MCHP SiC 的優勢

A Leading Provider of Smart, Connected and Secure Embedded Solutions

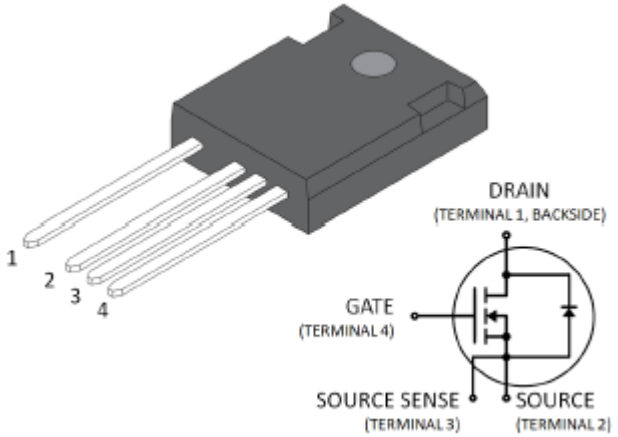
ESE Sam Liu

2022.09.22

Competitors ex 1200V/ 40mR -4L

PN : M S C 040 S MA 120 B 4

- **Wolfspeed :** C3M0040120K
- **Infineon :** IMZA120R040M1H
- **STMicro :** SCTW100N120G2A
- **Onsemi :** NTH4L040N120SC1 ($17.7749)
- **Rohm :** SCT3040KR
- **Toshiba :** TW045N120C
- **UnitedSiC :** UF4SC120030K4S
- **IXYS, Littelfuse :** LSIC1MO120G0040
- **GeneSiC :** G3R40MT12K -4L
- **Inventchip :** IV1Q12050T4
- **BOSCH :** BT1M1200031T4A
- 瀚薪 : H1M120Q040



下課?

SiC Discretes: 700-1700 V

- www.microchip.com/SiC
- Microchip Treelink Product Navigation

AEC-Q101

All in mass production

TO-263-7L

Coming soon
PN# >1xx

Module: AQG-324

SiC Schottky Barrier Diodes (SBDs)

Voltage	$I_{F(avg)}$ Amps	V_F Volts	Part Number	Package
700	10	1.5	MSC010SDA070D/S	Die
			MSC010SDA070K	TO-220
			MSC010SDA070B	TO-247
	30	1.5	MSC030SDA070D/S	Die
			MSC030SDA070K	TO-220
			MSC030SDA070B	TO-247
			MSC030SDA070S	D³PAK
	50	1.5	MSC050SDA070D/S	Die
			MSC050SDA070B	TO-247
			MSC050SDA070S	D³PAK
1200	10	1.5	MSC010SDA120D/S	Die
			MSC010SDA120B	TO-247
			MSC010SDA120K	TO-220
	15	1.5	MSC015SDA120D/S	Die
			MSC015SDA120B	TO-247
			MSC015SDA120K	TO-220
	20	1.5	MSC020SDA120D/S	Die
			MSC020SDA120B	TO-247
			MSC020SDA120K	TO-220
	30	1.5	MSC030SDA120D/S	Die
			MSC030SDA120B	TO-247
			MSC030SDA120K	TO-220
			MSC030SDA120S	D³PAK
	50	1.5	MSC050SDA120D/S	Die
			MSC050SDA120B	TO-247
			MSC050SDA120S	D³PAK
1700	10	1.5	MSC010SDA170D/S	Die
			MSC010SDA170B	TO-247
	30	1.5	MSC030SDA170D/S	Die
			MSC030SDA170B	TO-247
	50	1.5	MSC050SDA170D/S	Die
			MSC050SDA170B	TO-247

SiC MOSFETs

AEC-Q101

Voltage	$R_{DS(On)}$ (typical)	Part Number	Package
700 V	90 mΩ	MSC090SMA070D/S	Die
		MSC090SMA070B	TO-247
		MSC090SMA070S	D3PAK
	60 mΩ	MSC060SMA070D/S	Die
		MSC060SMA070B	TO-247
		MSC060SMA070B4	TO-247-4L
		MSC060SMA070S	D3PAK
	35 mΩ	MSC035SMA070D/S	Die
		MSC035SMA070B	TO-247
		MSC035SMA070B4	TO-247-4L
		MSC035SMA070S	D3PAK
	15 mΩ	MSC015SMA070D/S	Die
		MSC015SMA070B	TO-247
		MSC015SMA070B4	TO-247-4L
		MSC015SMA070S	D3PAK
1200 V	80 mΩ	MSC080SMA120D/S	Die
		MSC080SMA120B	TO-247
		MSC080SMA120B4	TO-247-4L
		MSC080SMA120S	D3PAK
		MSC080SMA120J	SOT-227
	40 mΩ	MSC040SMA120D/S	Die
		MSC040SMA120B	TO-247
		MSC040SMA120B4	TO-247-4L
		MSC040SMA120S	D3PAK
		MSC040SMA120J	SOT-227
	25 mΩ	MSC025SMA120D/S	Die
		MSC025SMA120B	TO-247
		MSC025SMA120B4	TO-247-4L
		MSC025SMA120S	D3PAK
		MSC025SMA120J	SOT-227
	17 mΩ	MSC017SMA120D/S	Die
		MSC017SMA120B	TO-247
		MSC017SMA120B4	TO-247-4L
		MSC017SMA120S	D3PAK
		MSC017SMA120J	SOT-227
1700 V	750 mΩ	MSC750SMA170D/S	Die
		MSC750SMA170B	TO-247
		MSC750SMA170B4	TO-247-4L
		MSC750SMA170S	D3PAK
	35 mΩ	MSC035SMA170D/S	Die
		MSC035SMA170B	TO-247
		MSC035SMA170B4	TO-247-4L
		MSC035SMA170S	D3PAK

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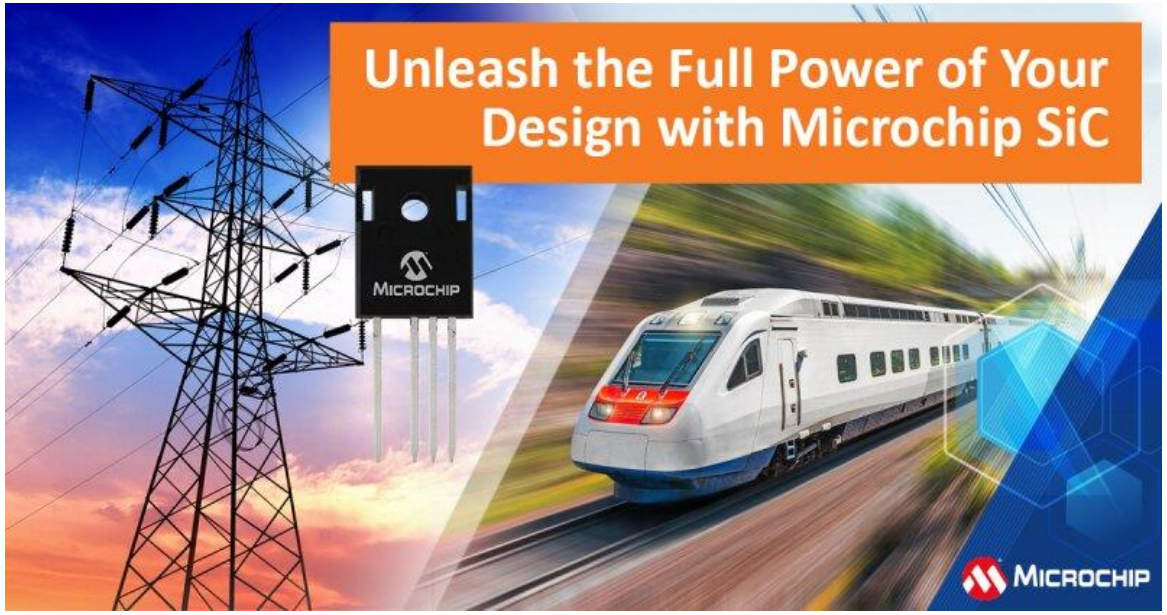
3.3 kV SiC MOSFETs and Diodes

Package and Die Options

Device Type	Part Number	Voltage (V)	R_{DSon} (mOhm)	Current (A)	Package
SiC MOSFET	MSC025SMA330D/S	3300	25	104	Die
SiC MOSFET	MSC025SMA330B4	3300	25	104	TO-247-4L
SiC MOSFET	MSC027SMA330D/S	3300	27	104	Die
SiC MOSFET	MSC080SMA330D/S	3300	80	43	Die
SiC MOSFET	MSC080SMA330B4	3300	80	43	TO-247-4L
SiC MOSFET	MSC400SMA330D/S	3300	400	8	Die
SiC MOSFET	MSC400SMA330B4	3300	400	8	TO-247-4L
SiC SBD	MSC030SDA330D/S	3300	-	30	Die
SiC SBD	MSC030SDA330B	3300	-	30	TO-247-2L
SiC SBD	MSC090SDA330D/S	3300	-	90	Die
SiC SBD	MSC090SDA330B2	3300	-	90	T-MAX (-2L)



PNs in red mark is just released.

700V, 1200V, 1700V

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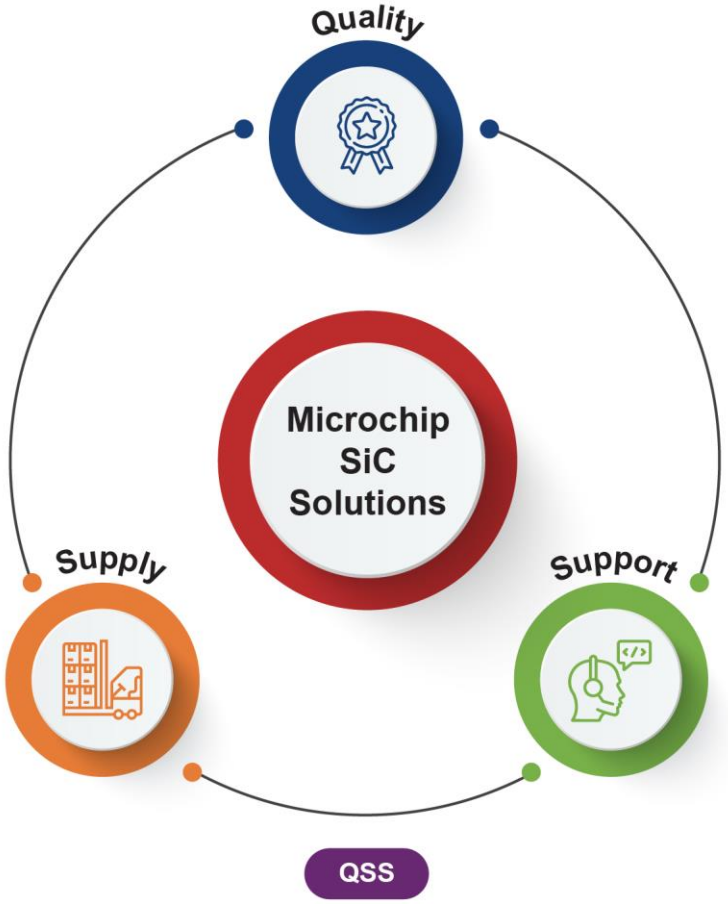
Microchip Quality, Supply and Support (QSS)



- **Quality**: Proven reliability and ruggedness
- **Supply**: Risk adverse approach throughout the supply chain
- **Support**: Standard & custom die, discrete, module & gate driver options for small to large customers

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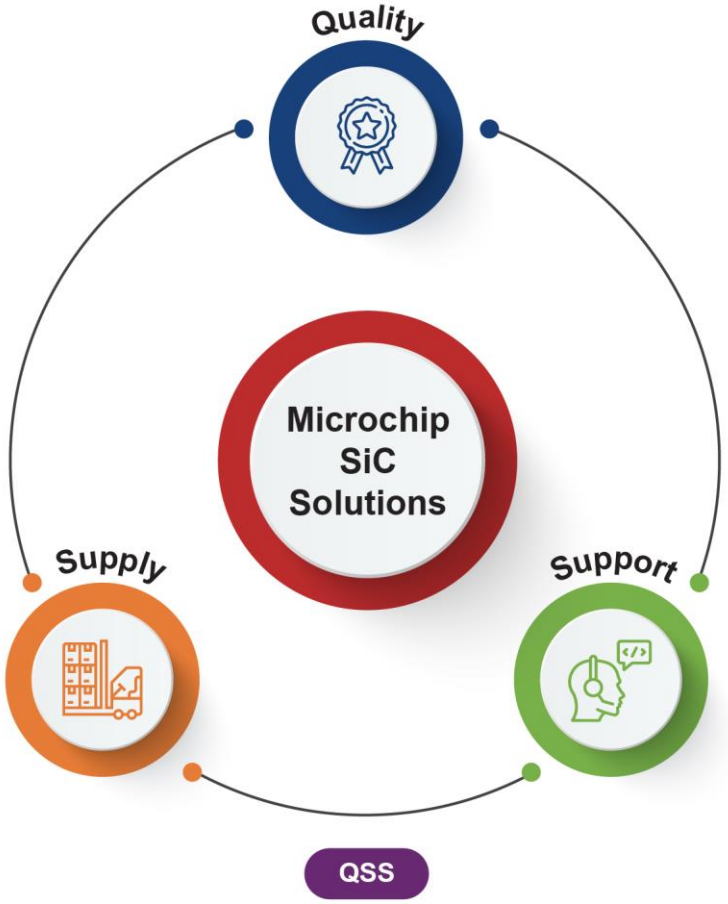
Supply: Risk Averse Supply Chain



- Qualified and secured long-term **substrate and epi** supply with multiple vendors that exceeds high side demand
  - Not reliant on competitor substrate/epi material
- **Dual fab location strategy**
- protecting the supply chain from a natural disaster or major line yield issue
- **In line with Microchip well established no EOL policy**
- **Competitive lead times of less than 16 weeks in most cases**

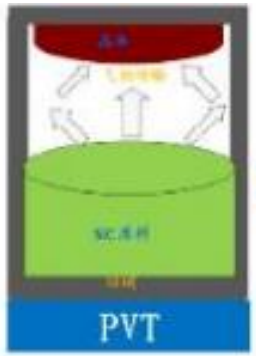
3rd SiC Device Production

IDM

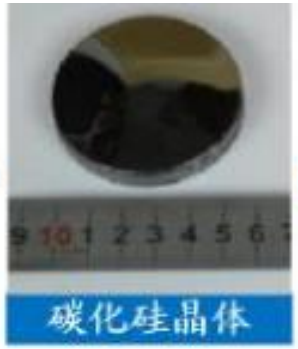
ROHM SEMICONDUCTOR, infineon, Osemi, ST, Texas Instruments, NXP, CREE

基板 | 磊晶/晶圓代工 | 封測相關

1个月



单晶生长



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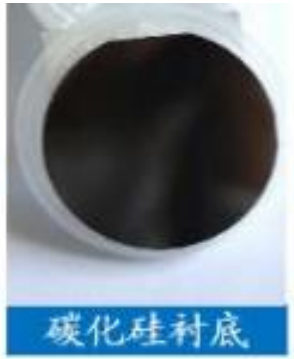


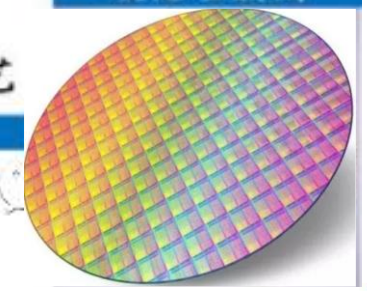
外延生长

6到12个月

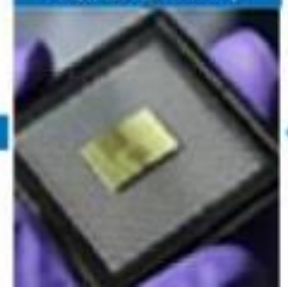
碳化矽需要7天時間才能長出2～5公分的晶錠
矽則是3天就能製作出200公分的晶棒，長晶效率相差100～200倍。

- 光刻
- 沉积
- 离子注入
- 金属钝化
- ……

前段工艺



后段工艺



封装

1到2年

此資料引用: MCHP 大陸同事Westbrook Zhang's SiC Product Selling Guide

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Microchip SiC Supply Chain

Substrate

- **Primary**
  - II-VI
  - Showa Denko
- **Secondary**
  - SK Siltron
- **In Eval**
  - Cree
  - SiCrystal

Epi

- **Primary**
  - Showa Denko
- **Secondary**
  - Xfab
- **In Eval**
  - **Microchip**

Fabrication

- **Dual Fab Strategy**
  - Foundry – USA (30k wafers per month)
  - **Microchip Fab 5** – Colorado, USA (60k wafers per month)

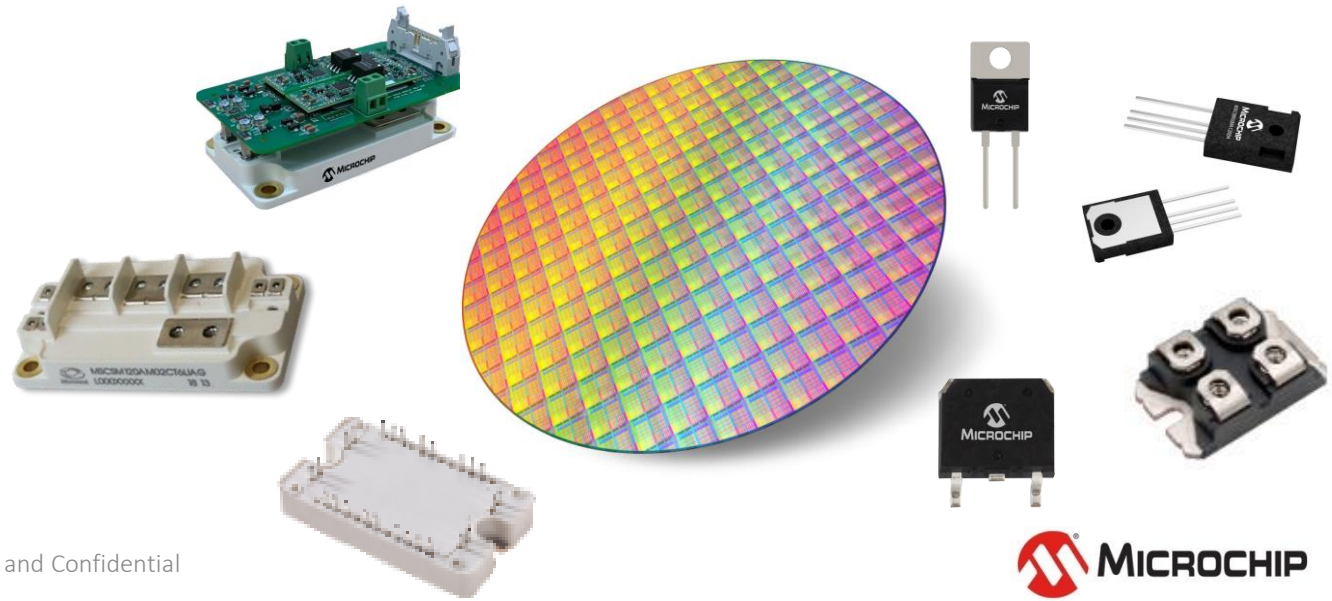
Assembly

- **Philippines**
  - TO-247, TO, 264, TO-268, SOT-227
- **Philippines**
  - TO-220, TO-247, TO-264, SOT-227
- **Microchip Philippines**
  - Modules
  - Die

Test

- Each Assembly Site performs Final Test as well
- **Microchip provides** test equipment
- Microchip controls the test program

- Continuously evaluating new vendors for quality and expansion
- Not reliant on key power semi competitor for substrate material
- Matrix qual of substrate and epi maximizing flexibility in usage combinations
- Evaluating Epi in Microchip Fab 5



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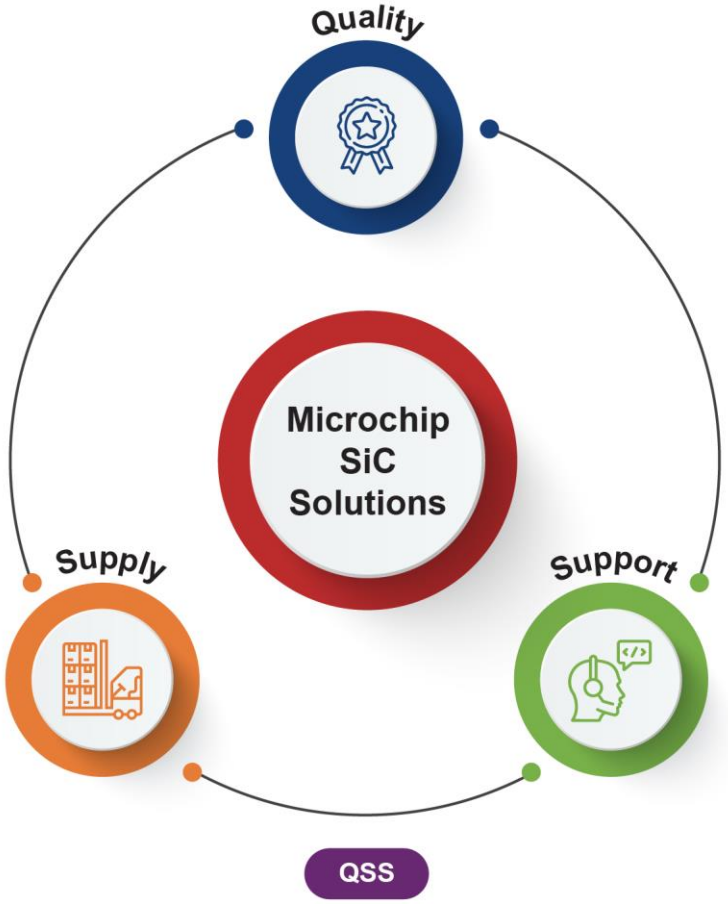
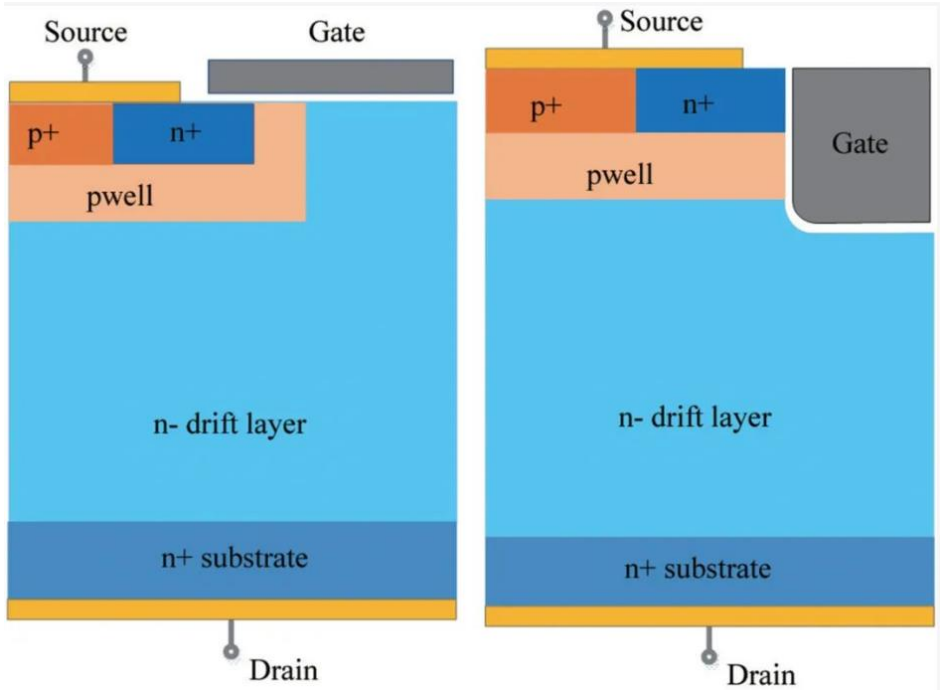
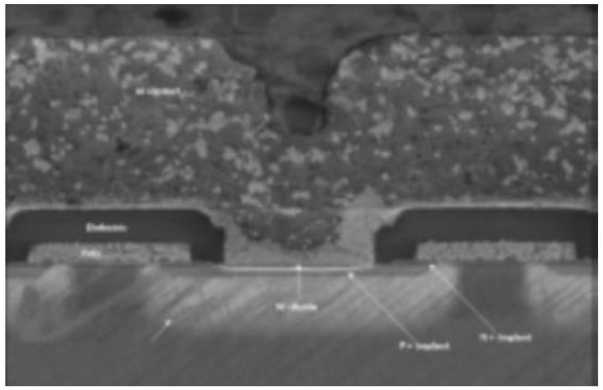
Quality: Proven Reliability and Ruggedness

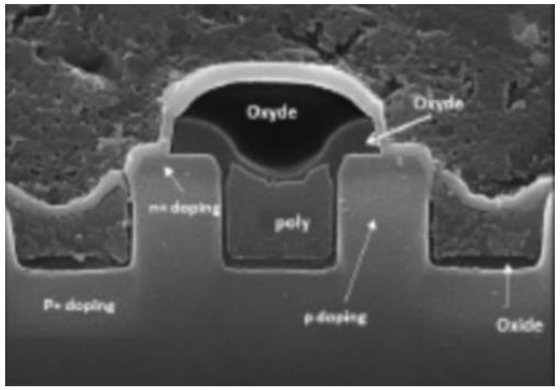


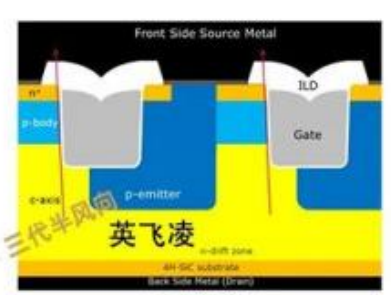
- **Designing discretes and power modules for 30+ years**
- **Proven A&D quality and expertise can be leveraged to other markets**
- **Contributing member of JEDEC JC-70 sub-committee focusing on SiC reliability and test standardization**
  - Ensures we stay on forefront of industry requirements and best practices
- **Execute "beyond datasheet" ruggedness testing (RUIS/UIS/Short Circuit) to validate design resilience and performance degradation**
  - ~1.5-2x higher UIS and RUIS performance versus competitor
  - ~1.5-5x higher Short circuit withstand rating

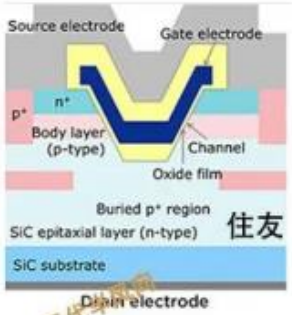
SiC MOSFET Structure

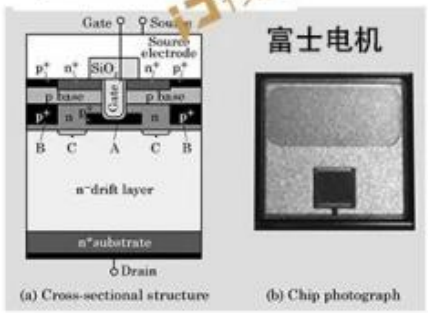


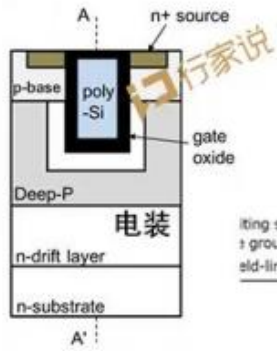


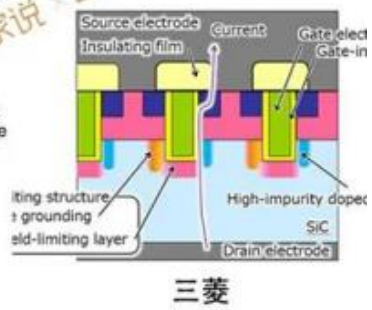












	優點	缺點	代表品牌
平面型 **Planar**	柵極氧稳定性高，抗擊穿能力高	導通内阻高	WOLFSPEED, ON, MICROCHIP
溝槽型 trench	道通内阻低	柵氧穩定性低，抗擊穿能力低	ROHM, INFINEON

SiC Reliability Considerations

Why Ruggedness Matters In Power Conversion

Power Conversion System Should:	Operate routinely & reliably	Meet or exceed desired service lifetime	Survive electrical transients
You should care about:	**Oxide stability**	Oxide stability	**Avalanche ruggedness**
	Oxide lifetime	Oxide lifetime	**Short circuit withstand**
	Body diode stability	Body diode stability (also improves cost)	
	Survivability		

Not rugged?

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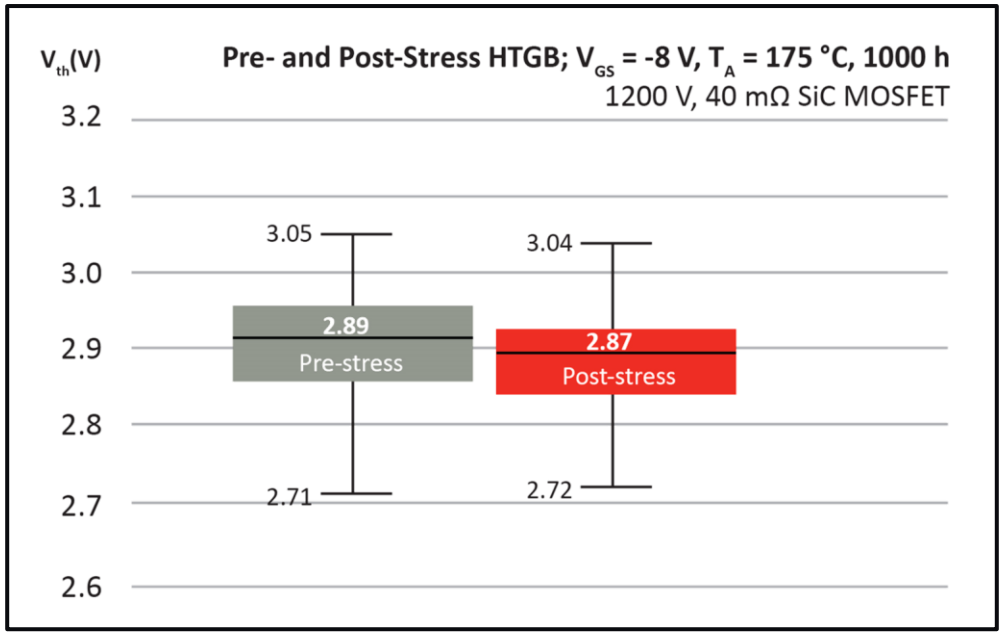
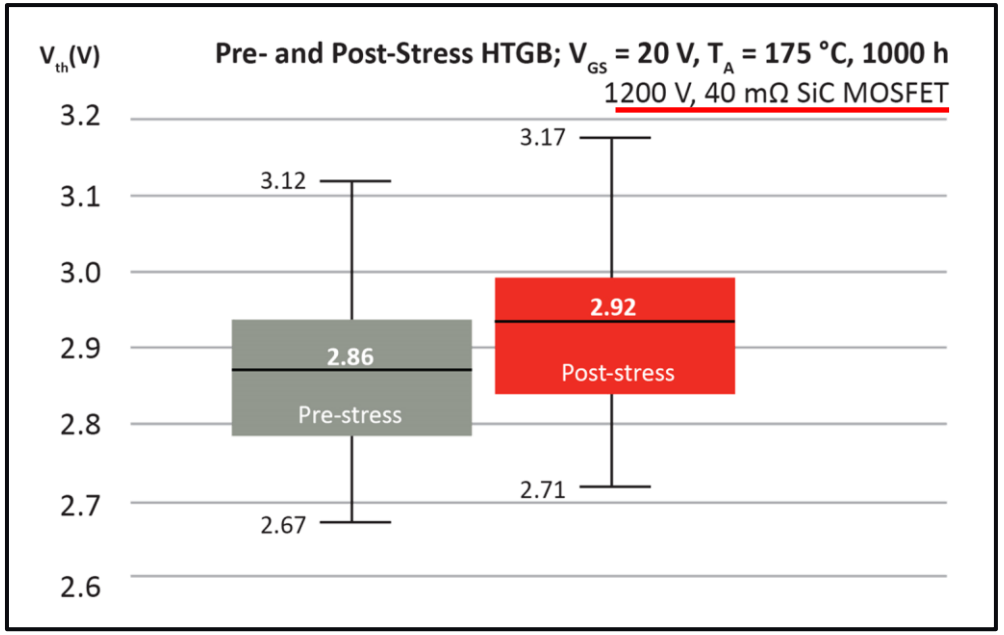
Ruggedness | *Gate Oxide Stability*

Stress: V_{GS} = -8 V, 1000 h at T_A = 175 C | Change: -0.02 V



Stress: V_{GS} = 20 V, 1000 h at T_A = 175 C | Change: +0.06 V



V_{th} measurements before and after 1000 hours of high-temperature gate bias (HTGB) stress show negligible shift.

Application benefits

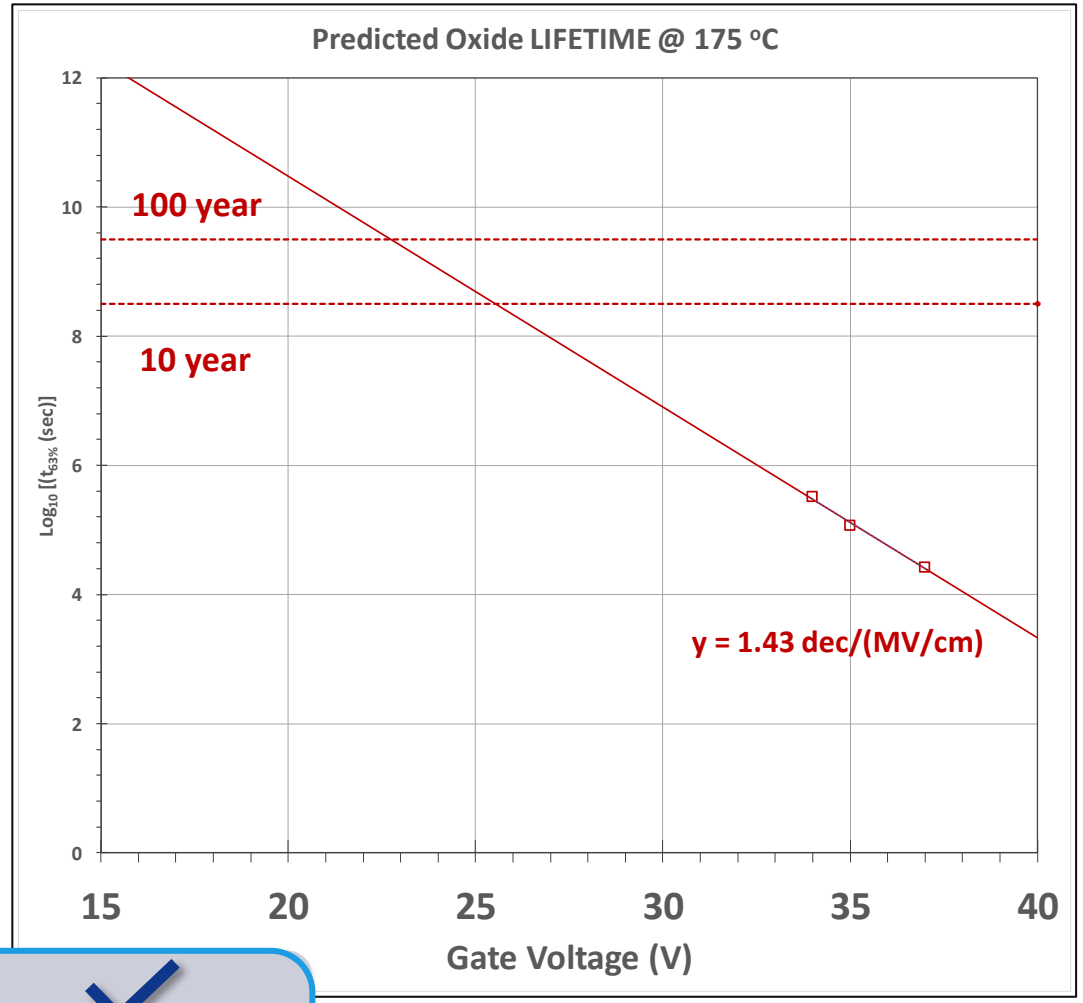
- Operate routinely & reliably
- Meet (exceed) desired service lifetime

Ruggedness | *Gate Oxide Lifetime*

*Data from production-grade **1200 V, 40 mOhm MOSFET***

i. Oxide failure (breakdown) accelerated with temperature and electric field across the oxide
ii. Failure modes extracted from **Weibull plots**
iii. Arrhenius equation used to predict oxide lifetime

Oxide predicted to last more than 100 years at recommended V_{GS} and Tj = 175 ℃ ,VGS=20V



Application benefits

- Operate routinely & reliably
- Meet (exceed) desired service lifetime
- Survive electrical transients

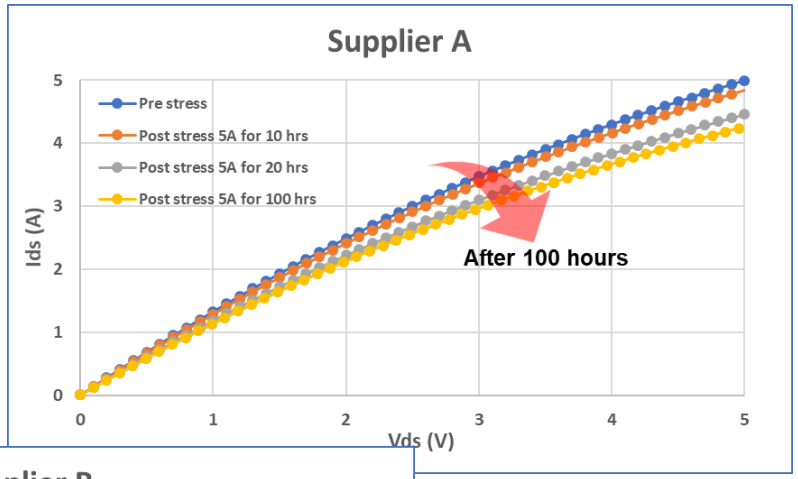
Ruggedness | *Body Diode Stability*

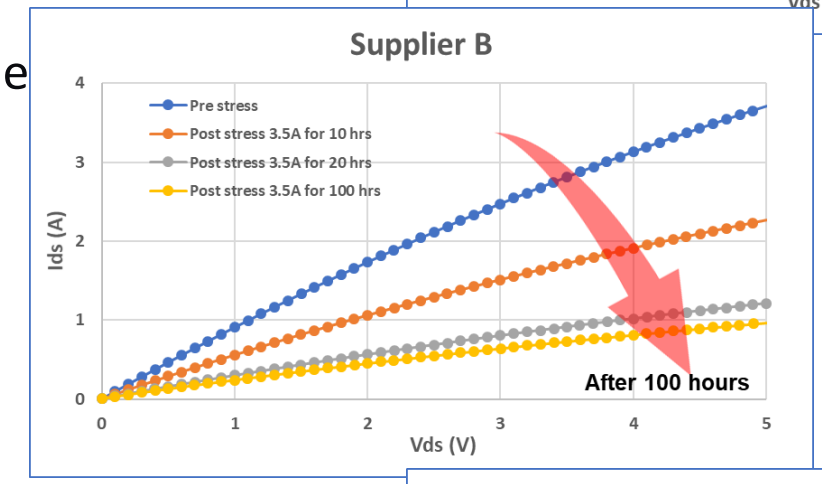
i. SiC MOSFET body diodes stressed with a constant forward current

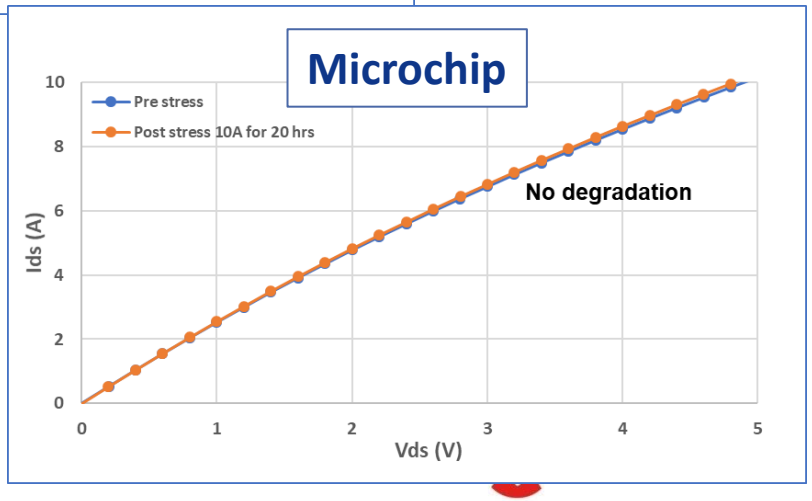
ii. Body diode I-V curves and R_{DSon} measurements made before and after stress

Data from commercially available 1200 V, 80 mOhm MOSFETs*

*Courtesy: A. Agarwal and M. Kang, Ohio State University







No degradation observed in Microchip body diodes

Also, lower component cost by using body diode and eliminating Schottky

Application benefits

- Operate routinely & reliably
- Meet (exceed) desired service lifetime

Ruggedness | *Short Circuit Capability*

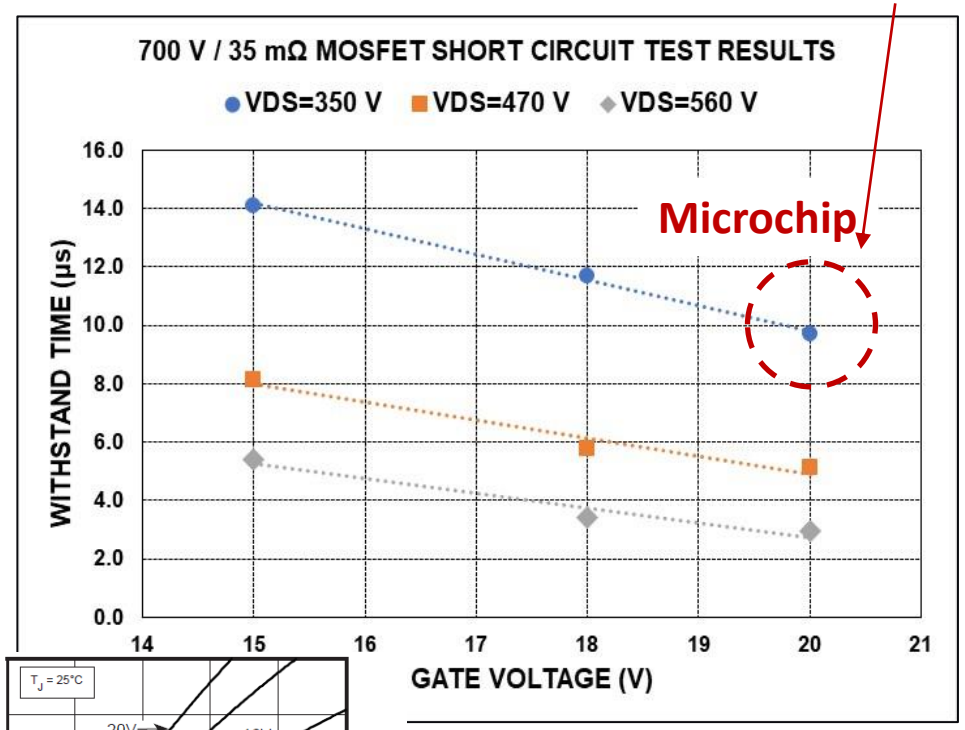
i. Short circuit emulates the application condition of shorting the MOSFET's drain-source across the dc link

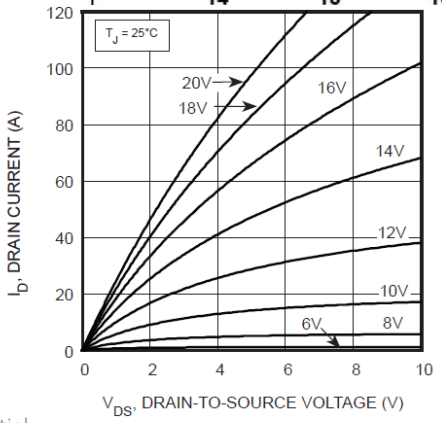
ii. Cells are enhanced (MOSFET is ON); peak current intended to distribute uniformly across die

Data from production-grade 700 V, 35 mOhm MOSFET

Designed to survive short circuit events, even at higher dc voltages (with adequate gate driver)

10 us
comparable to IGBTs





Application benefits

Safely ride through harmful electrical transients

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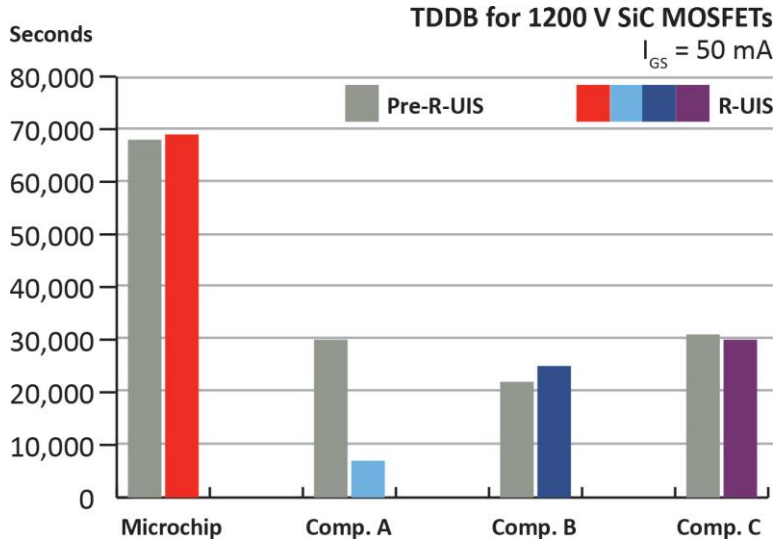
Ruggedness | *Avalanche / Repetitive-UIS*

unclamped inductive switching

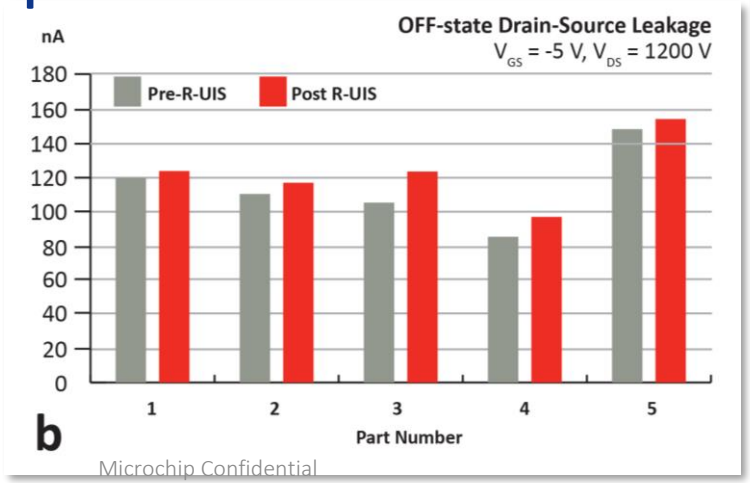
i. Measures the MOSFET's ability to repetitively sustain an avalanche current being switched off from an **unclamped inductive load** (R-UIS)

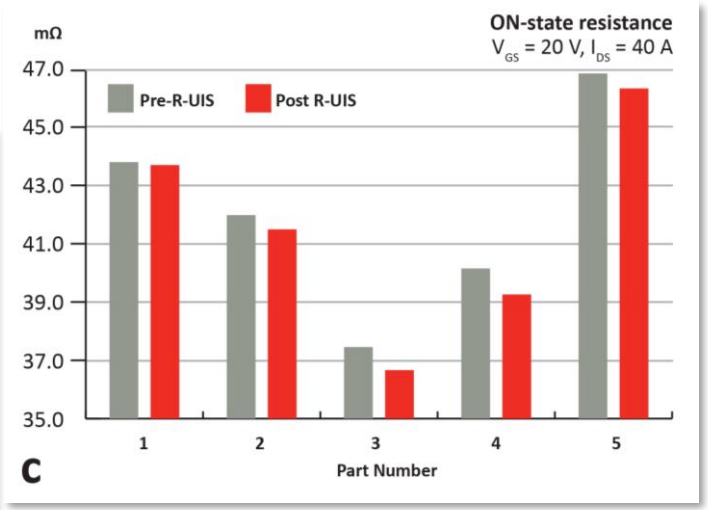
ii. Cells are not enhanced (MOSFET is OFF); peak current increases rapidly until $V_{DS} = V_{BR}$; avalanche current likely to crowd around die edge

Data from commercially available 1200 V, 80 mOhm MOSFETs



Microchip devices show excellent avalanche ruggedness and parametric stability following 100K pulses of R-UIS





Application benefits

Safely ride through harmful electrical transients

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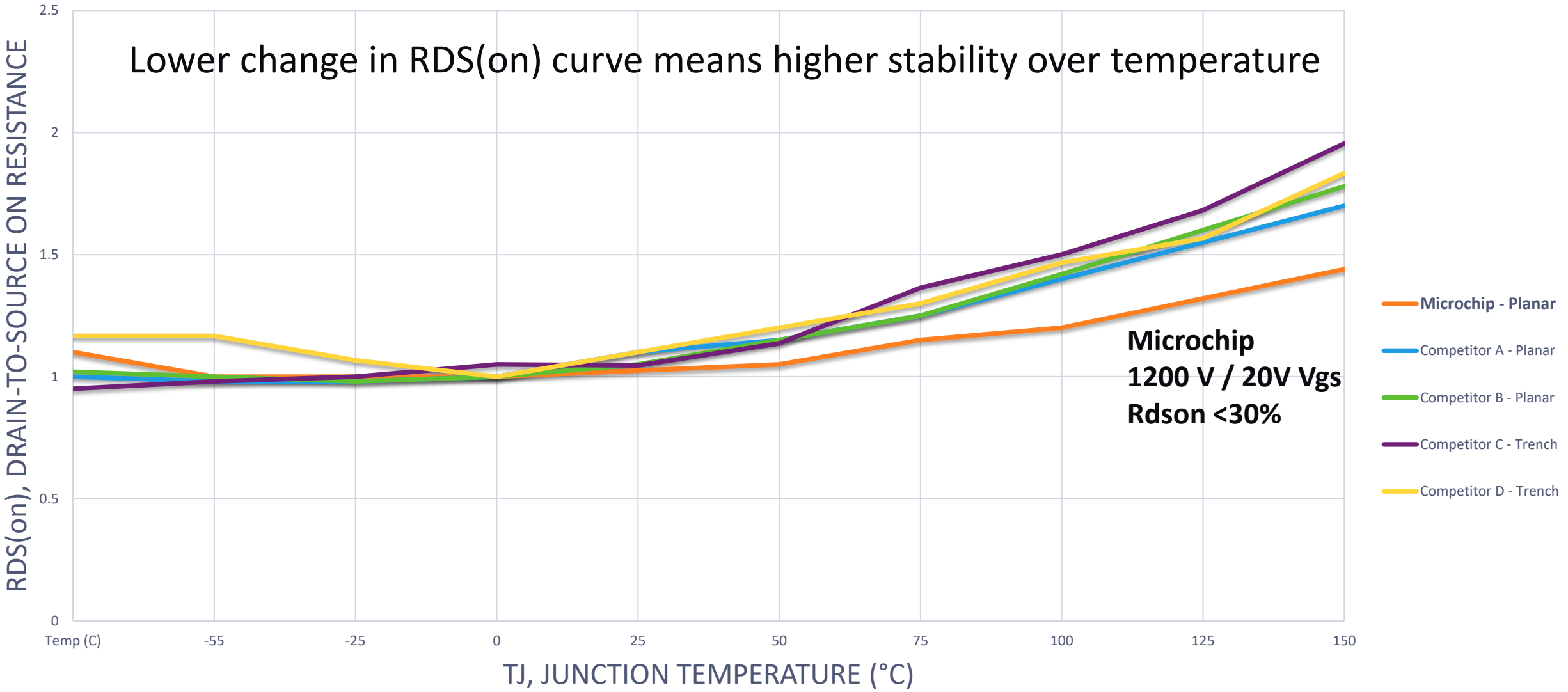
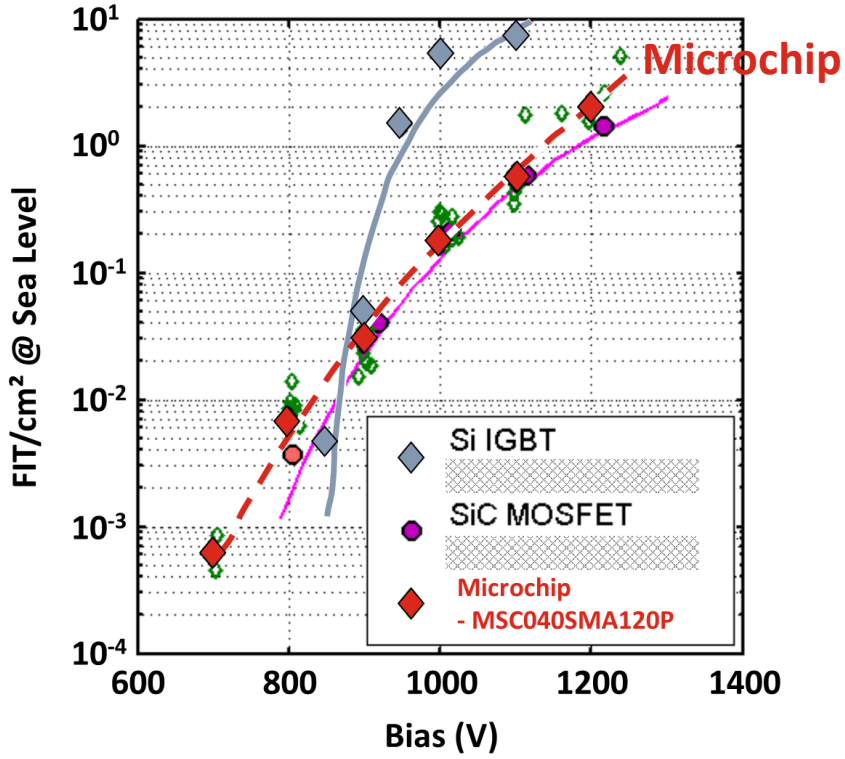
Ruggedness | *RDSon Vs. Temperature*

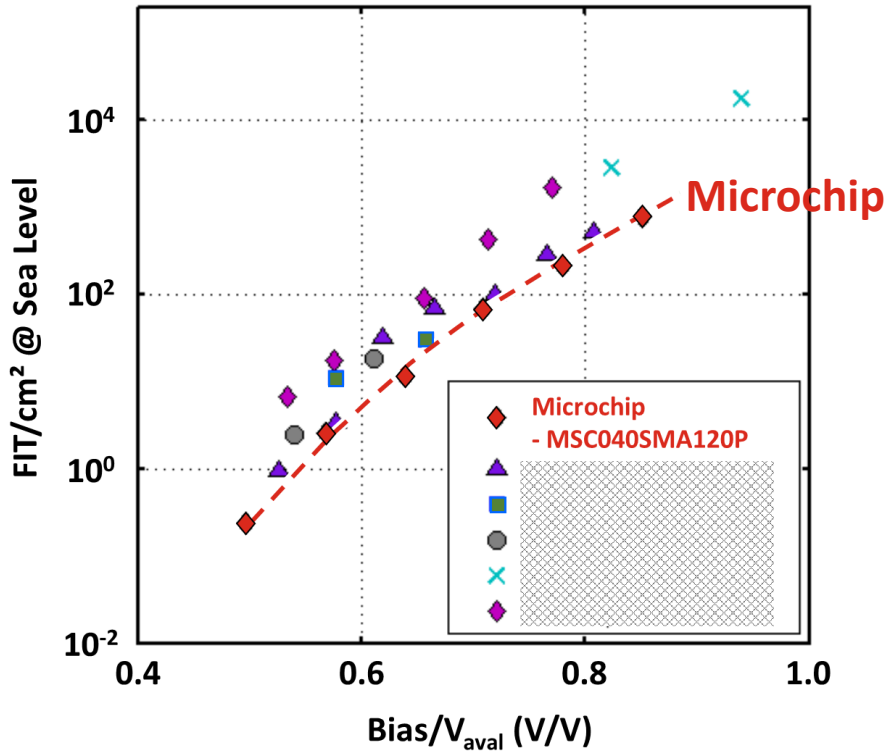


Ruggedness | *Terrestrial Neutron Susceptibility*

- Neutrons can damage or degrade system performance at sea level or in higher elevations
- **Application benefit: Using SiC provides higher immunity to terrestrial radiation and lowers FIT rate across low to high elevations**



SiC MOSFETs have 10X lower FIT rate than comparable Si IGBTs @ rated voltage



Microchip SiC MOSFETs perform well against SiC competition regarding neutron irradiation

Support: Standard and Custom Products

- Standard and custom die, discrete and module options
- Models and Simulation
  - a. Silicon Carbide Products SPICE & PLECS Files
  - discrete: Diodes, Mosfets
  - b. Vienna 3-phase ref-design & PLECS Model
- Evaluation Kits and Reference Designs
  - a. 150KVA 3-phase SiC power stack evaluation kit.
  - b. SiC Digital Gate Driver Development Kits
  - c. E-Fuse User Guide (EVB kits coming soon)
- Local Sales, ESEs , BU, AEs supports

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Thank You

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