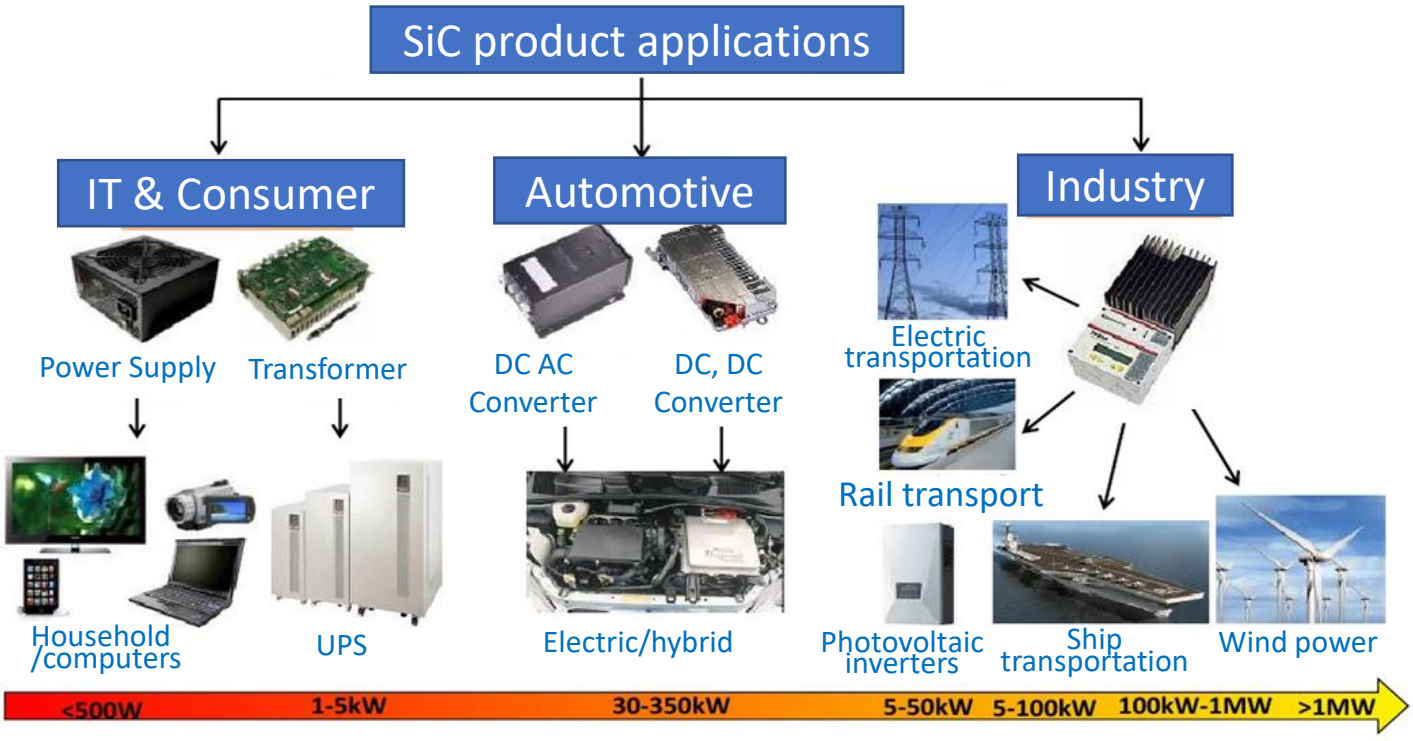
SiC MOSFET parasitic diode The higher the temperature, the VF value will increase, which does not exist the SiC MOSFET thermal run away , thus making the SiC MOSFET extremely suitable for operation at high temperatures

7. Reduced substrate usage for high-speed applications of SiC MOSFETs
8. Reducing the size of peripheral parts for high-speed applications of SiC MOSFETs



Same output power, both substrate and parts can be reduced in size due to the use of high-speed switching SiC MOSFETs

美麗微半導體股份有限公司
FORMOSA MICROSEMI CO., LTD

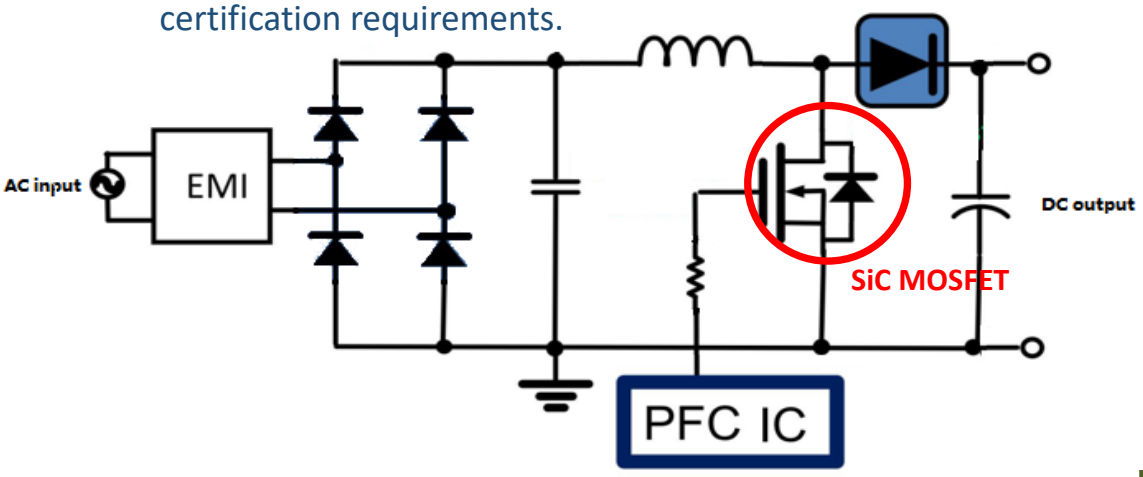


List of SiC MOSFETs

FMS P/N	FMS Package	規格												
		ESD	BVDSS	ID	PD	VGS(th)			RDSON1(Ω)				Ciss Typ.(pF)	Qg Typ.(nC)
			(V	(A	(W	MIN	MAX	ID(m	Typ	Ma	VGS	ID(		
FMOSCPW32N120	TO-247	N/A	1200	32	136	1.8	3.6	5	75m	90m	15	20	1390	54
FMOSCPW36N90	TO-247	N/A	900	36	125	1.8	3.5	5	65m	78m	20	20	760	35
FMOSCPW36N120	TO-247	N/A	1200	36	192	2.0	4.0	5	80m	98m	20	20	1130	71
FMOSCPW90N120	TO-247	N/A	1200	90	463	2.0	4.0	15	25m	34m	20	20	2788	161
FMOSCPW60N120A	TO-247	N/A	1200	60	330	2.0	4.0	10	40m	52m	20	20	1893	115
FMOSCPW72N170A	TO-247	N/A	1700	72	520	2.0	4.0	18	45m	70m	20	20	3672	188
FMOSCPW19N120	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
FMOSCPW05N170	TO-247	N/A	1700	5	69	2.0	4.0	0.5	1000m	1400m	20	2	200	13
FMOSCPW37N65A	TO-247	N/A	650	29	150	1.8	3.6	5	60m	79m	15	13.2	1020	46
FMOSCPW11P5N90	TO-247	N/A	900	10.2	45	1.8	3.5	1.2	320m	360m	15	7.5	204	9.7
Under-Development	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
Under-Development	TO-247	N/A	1200	115	556	1.8	3.6	23	16m	22.3m	15	75	6085	207
Under-Development	TO-247	N/S	650	120	416	1.8	3.6	15.5	15m	21m	15	55.8	5011	188
Under-Development	TO-247	N/S	1200	81	469	1.8	3.6	17.7	21m	28.8m	15	50	4818	160
Under-Development	TO-247	N/S	650	97	326	1.8	3.6	9.22	25m	34m	15	33.5	2980	108
Under-Development	TO-247	N/S	650	22	98	1.8	3.6	1.86	120m	157m	15	6.76	640	28

1. Gold certified PC power supply/server power supply/mining machine power supply/industrial LED power supply

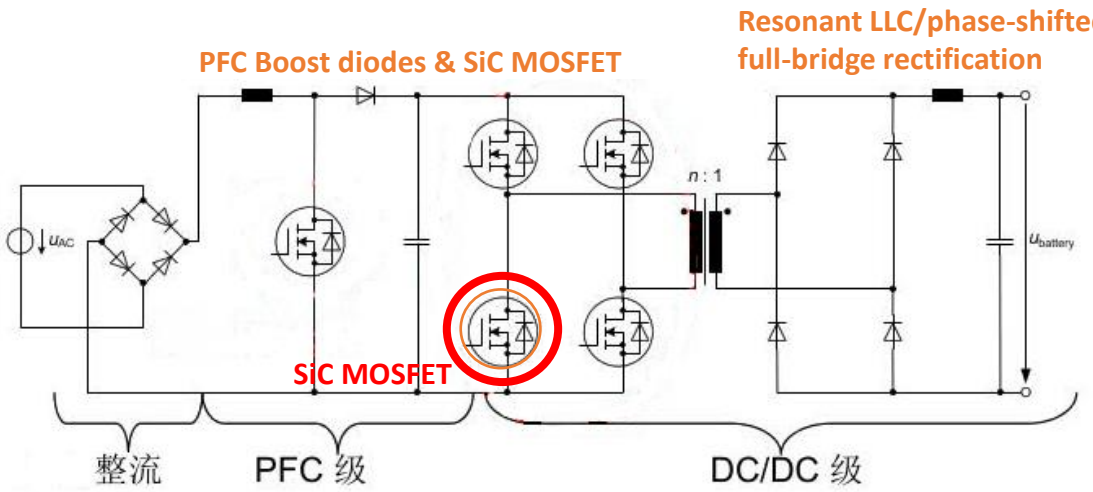
- The use of SiC MOSFET in power PFC circuits brings improvements in power efficiency, When other conditions remain unchanged, the loss can be reduced by simply replacing the MOSFET. Reduces electromagnetic interference to surrounding circuits and improves power supply reliability. Meet power supply energy efficiency certification requirements.



FMS P/N	FMS Package	規格												
		ESD	BVDSS	ID	PD	VGS(th)			RDSON1(Ω)				Ciss	Qg
			(V	(A	(W	MIN	MAX	ID(m	Typ	Ma	VGS	ID(	Typ.(pF)	Typ.(nC)
FMOSCPW32N120	TO-247	N/A	1200	32	136	1.8	3.6	5	75m	90m	15	20	1390	54
FMOSCPW36N90	TO-247	N/A	900	36	125	1.8	3.5	5	65m	78m	20	20	760	35
FMOSCPW36N120	TO-247	N/A	1200	36	192	2.0	4.0	5	80m	98m	20	20	1130	71
FMOSCPW90N120	TO-247	N/A	1200	90	463	2.0	4.0	15	25m	34m	20	20	2788	161
FMOSCPW60N120A	TO-247	N/A	1200	60	330	2.0	4.0	10	40m	52m	20	20	1893	115
FMOSCPW72N170A	TO-247	N/A	1700	72	520	2.0	4.0	18	45m	70m	20	20	3672	188
FMOSCPW19N120	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
FMOSCPW05N170	TO-247	N/A	1700	5	69	2.0	4.0	0.5	1000m	1400m	20	2	200	13
FMOSCPW37N65A	TO-247	N/A	650	29	150	1.8	3.6	5	60m	79m	15	13.2	1020	46
FMOSCPW11P5N90	TO-247	N/A	900	10.2	45	1.8	3.5	1.2	320m	360m	15	7.5	204	9.7
Under-Development	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
Under-Development	TO-247	N/A	1200	115	556	1.8	3.6	23	16m	22.3m	15	75	6085	207
Under-Development	TO-247	N/S	650	120	416	1.8	3.6	15.5	15m	21m	15	55.8	5011	188
Under-Development	TO-247	N/S	1200	81	469	1.8	3.6	17.7	21m	28.8m	15	50	4818	160
Under-Development	TO-247	N/S	650	97	326	1.8	3.6	9.22	25m	34m	15	33.5	2980	108
Under-Development	TO-247	N/S	650	22	98	1.8	3.6	1.86	120m	157m	15	6.76	640	28

2. New Energy Vehicle Charging Pile/OBC (On-Board Charger)

- The use of SiC MOSFETs in PFC circuits improves power source efficiency;
- SiC is used in DC-DC circuits of phase-shifting full-bridge or vibration LLC MOSFETs reduce switching losses

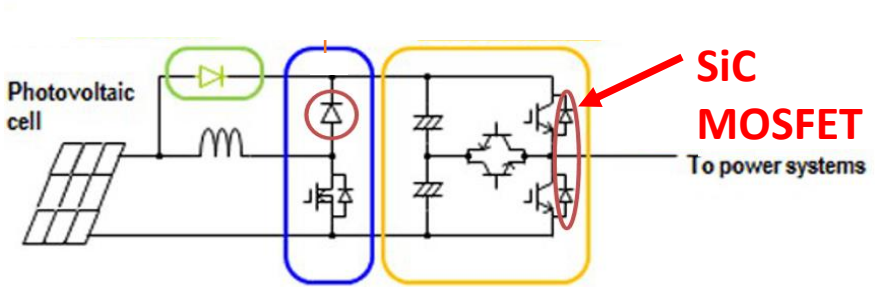


List of SiC MOSFETs

FMS P/N	FMS Package	規格												
		ESD	BVDSS	ID	PD	VGS(th)			RDSON1(Ω)				Ciss Typ.(pF)	Qg Typ.(nC)
			(V	(A	(W	MIN	MAX	ID(m	Typ	Ma	VGS	ID(		
FMOSCPW32N120	TO-247	N/A	1200	32	136	1.8	3.6	5	75m	90m	15	20	1390	54
FMOSCPW36N90	TO-247	N/A	900	36	125	1.8	3.5	5	65m	78m	20	20	760	35
FMOSCPW36N120	TO-247	N/A	1200	36	192	2.0	4.0	5	80m	98m	20	20	1130	71
FMOSCPW90N120	TO-247	N/A	1200	90	463	2.0	4.0	15	25m	34m	20	20	2788	161
FMOSCPW60N120A	TO-247	N/A	1200	60	330	2.0	4.0	10	40m	52m	20	20	1893	115
FMOSCPW72N170A	TO-247	N/A	1700	72	520	2.0	4.0	18	45m	70m	20	20	3672	188
FMOSCPW19N120	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
FMOSCPW05N170	TO-247	N/A	1700	5	69	2.0	4.0	0.5	1000m	1400m	20	2	200	13
FMOSCPW37N65A	TO-247	N/A	650	29	150	1.8	3.6	5	60m	79m	15	13.2	1020	46
FMOSCPW11P5N90	TO-247	N/A	900	10.2	45	1.8	3.5	1.2	320m	360m	15	7.5	204	9.7
Under-Development	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
Under-Development	TO-247	N/A	1200	115	556	1.8	3.6	23	16m	22.3m	15	75	6085	207
Under-Development	TO-247	N/S	650	120	416	1.8	3.6	15.5	15m	21m	15	55.8	5011	188
Under-Development	TO-247	N/S	1200	81	469	1.8	3.6	17.7	21m	28.8m	15	50	4818	160
Under-Development	TO-247	N/S	650	97	326	1.8	3.6	9.22	25m	34m	15	33.5	2980	108
Under-Development	TO-247	N/S	650	22	98	1.8	3.6	1.86	120m	157m	15	6.76	640	28

3.Photovoltaic inverters

- To improve the efficiency of PV inverters, SiC components are usually used in the step-up circuit of BOOST
- In order to reduce the losses of MOSFET/IGBT switching, the inverter AC-DC inverter circuits use SiC components to reduce switching losses
- The typical average efficiency of silicon-based inverters is close to 96%, and the inverters are inverted using SiC devices
- The average efficiency could be increased to 97.5%, which is equivalent to a 25% reduction in inverter losses.



List of SiC MOSFETs

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		ESD	BVDSS	ID	PD	VGS(th)			RDSON1(Ω)				Ciss Typ.(pF)	Qg Typ.(nC)
			(V	(A	(W	MIN	MAX	ID(m	Typ	Ma	VGS	ID(		
FMOSCPW32N120	TO-247	N/A	1200	32	136	1.8	3.6	5	75m	90m	15	20	1390	54
FMOSCPW36N90	TO-247	N/A	900	36	125	1.8	3.5	5	65m	78m	20	20	760	35
FMOSCPW36N120	TO-247	N/A	1200	36	192	2.0	4.0	5	80m	98m	20	20	1130	71
FMOSCPW90N120	TO-247	N/A	1200	90	463	2.0	4.0	15	25m	34m	20	20	2788	161
FMOSCPW60N120A	TO-247	N/A	1200	60	330	2.0	4.0	10	40m	52m	20	20	1893	115
FMOSCPW72N170A	TO-247	N/A	1700	72	520	2.0	4.0	18	45m	70m	20	20	3672	188
FMOSCPW19N120	TO-247	N/A	1200	19	125	2.0	4.0	2.5	160m	196m	20	10	525	34
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Thank You