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SiC Power Device Introduction

Zhuzhou CRRC Times Semiconductor Co., Ltd.

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Contents

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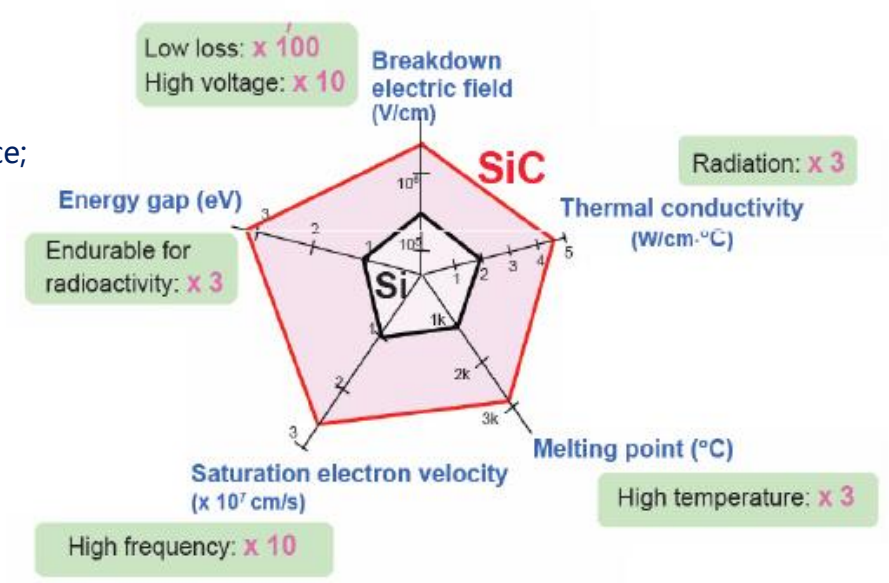
Part 1 Device Characteristics

SiC--More Advanced Material Performance than Si

Physical characteristics	4H-SiC	Si
Bandgap (eV)	3.26	1.12
Breakdown electric field (MV/cm)	3	0.25
Thermal conductivity (W/cm/K)	~3.4	1.5
Electronic saturation speed (cm/s)	2e7	1e7

Advantage

- Higher blocking voltage and lower on-resistance;
- Higher operation frequency;
- Higher operation temperature;
- Stronger durability to cosmic rays.



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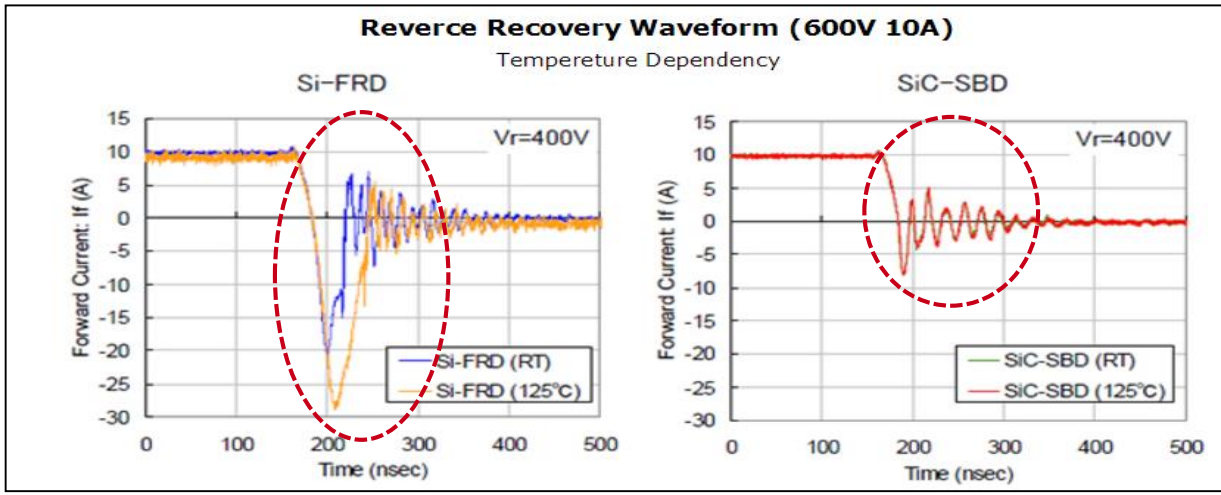
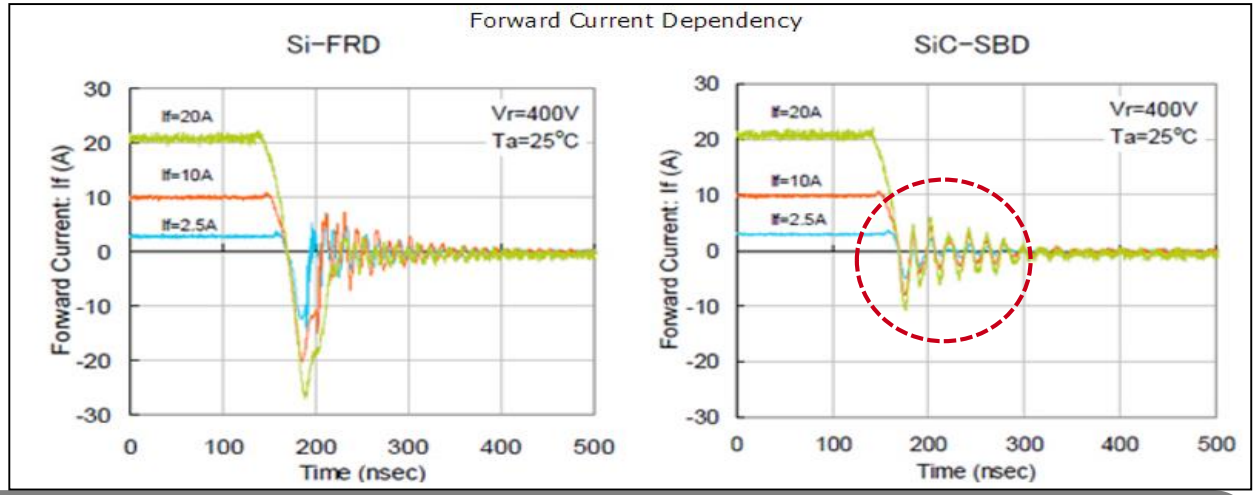
Part 1 Device Characteristics

Si-FRD Reverse Recovery Feature Comparison with SiC-SBD

- SiC-SBD has low reverse recovery loss;
- SiC-SBD has almost the same reverse recovery characteristics at 25-125°C;
- SiC-SBD maintains relatively stable reverse recovery characteristics under different forward current conditions.





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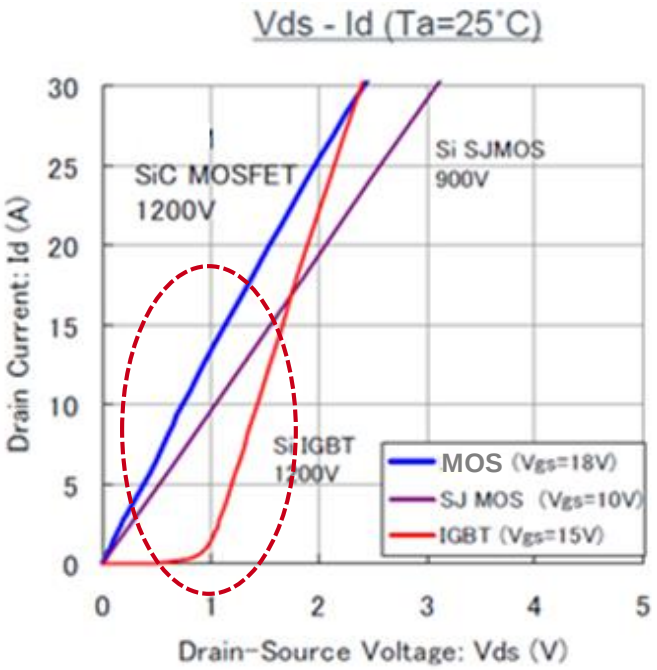
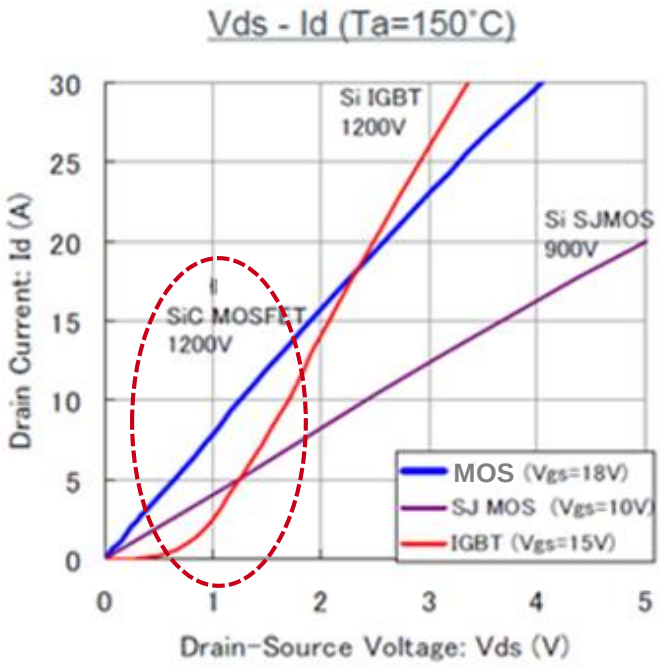
Part 1 Device Characteristics

SiC-MOSFET On-state Characteristics

- No turn-on voltage;
- Low conduction loss.

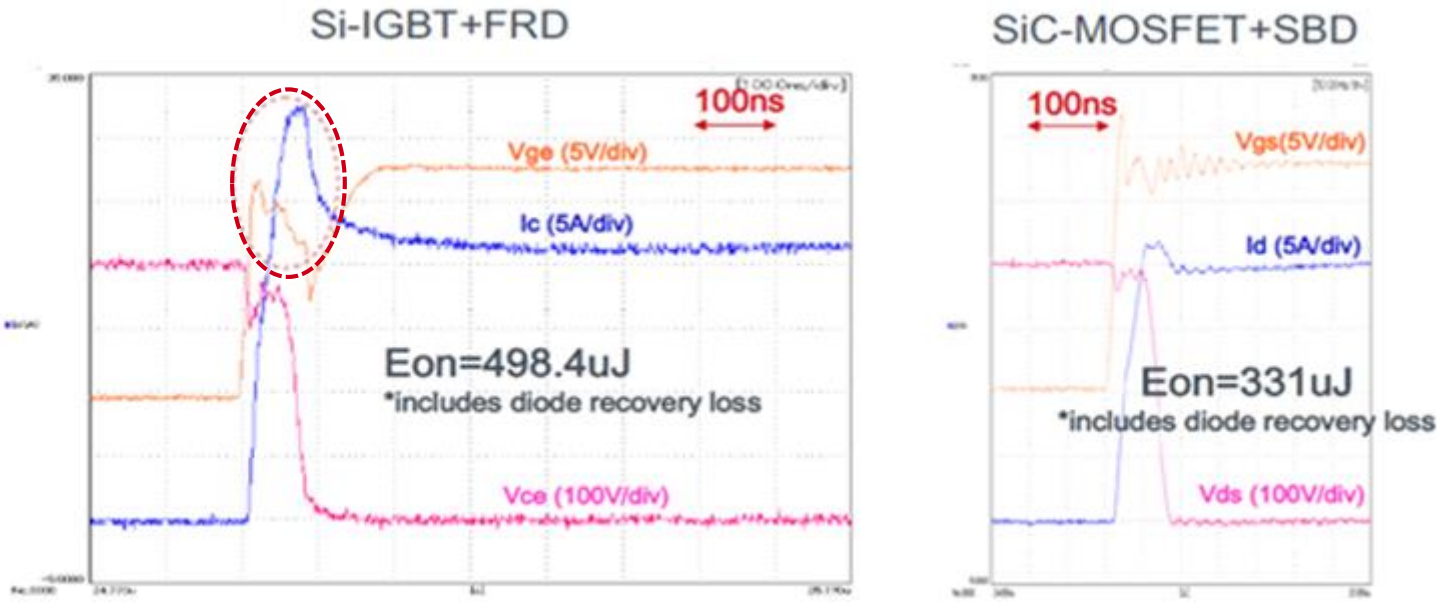




Part 1 Device Characteristics

SiC-MOSFET Turn-on Characteristics

- SiC-MOSFET work with SiC SBD，when MOSFET turn on, the reverse recovery current of SBD is extremely low, which can reduce the turn-on loss.

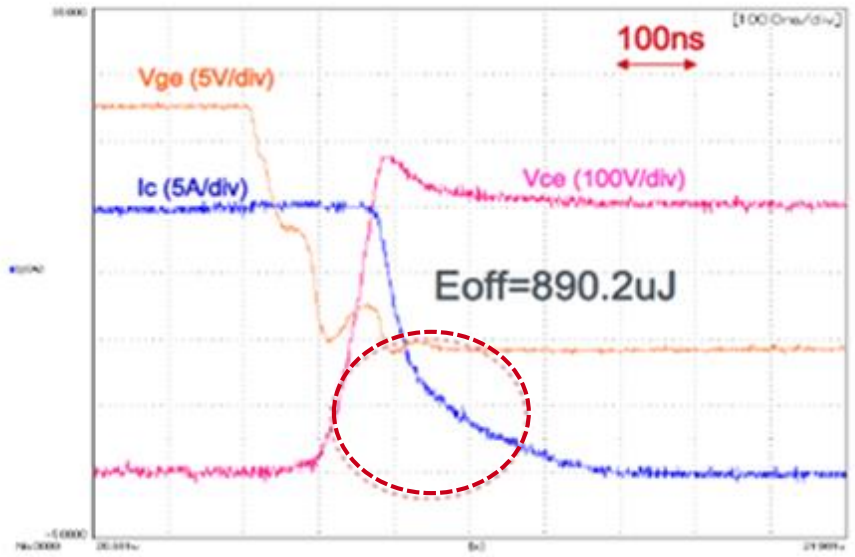


Part 1 Device Characteristics

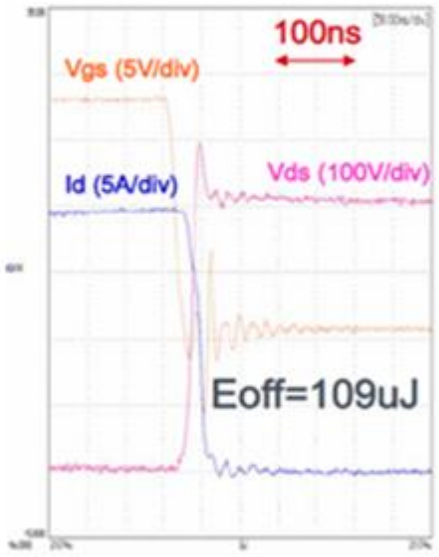
SiC-MOSFET Turn-off Characteristics

- SiC-MOSFET turn off，there is almost no tail current, which greatly reduces the turn-off loss.

Si-IGBT+FRD



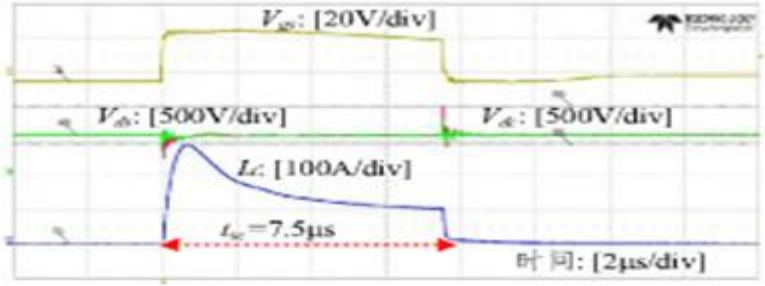
SiC-MOSFET+SBD



Part 1 Device Characteristics

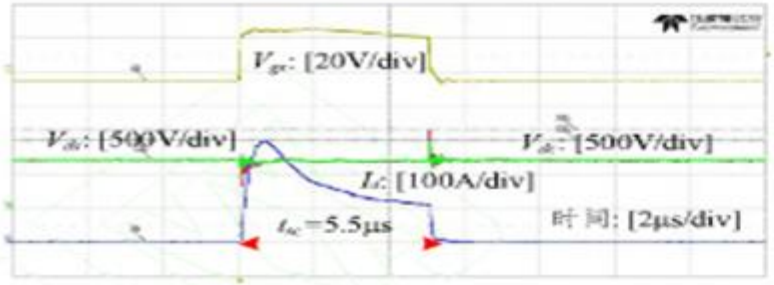
SiC-MOSFET Short Circuit Characteristics

- The short-circuit capability of SiC MOSFET is worse than the same level of Si IGBT due to the high current density ,it is about 2~3 us for product, and the withstand times would decrease with the increasing of DC bus voltages.



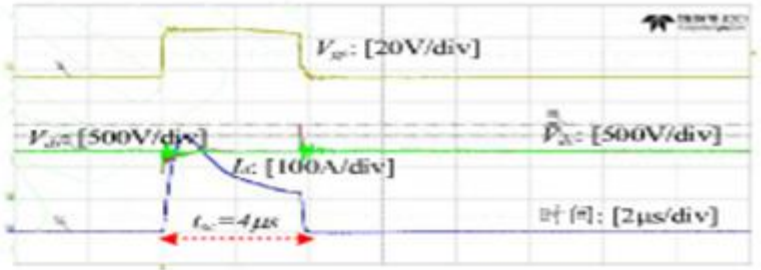
(a) 600V 直流母线电压

(a) 600V DC bus voltages.



(b) 700V 直流母线电压

(b) 700V DC bus voltages.



(c) 750V 直流母线电压

器件短路特性测试结果

(c) 700V DC bus voltages.

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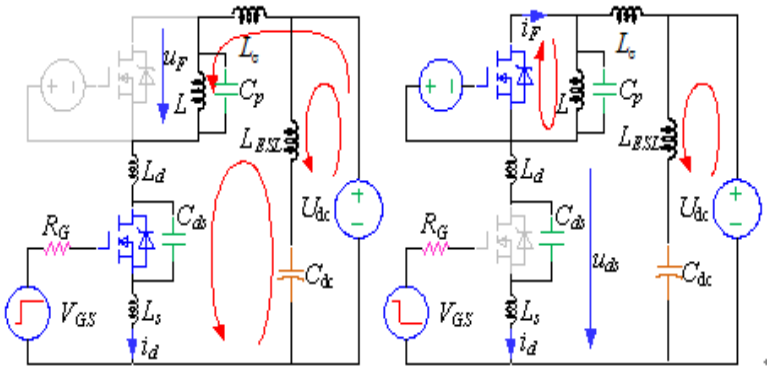
Part 1 Device Characteristics

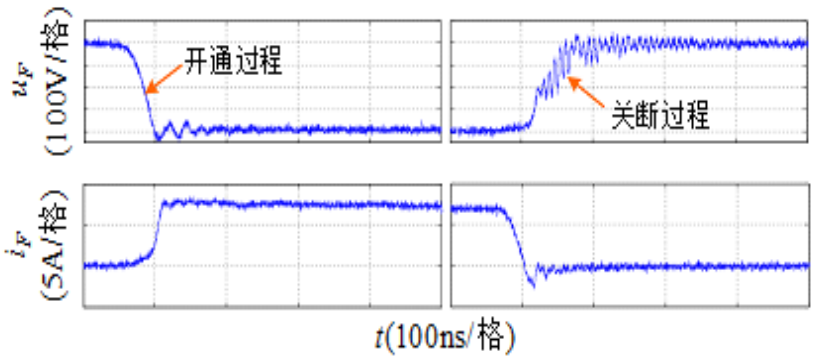
Switching Oscillation

- Since the switching speed of the SiC device is very fast, it is very sensitive to parasitic parameters, and the switching oscillation is very serious.



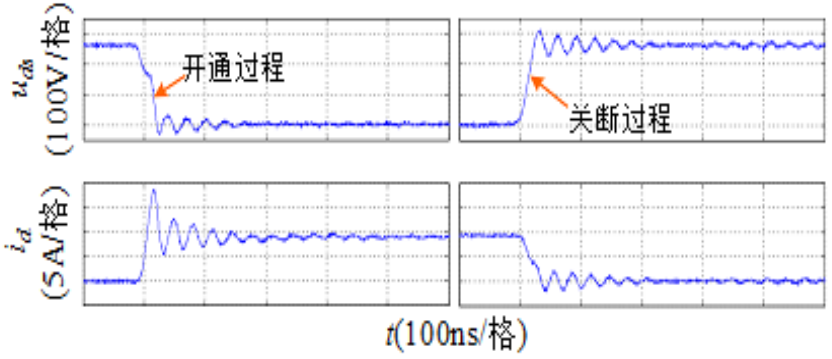
(a) 开通和关断过程的振荡回路

(a) Oscillation loop in turn-on and turn-off process



(b) SiC 二极管的开关过程

(b) turn-on and turn-off process in SiC SBD



(c) SiC MOSFET 的开关过程

(c) turn-on and turn-off process in SiC MOSFET

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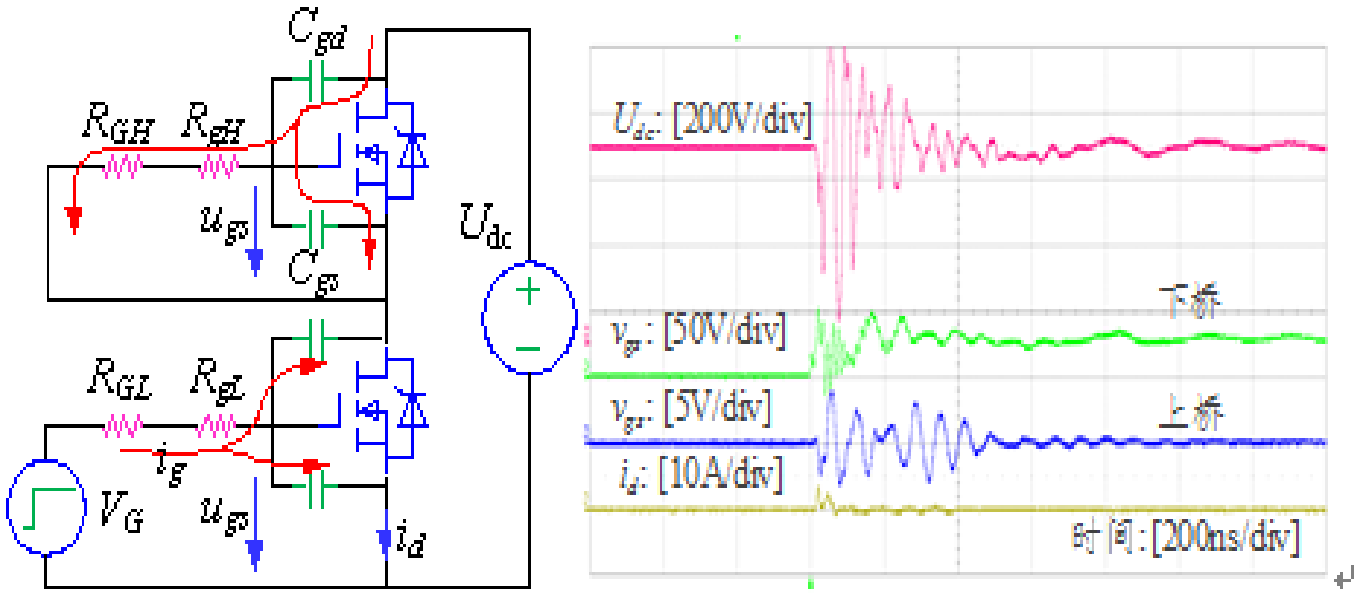
Part 1 Device Characteristics

Crosstalk

- The higher dv/dt will form a coupling disturbance through the Miller capacitance of the device, which will cause a crosstalk phenonmenon.



(a) 串扰的机理　　(b) 串扰的实验结果

(a)The principle of crosstalk　　(b)The experimental results of crosstalk

Contents

Part 2 Product Introduction

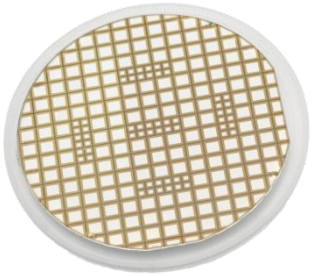
Capacity

- Ability of manufacturing SiC diodes and MOS switches devices ;
- Productivity of 10,000 SiC wafers/year.

Part 2 Product Introduction

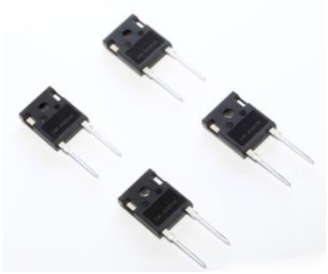
Product Type

- Bare Die

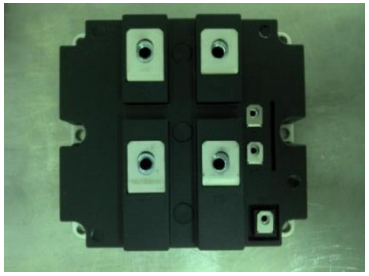


- MV&LV Module

- Discrete Device



- HV Module

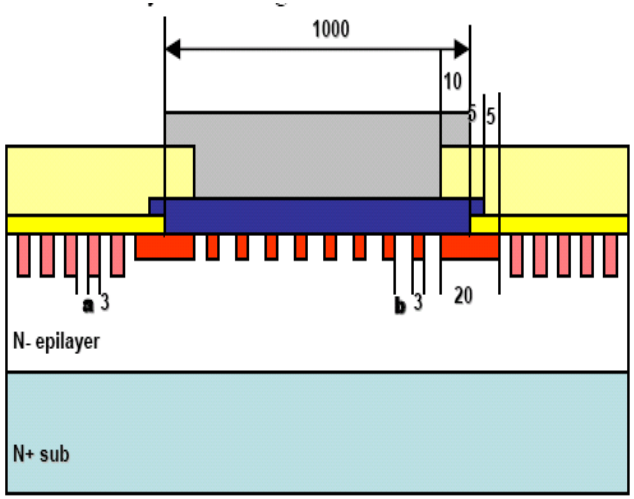


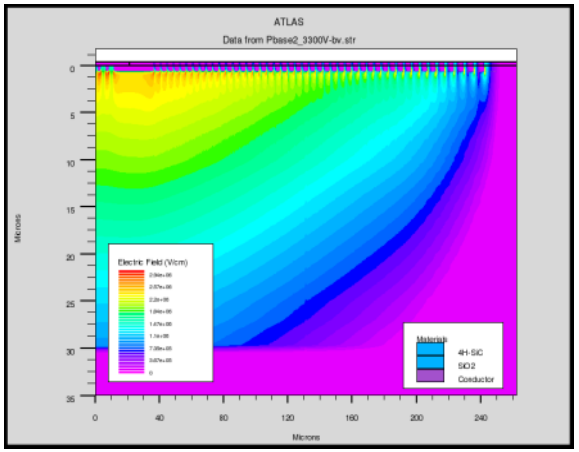
Part 2 Product Introduction

Technique Characteristics

On Technique Side

- SiC JBS or MPS device structure;
- Low interface state density terminal passivation;
- High temperature ion implantation;
- Ti schottky contact.





On Product

- Zero reverse recovery current, zero forward overshoot voltage;
- Higher avalanche tolerance;
- Low switching loss for higher frequency operation;
- Positive temperature coefficient, easy to parallel.

Part 2 Product Introduction

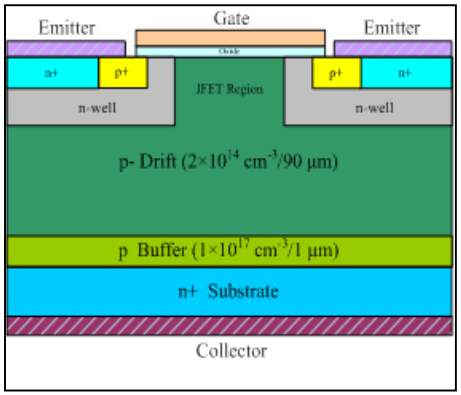
Technique Characteristics

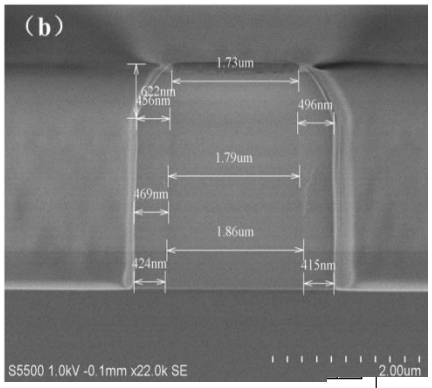
On technique side

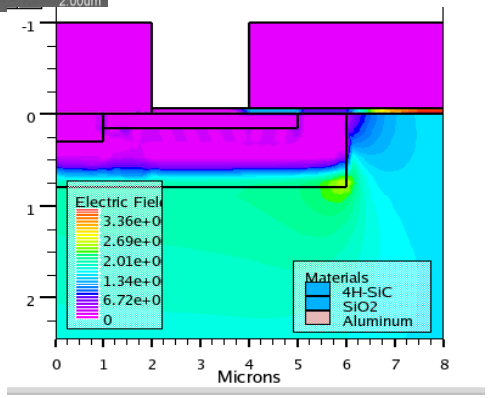
- Planar gate structure of SiC MOSFET;
- Self-aligned process technology;
- Gate oxide nitride annealing;
- Smaller cell size.

On product

- High reliability and stability;
- High switching frequency, no tail current;
- Low on-state resistance;
- Positive temperature coefficient, easy to parallel.







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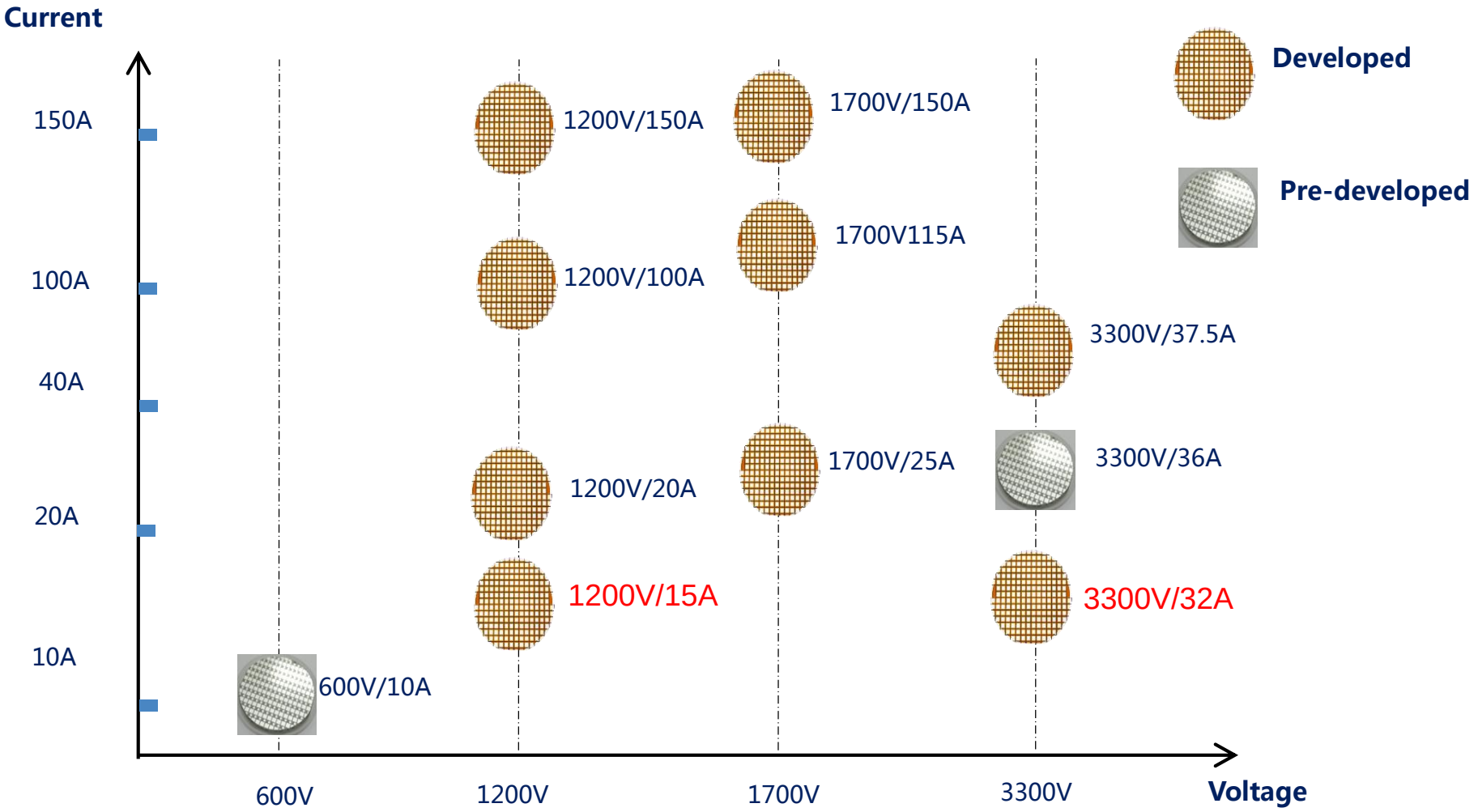
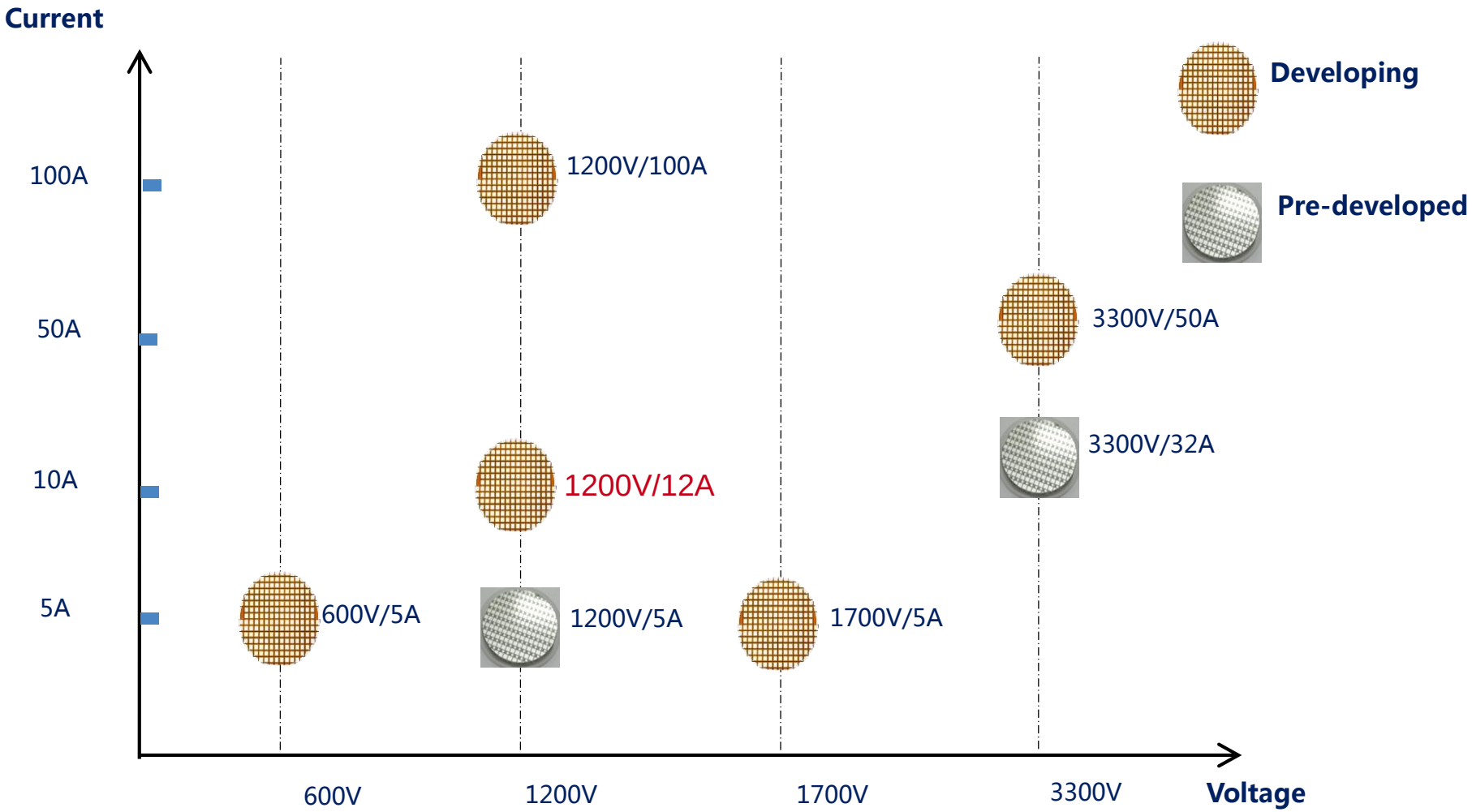
Part 2 Product Introduction

SiC SBD Product Lineup



Part 2 Product Introduction

SiC MOSFET Product Lineup



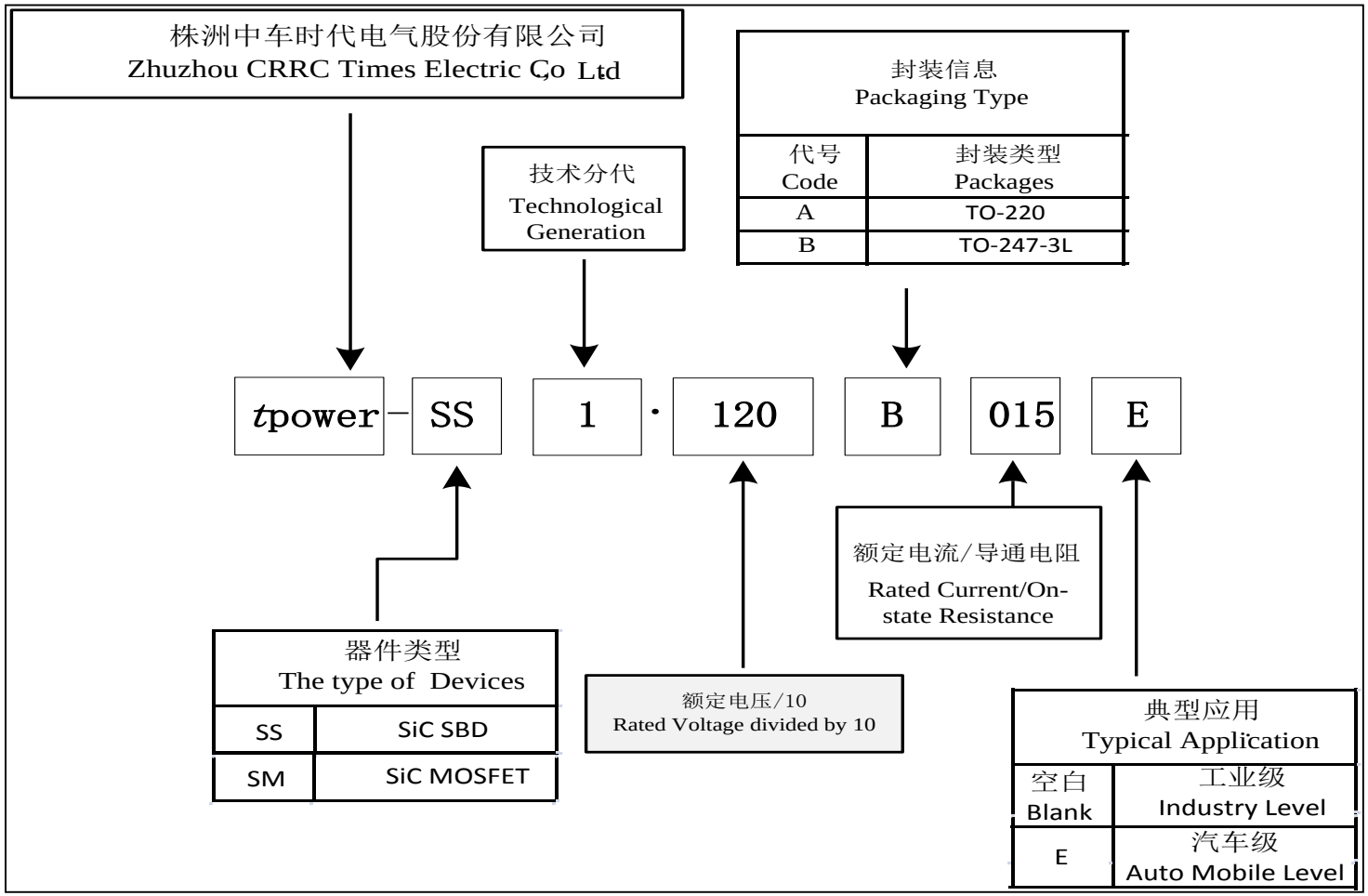
Part 2 Product Introduction

Discrete Devices Lineup

Part number	Product name	Voltage	Current	Package	State
SiC Schottky SBD	Tpower-SS2·065A010	650V	10A	TO-220	Developing
	Tpower-SS2·120A015	1200V	15A	TO-247 /TO-220	Engineering sample
	Tpower-SS2·170A025	1700V	25A	TO-247	R&D sample
	Tpower-SS2·170A050	1700V	50A	TO-247	R&D sample
SiC MOSFET	Tpower-SS2·065A040	650V	40mΩ	TO-247	Developing
	Tpower-SS2·120A050	1200V	50mΩ	TO-247	R&D sample
	Tpower-SS2·120A130	1200V	130mΩ	TO-247	Engineering sample
	Tpower-SS2·170A080	1700V	80mΩ	TO-247	Developing

Part 2 Product Introduction

Naming systems for SiC discrete devices



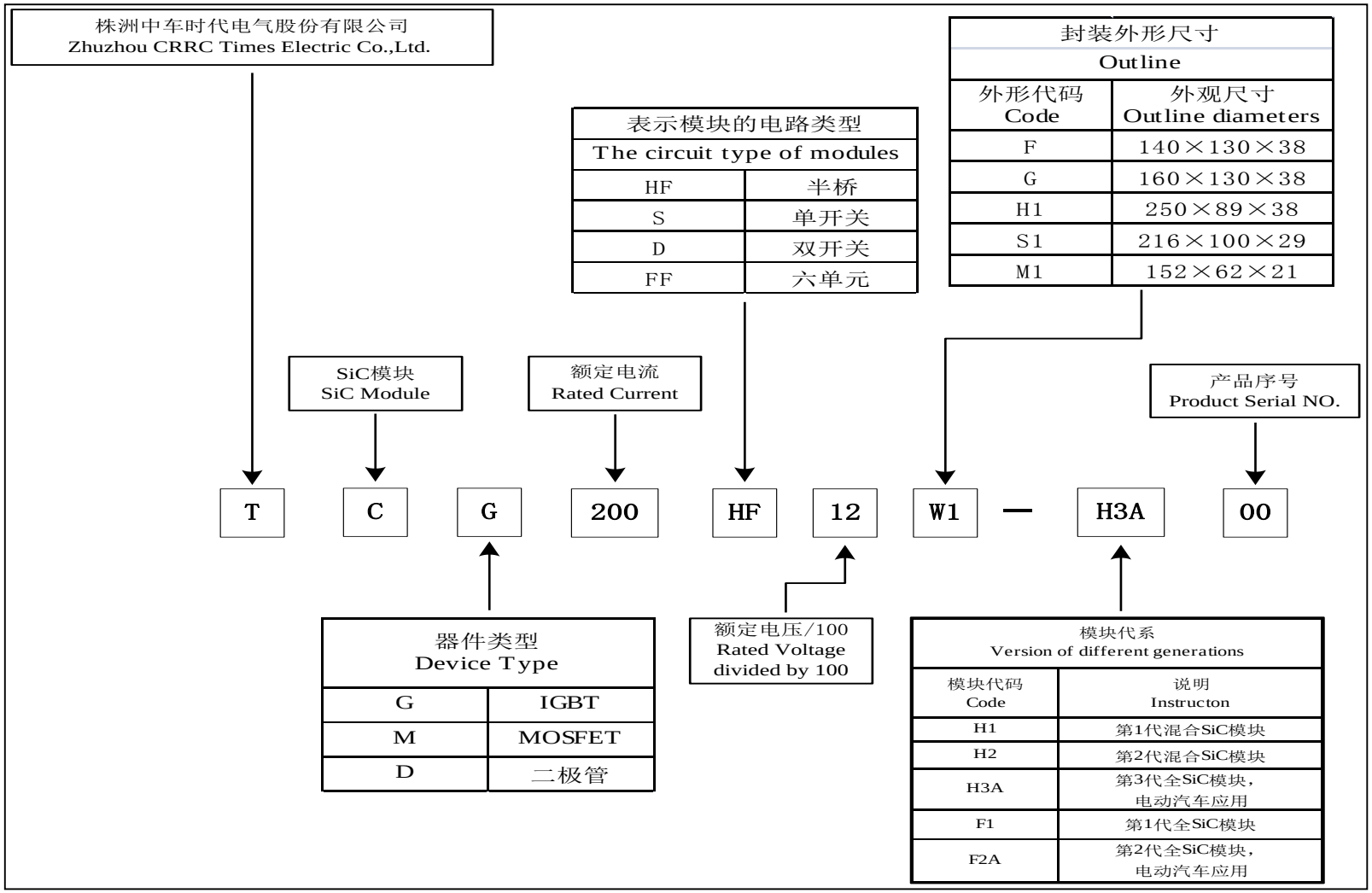
Part 2 Product Introduction

Power Module Lineup

Part number	Product name	Voltage	Current	Package	State
TCM200H12H2F1	W1 full SiC module	1200V	200A	Half bridge	R&D sample
TCG200H12H2H1	W1 hybrid module	1200V	200A	Half bridge	Engineering sample
TCG600H12M1H1A	M1 hybrid module	1200V	600A	Half bridge	R&D sample
TCG1600S17FH1	F hybrid module	1700V	1600A	Single switch	R&D sample
TCG500H33GH1	G hybrid module	3300V	500A	Dual switch	Engineering sample
TCM500H33GF1	G full SiC module	3300V	500A	Dual switch	R&D sample
TCG1500D33GH1	E hybrid module	3300V	1500A	Dual switch	Engineering sample

Part 2 Product Introduction

Naming systems for SiC power module



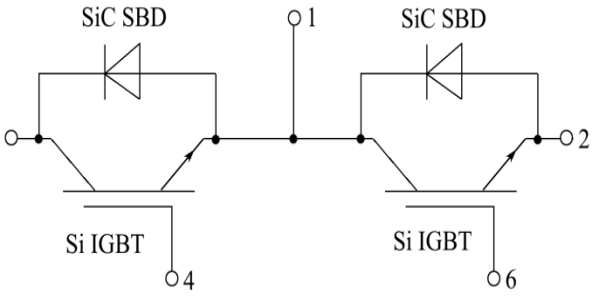
Contents

Part 3 Application Performance

1200V/200A SiC Module--Photovoltaic Inverter

Product Information

- Half bridge, NTC inside;
- Hybrid SiC/full SiC MOSFET module;
- Low loss, high operation frequency;
- Suitable for power supply, photovoltaic inverter etc.



Module Size

Symbol	Value	Unit
L	108	mm
W	62	mm
H	31	mm

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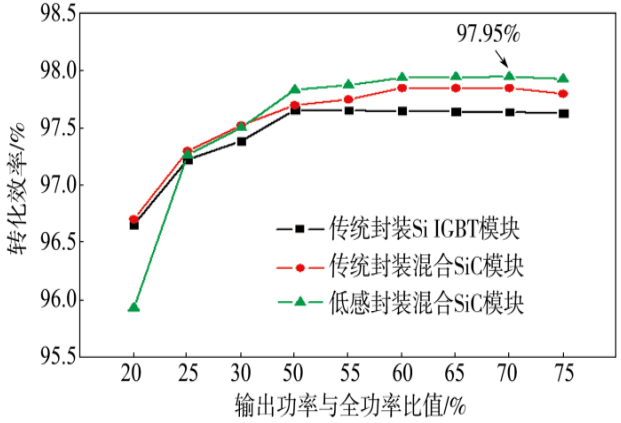
Part 3 Application Performance

1200V/200A SiC Module--Photovoltaic Inverter

Application Information

- A photovoltaic electric field in Qinghai Golmud;
- Model：50kW-SPS50、100KW-SPS100、250kW-SPS250;
- Conversion efficiency, temperature rise, harmonics, EMC are superior to traditional modules.



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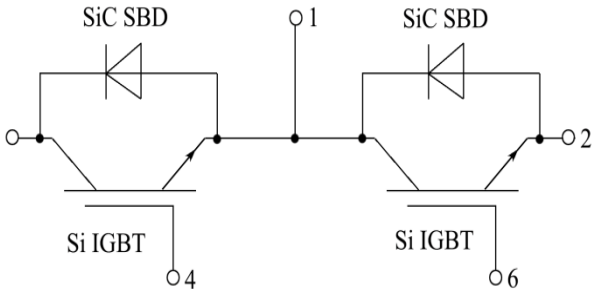
Part 3 Application Performance

1200V/600A Hybrid SiC Module--EV

Product Information

- Half bridge, NTC inside
- Hybrid SiC module
- Low loss, high operation frequency
- Suitable for motor drive, EV etc.



1200V/600A M1 module

Module Size

Symbol	Value	Unit
L	152	mm
W	62	mm
H	21	mm

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Part 3 Application Performance

1200V/600A Hybrid SiC Module--EV

Application Information

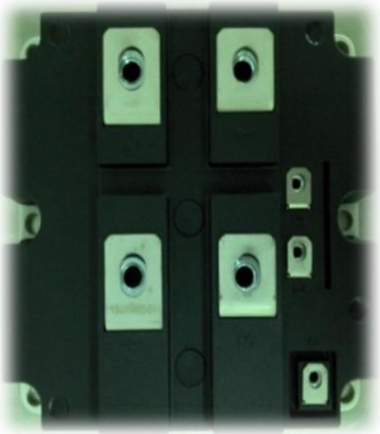
- EV bus;
- Type: D015 motor drive controller;
- Motor controller loss is reduced by 20% using hybrid SiC modules;
- Conversion efficiency and temperature rise are better than traditional IGBT modules.

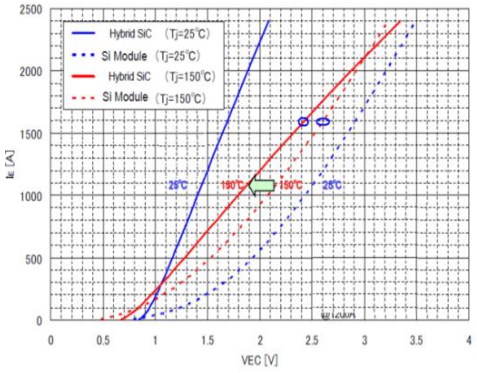
Part 3 Application Performance

1700V/1600A Hybrid SiC Module--Railway

Product Information

- Single switch;
- hybrid SiC module;
- Low turn on loss;
- Suitable for motor drive and traction.



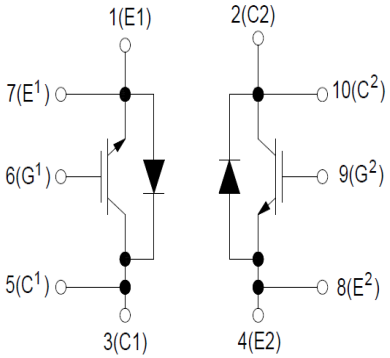


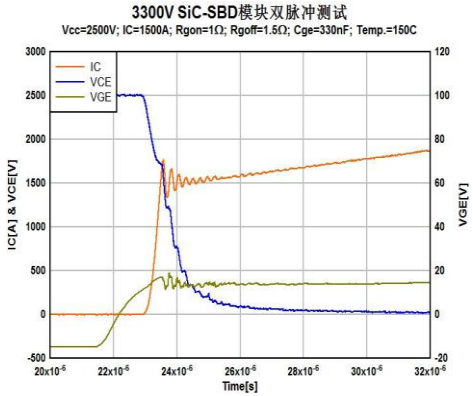
Part 3 Application Performance

3300V/500A SiC Module--Railway

Product Information

- Half bridge, NTC inside;
- Hybrid SiC/full SiC MOSFET module;
- Low loss, high operation frequency;
- Suitable for motor drive and traction.





Part 3 Application Performance

3300V/500A SiC Module--Railway

Application Information

- A city operating subway;
- Type：IBCH5062-SiC metro converter module;
- 30% reduction in power loss at full load;
- Temperature rise down 2℃.

Part 3 Application Performance

SiC Traction Converter Performance Comparison--Railway

Type	Si Converter	SiC Converter	Discrepancy
Weight	96kg	78kg	-23%
Volume	700x500x380mm^3 (133L)	700x500x300mm^3 (105L)	-26%
Efficiency	98%	98.5%	SiC better
Power density	4.13MW/m^3	5.23MW/m^3	+26%
Wind system	10m/s	8m/s	SiC better

Contents

Part 4 R&D Plan

Market Positioning

- Cooperate with IGBT industry, match market positioning with IGBT and form market supplement

Product Positioning

- Automotive-grade 900V and 1200V chips, and the corresponding voltage rating S3 and L modules

- 3300V and 6500V chips and the corresponding voltage rating X1 modules.

- Partial discrete device products for rail transportation and other components of electric vehicles.

Positioning in the coming 3 years.

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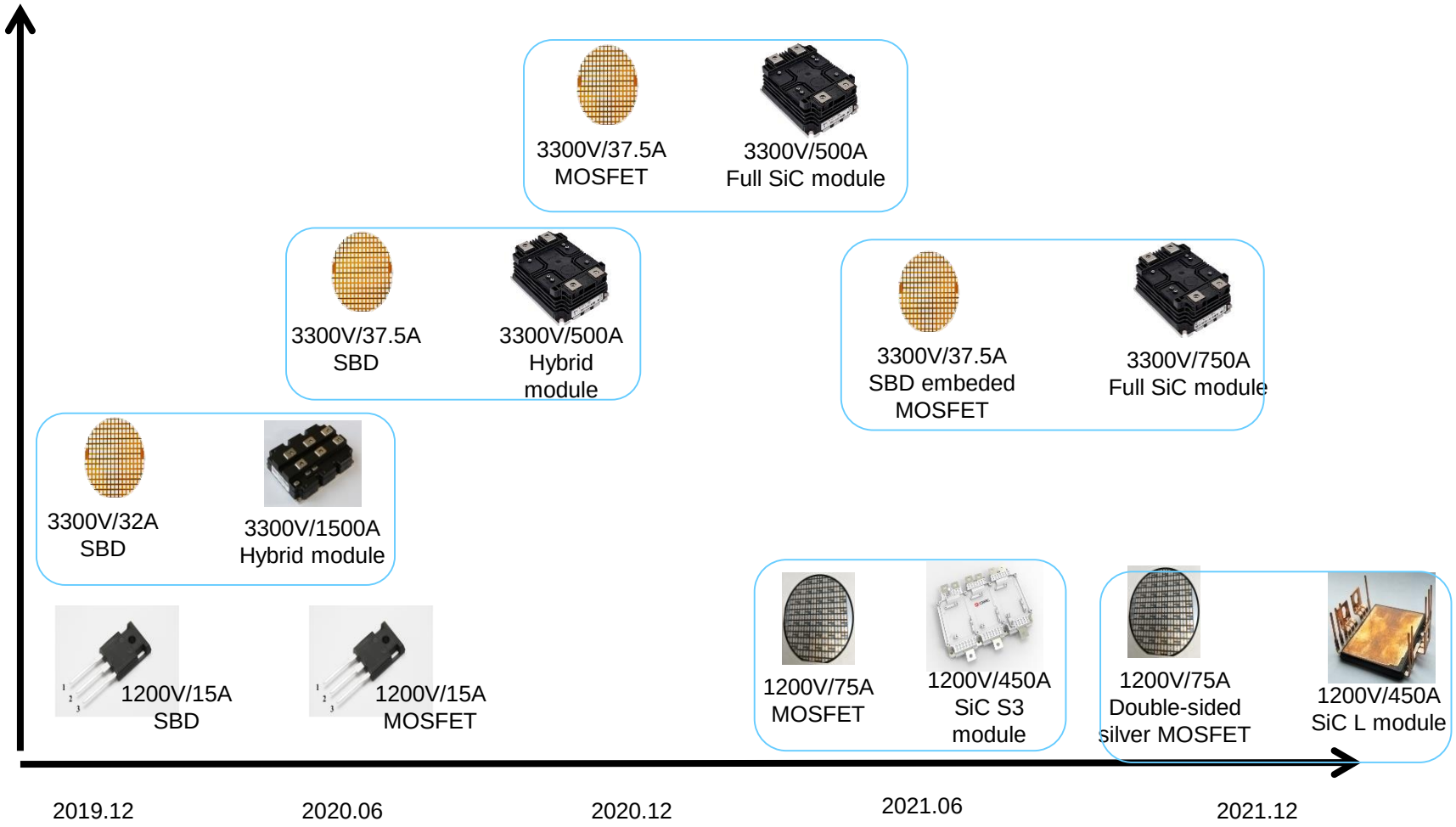
Part 4 R&D Plan

Product Roadmap



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