GeneSiC™ SEMICONDUCTOR

Energy Efficiency Through Innovation

Company Introduction

October 2020

Introduction

Founded in 2004

USA

10 + Patents

SiC

Research Funding

US Govt.

GeneSiC is dedicated to providing SiC power devices that offer -

- ✓ Best-in-class performance and reliability with innovative technology
- ✓ Highest quality
- ✓ Competitive pricing and high-volume turnaround with low lead times
- ✓ Comprehensive portfolio applicable to wide range of applications (100+ SiC products)
- ✓ Strong product and customer support

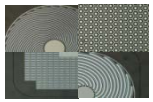
History (2004 – 2012)

2004

Company Founded

GeneSiC Semiconductor Inc. founded by Dr. Ranbir Singh (President) as a Maryland registered company

2006



SiC Patents

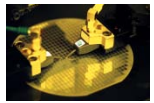
First patents on SiC devices issued

2007

New Facility

Company HQ moved to the present facility in Dulles, VA near the IAD airport

2009



SiC Schottky Gen1
SiC Thyristor Gen1

First generation prototypes of SiC schottky diodes (1200V and 1700V) and thyristors (6.5 kV) developed

2010

MOUSER ELECTRONICS

Premier Farnell

SiC Schottky Release
Mouser, Farnell

First broad-line distributors appointed for commercial sale of GeneSiC's products

SiC schottky Gen1 introduced to the market through Mouser and Farnell

2011

R&D 100 CONFERENCE & AWARDS

Digi-Key ELECTRONICS

ARROW

R&D 100 Award
Digi-Key, Arrow
US Sales Reps

Won prestigious US R&D 100 award for SiC Thyristors

New distributors and sales reps

2012

SiC Schottky Gen2
SiC Transistor Gen1
OSAT Partners

First generation of SiC Junction Transistors (1200V & 1700V)

Over-seas assembly & test partners

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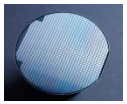
History (2012 – Present)

2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020

SiC Junction Transistors High Power Market Leader

Highest power rated SiC power devices in the commercial market :

- 1700V 10mΩ SiC Transistor
- 1200V 200A SiC Schottky Diode



150 mm (6 inch) Wafers Gen1 SiC MOSFETs

Initiated transition to 150 mm wafers with X-Fab and started development of Gen1 SiC MOSFETs

Recognized with industry's best performing SiC diodes

3.3kV SiC MOSFETs

350mΩ (5A) 3.3kV SiC MOSFET engineering sample with high performance and ruggedness, delivered to key collaborators

X-Fab, Texas Distributors - Asia

Transition to X-Fab (automotive qualified) completed and full production lines for all SiC diodes and SiC MOSFETs on 150 mm wafers.

New distributors in CN, JP, HK and KR

1700V Schottky MPS™ 3300V Schottky MPS™ Distributors - EMEA

Released Gen3 1700V and 3300V SiC Schottky MPS™ Diodes – industry's most comprehensive portfolio.

650V Schottky MPS™ SiC MOSFETs (Gen2)

Initiated release of commercial Gen2 SiC MOSFETs to key customers.

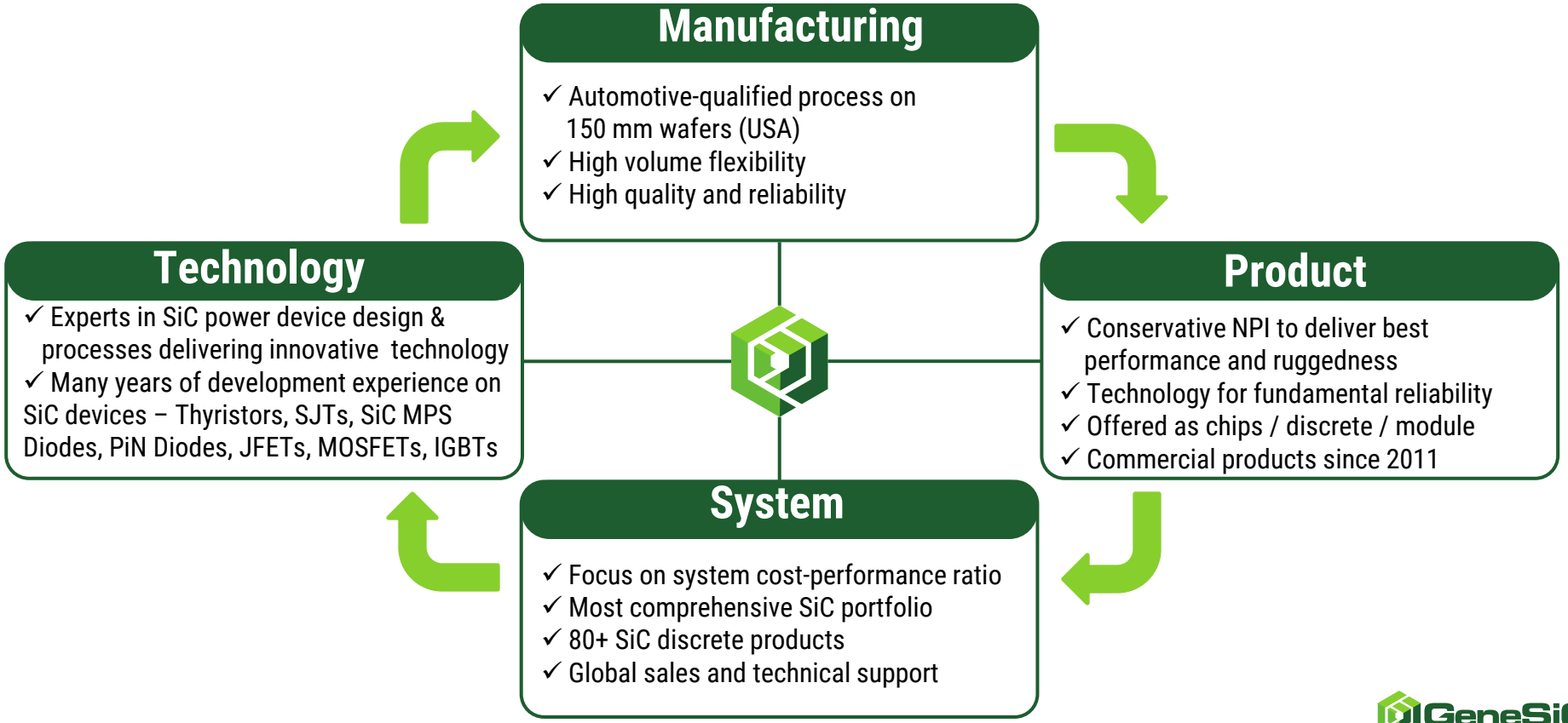
Industry's highest power rated Gen3 650V SiC Schottky MPS™ - 50A, 100A and 200A

MOSFETs (G3R™) Schottky MPS™ (Gen4)

Full portfolio release –

- Gen3 SiC MOSFETs (G3R™) – 1200V, 1700V and 3300V
- Gen4 SiC Scottky MPS – 650V, 1200V and 1700V

Why GeneSiC ?



GeneSiC SEMICONDUCTOR

Sales and Distribution

- ✓ Global Sales and Technical Support
- ✓ Broad-line Worldwide Distributors
  - Arrow Electronics
  - Digi-Key Electronics
  - Mouser Electronics
  - Newark / Farnell / Element14
- ✓ Local FAE and FSE Support in 20+ Countries
- ✓ Strong Sales-Rep Network in North America
- ✓ Easy Sample Availability and Industry's Lowest Lead Times
- ✓ Most Comprehensive SiC Portfolio – 100+ SiC Products

CONQUER 港晟國際

Premier Farnell

Newark

element14

alfatec

MASTER ELECTRONICS

ALENERGY

MELBRIN KOREA Co., Ltd.

SHINETECH ELECTRICAL TECHNOLOGY CO., LTD.

Iberica Semiconductores de potencia S.L.

Sinox

NAC

DACPOL

COMPOMILL Nordic Components

TEM Electronic Components

RICHWOOD ELECTRONICS CO., LTD. 豐林電子有限公司

SemiSolution Supply

GeneSiC SEMICONDUCTOR

Commercial Products

Silicon Carbide

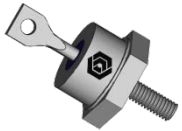
(100 + Products)

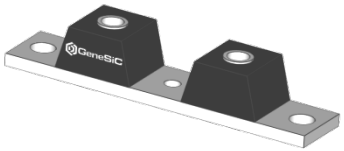
- SiC MOSFET
- SiC Schottky MPS™
- SiC Module
- SiC PiN Diode
- SiC Junction Transistor
- SiC Custom Services

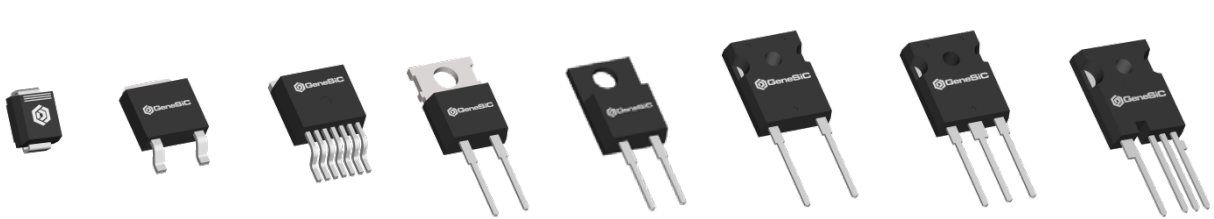
Silicon

(1500 + Products)

- Rectifier Module
- Stud Rectifier
- Bridge Rectifier



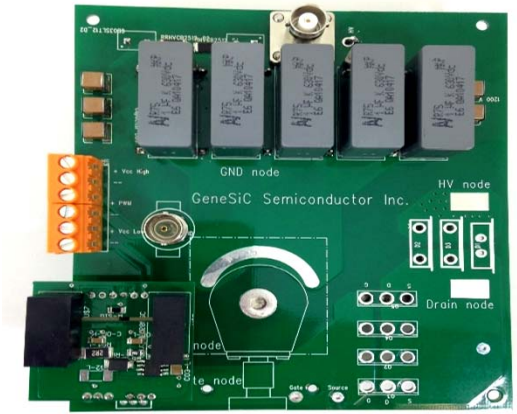




GeneSiC SEMICONDUCTOR

Product Support

- ✓ Industry's **most detailed and accurate datasheets**
- ✓ Detailed and accurate **SPICE** models (**Level-I and Level-III**) for ALL its products; PLECS models coming soon
- ✓ Customer designs can be simulated by GeneSiC engineers on LTSPICE upon request
- ✓ High quality, cost effective **gate driver boards** and **evaluation boards** for benchmarking SiC devices. Gerber files, BOMs and design notes available
- ✓ **SiC custom services** based on customer's needs (Example - device voltage, current ratings, package types, lead finishes etc.)
- ✓ Competitor **cross-references** on website
- ✓ **Application Notes** and **Technical Articles**



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Awards and Recognitions

- ✓ 2011 → R&D100 Award : Ultra-high Voltage SiC Thyristor (6.5kV)
- ✓ 2016 → GeneSiC named among Top-30 Power Semiconductor Companies by EETimes
- ✓ 2016 → EETimes recognized GeneSiC's Founder as "Forty of the Top Innovators Changing the Face of Electronics"
- ✓ 2019 → R&D100 Award : SiC-based Monolithic Transistor-Rectifier Semiconductor Switch

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Why SiC ?

Intrinsic properties

- 3X Thermal conductivity of Si
- 3X High bandgap of Si → 10 X high breakdown field

Device performance

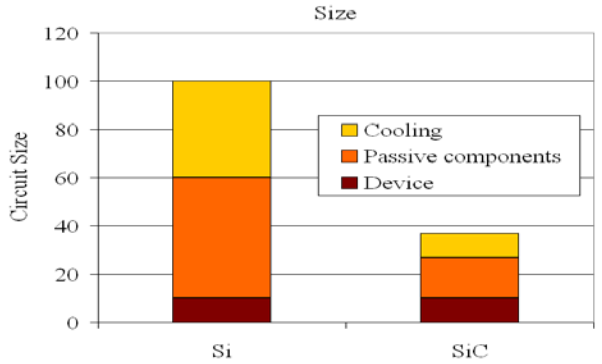
- High current density
- Fast switching
- Low Rdson

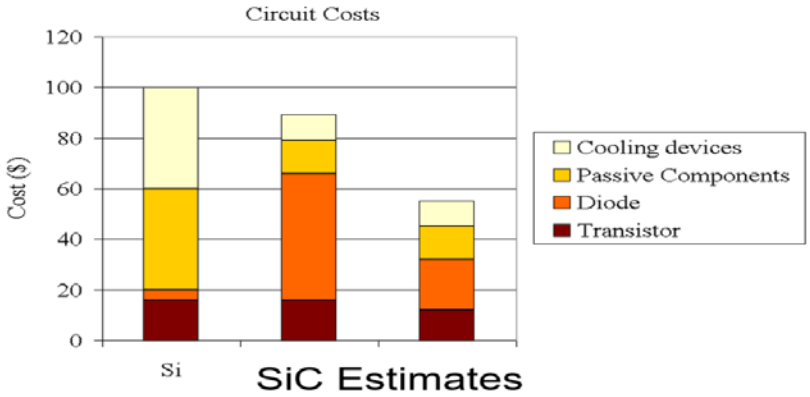
System benefits

- High temperature operation
- System size and weight reduction
- Reduction of conduction and switching loss

SiC is Critical for High Power Density

- ✓ SiC devices allow **higher frequency** of power conversion (>10kHz v/s <1kHz)
- ✓ High power conversion **efficiency** (3-6x lower power losses)
- ✓ SiC based circuits estimated to be **1/3rd in size / weight** of Si circuits
- ✓ The **cost** of a SiC circuit estimated to be **50% less** of a comparable circuit of Si even with higher priced devices
- ✓ **Simplification** of power conversion circuits (2 level instead of 5 level voltage stages)
- ✓ Efficient **high temperature** operation





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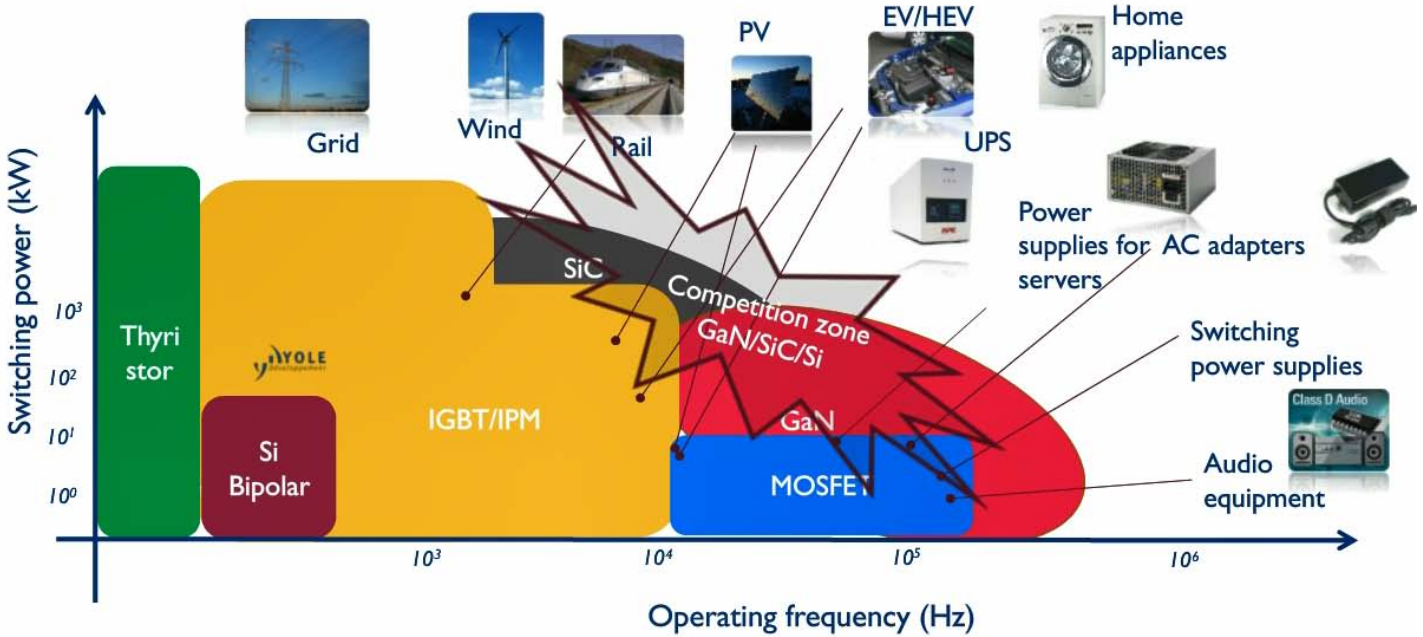
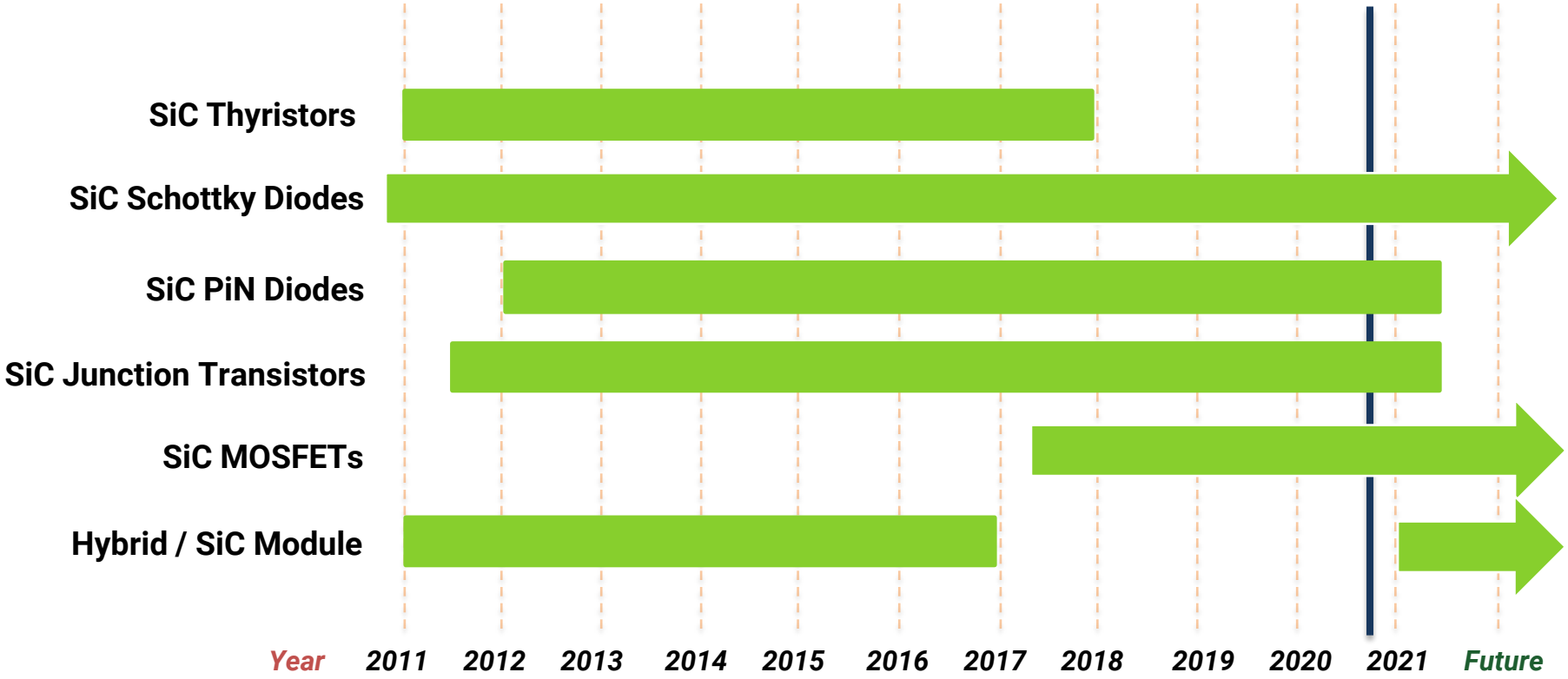
Applications for SiC Devices



SiC is promising for applications that require >10 kHZ switching frequency and/or >350/400 V bus voltage rating

GeneSiC's SiC Power Device History



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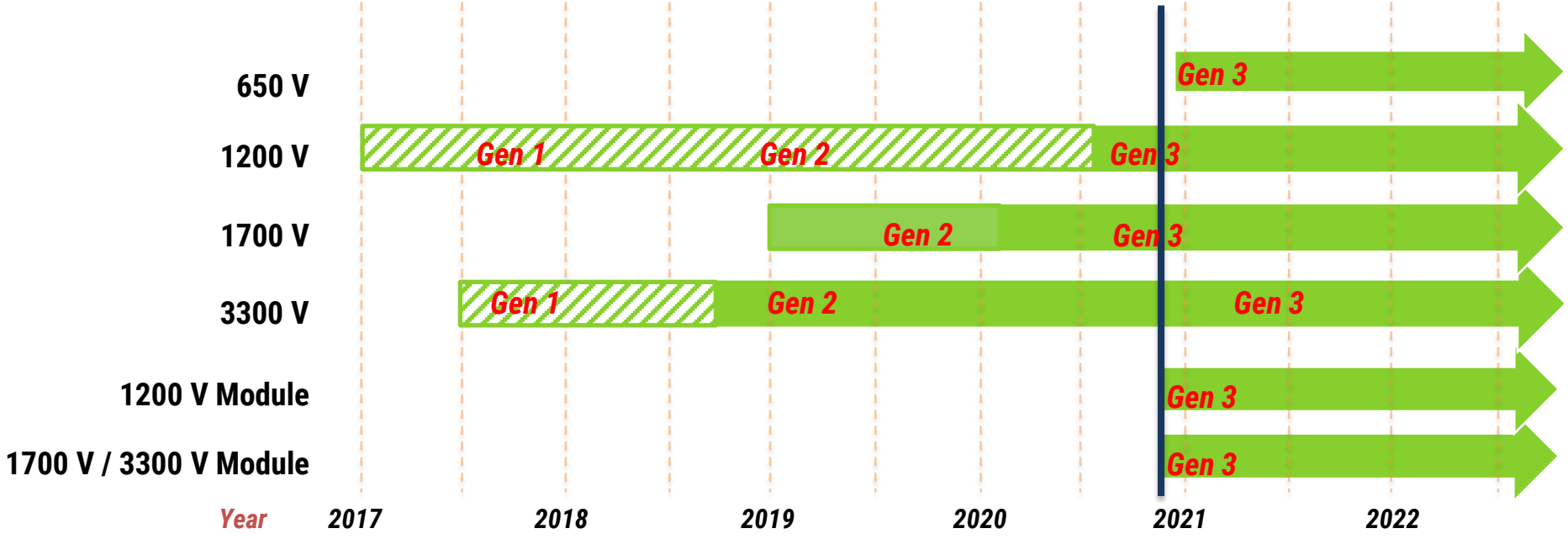
SiC MOSFET Technology Roadmap

Gen 1 100mm,MOS Optimized Low $R_{DS(ON)}$-sp Planar MOSFET Process

Gen 2 150mm, High Short Ckt and E_{AS} Design

Gen 3 150mm, Industry's Lowest $R_{DS(ON)}$-sp High Short-Ckt and E_{AS}, High Reliability



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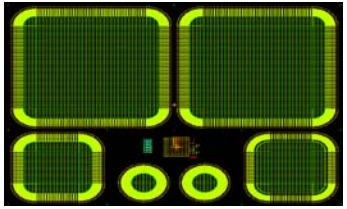
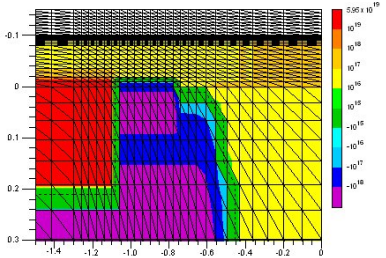
Expertise Areas

SiC Device Design & Concepts

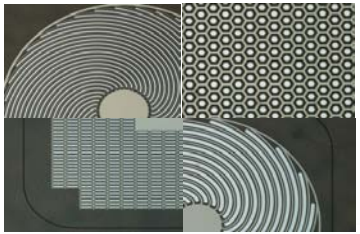
- ✓ Experts in SiC designs and concepts
- ✓ 2D device simulations and layout





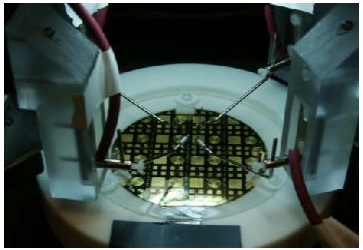
Device Fabrication

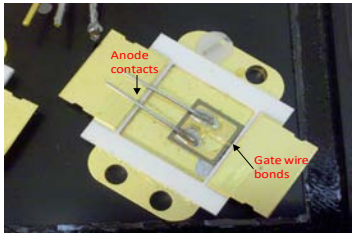
- ✓ Novel fabrication techniques for SiC
- ✓ State-of-the-art foundry for automotive qualified processes



Testing & Packaging

- ✓ On-wafer and packaged parts tested in-house at GeneSiC
- ✓ Packaging with high volume partners





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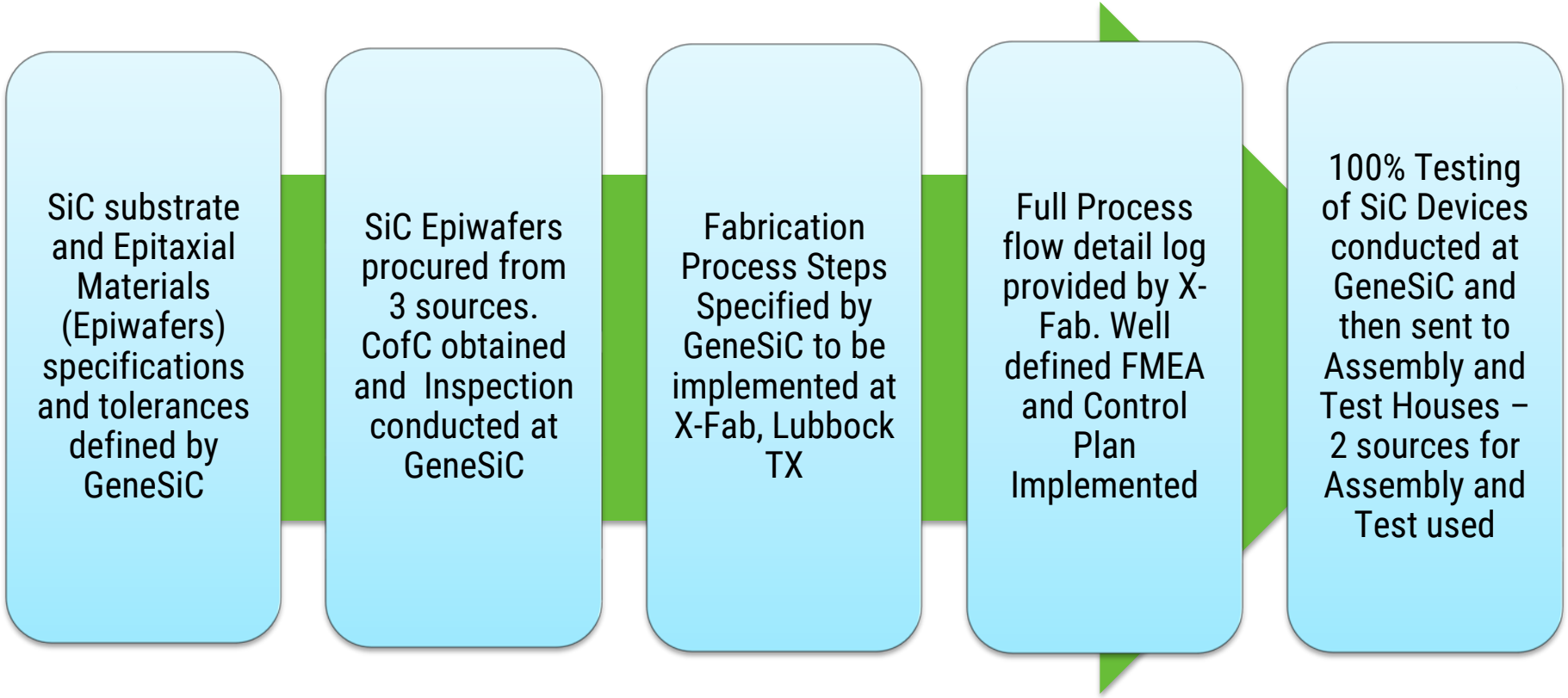
Foundry Strength

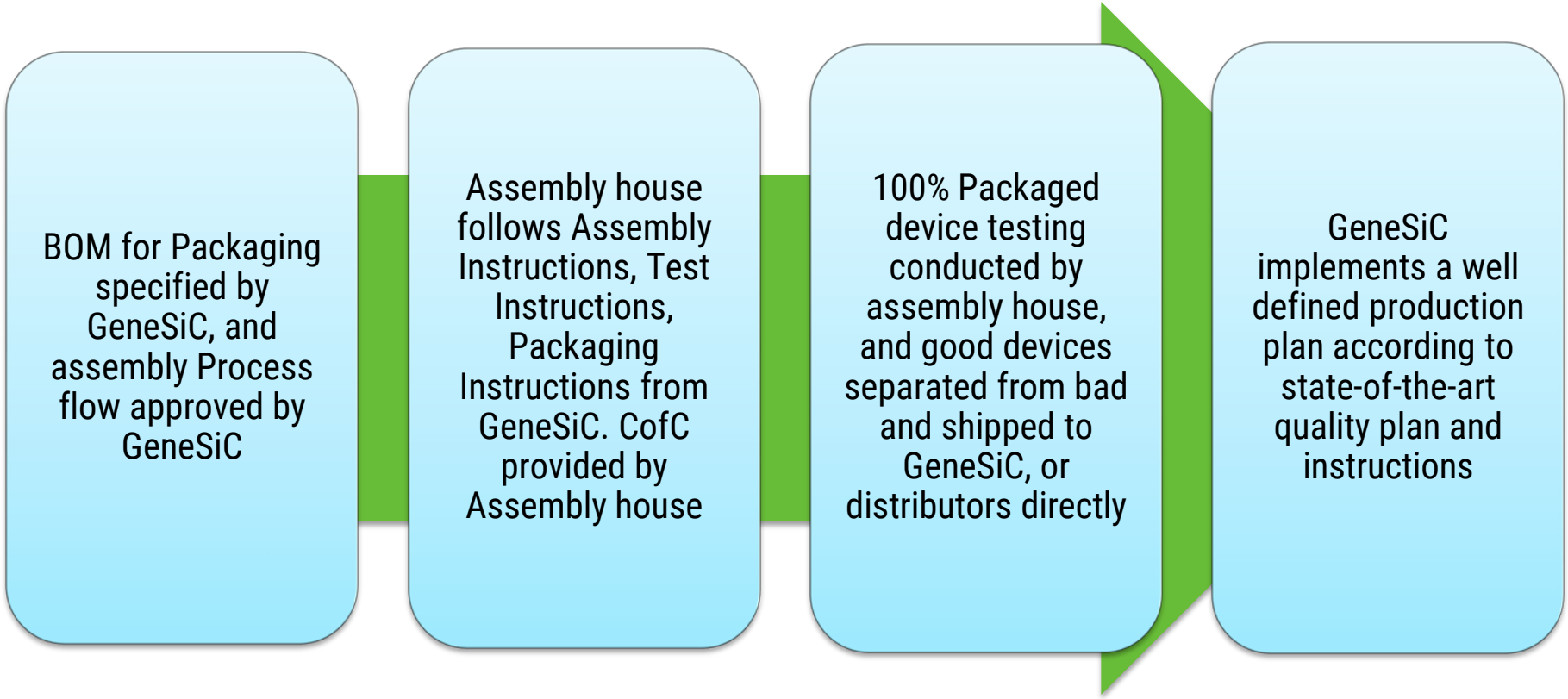
	GeneSiC (X-Fab, USA)	Competitor(s)
Wafer Size	6 inch (150 mm) – Since 2015	4 inch (100 mm)
Epi-Wafer Quality	Best in the market	Captive / less aware of top-quality suppliers
Fabrication Equipment	State-of-the-art fully automated, Class-10 CMOS line; Automotive qualified; 35k Wafers / Month	Previous generation, 4 inch partially automated line; 10k Wafers / Month
Quality Standard	ISO-TS16949, Highest automotive standards for 15 years	Legacy, non-automotive standards
Cost Structure	Scalable, 6 inch wafers offer 2.25x devices than 4 inch wafers	High fixed and running costs
Process Innovation	Fast turn-arounds; leverage large scale silicon innovations	Legacy knowledge-base with lack of cross-fertilization of silicon innovations

Design, Fabrication and Testing (1 of 2)



GeneSiC SEMICONDUCTOR

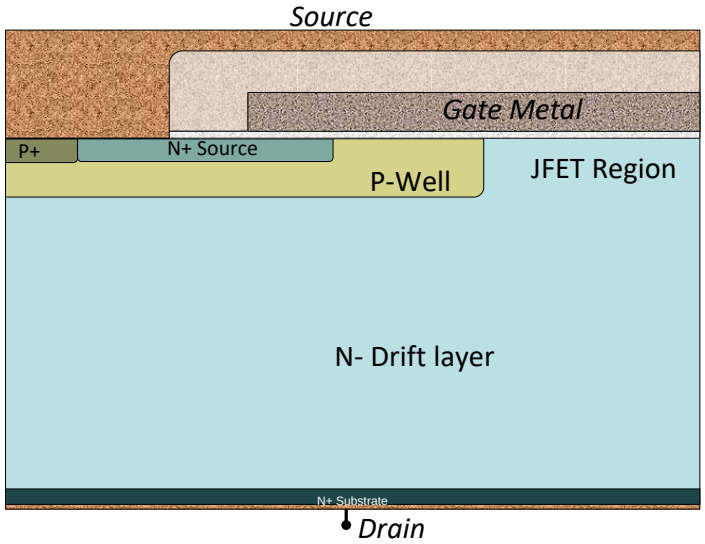
Design, Fabrication and Testing (2 of 2)



Technology for Fundamental Reliability

Standard DMOSFETs for highly uniform production and robust and reliable performance –

- ✓ Low drain-source resistance, $R_{DS(ON)}$
- ✓ Low gate charge and device capacitances for superior switching figure-of-merit (FOM)
- ✓ Robust design for high avalanche ruggedness
- ✓ Low conduction loss at high temperatures
- ✓ Fast and reliable intrinsic diode with low reverse recovery charge
- ✓ Low costs at high volumes



MOSFET Technology Comparison

	Planar	Trench
Pros	Less Complex Manufacturing Process Higher Reliability Better Ruggedness	(Potential) Reduction of On-Resistance Lower Gate Charge (Better Figure-of-Merit)
Cons	-	Poor Reliability of Gate Oxide in Trench Structure Poor Ruggedness (Avalanche and Short Circuit) Poor $R_{DS(ON)}$ v/s Temperature Dependence
Main Players	GeneSiC Semiconductor Wolfspeed / Cree ST Microelectronics ON Semiconductor / Fairchild Mitsubishi Microsemi Littelfuse	ROHM Infineon

650V SiC Schottky MPS™







	DO-214	TO-252-2	TO-263-7	TO-220-2	TO-247-2	TO-247-3	SOT-227
1 A	GB01SLT06-214						
4 A		GE04MPS06E		GE04MPS06A			
6 A		GE06MPS06E		GE06MPS06A			
8 A		GE08MPS06E		GE08MPS06A			
10 A		GE10MPS06E		GE10MPS06A			
12 A				GE12MPS06A			
16 A						GE2X8MPS06D	
20 A						GE2X10MPS06D	
30 A			GD30MPS06J	GD30MPS06A	GD30MPS06H		
50 A					GC50MPS06-247		
60 A							GD2X30MPS06N
100 A							GC2X50MPS06-227
200 A							GC2X100MPS06-227

Gen3 (Production) *Gen4 (November 2020)* *Gen5 (November 2020)*

GeneSiC SEMICONDUCTOR

1200V SiC Schottky MPS™

	DO-214	TO-252-2	TO-220-2	TO-247-2	TO-247-3	SOT-227	Bare Chip
1 A	GB01SLT12-214	GB01SLT12-252					
2 A	GB02SLT12-214	GB02SLT12-252	GC02MPS12-220				
2 A		GD02MPS12E					
5 A		GC05MPS12-252	GC05MPS12-220				
8 A		GC08MPS12-252	GC08MPS12-220				
10 A		GC10MPS12-252	GC10MPS12-220		GC2X5MPS12-247		
15 A			GC15MPS12-220	GC15MPS12-247	GC2X8MPS12-247		
20 A			GC20MPS12-220	GC20MPS12-247	GC2X10MPS12-247		
30 A					GC2X15MPS12-247		GD30MPS12-CAL
40 A					GC2X20MPS12-247		
50 A				GC50MPS12-247			GD50MPS12-CAL
60 A						GD2X30MPS12N	
100 A						GB2X50MPS12-227	GD100MPS12-CAL
200 A						GB2X100MPS12-227	

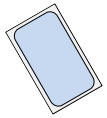
Gen3 (Production)

Gen4 (GD Series) – Production

GeneSiC SEMICONDUCTOR

1700V – SiC Schottky MPS™



		TO-263-7 (D2PAK-7L)	TO-247-2	SOT-227	Bare Chip
1700 V SiC Schottky MPS™	5 A	GB05MPS17-263 *Production*	GB05MPS17-247 *Production*		
	10 A		GB10MPS17-247 *Production*		
	10 A		**GD10MPS17H** *December 2020*		
	25 A		GB25MPS17-247 *Production*		
	50 A		GB50MPS17-247 *Available*		
	75 A				**GD75MPS17-CAL** *Production*
	100 A			GB2X50MPS17-227 *Production*	
	150 A			**GD2X75MPS17N** *November 2020*	

Availability Timeline

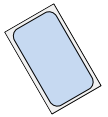
Gen3 (Production)

Gen4 (GD Series)

GeneSiC SEMICONDUCTOR

3300V – SiC Schottky MPS™



		DO-214 (SMB)	TO-263-7 (D2PAK-7L)	TO-220-FP	Bare Chip
3300 V SiC Schottky MPS™	0.3 A	GAP3SLT33-214 *Production*		GAP3SLT33-220FP *Production*	
	5 A		GB05MPS33-263 *Production*		
	50 A				GC50MPS33-CAL *Production*

Availability Timeline

GeneSiC SEMICONDUCTOR

650V – SiC MOSFETs





		TO-263-7 (D2PAK-7L)	TO-247-3	TO-247-4	SOT-227	Bare Chip
650 V SiC MOSFETs (G3R™)	15 mΩ		G3R15MT06D *February 2021*	G3R15MT06K *February 2021*		G3R15MT06-CAL *February 2021*
	60 mΩ	G3R60MT06J *December 2020*	G3R60MT06D *December 2020*	G3R60MT06K *December 2020*		

Availability Timeline

SiC Modules Under Development …

GeneSiC SEMICONDUCTOR

1200V SiC MOSFETs (G3R™)





		TO-263-7 (D2PAK-7L)	TO-247-3	TO-247-4	SOT-227	Bare Chip
1200 V SiC MOSFETs (G3R™)	13 mΩ				G3R13MS12N *December 2020*	G3R13MS12-CAL *December 2020*
	20 mΩ			G3R20MT12K *December 2020*	G3R20MT12N *December 2020*	G3R20MT12-CAL *Available*
	30 mΩ	G3R30MT12J *December 2020*		G3R30MT12K *December 2020*		G3R30MT12-CAL *Available*
	40 mΩ	G3R40MT12J *December 2020*	G3R40MT12D *December 2020*	G3R40MT12K *December 2020*		G3R40MT12-CAL *Available*
	75 mΩ	G3R75MT12J *November 2020*	G3R75MT12D *November 2020*	G3R75MT12K *December 2020*		G3R75MT12-CAL *Available*
	160 mΩ	G3R160MT12J *December 2020*	G3R160MT12D *December 2020*			
	350 mΩ	G3R350MT12J *October 2020*	G3R350MT12D *October 2020*			

Availability Timeline

SiC Modules Under Development …

GeneSiC SEMICONDUCTOR

1700V – SiC MOSFETs

G2R™ = +20 V / -5 V Gate Drive

G3R™ = +15 V / -5 V Gate Drive




		TO-263-7 (D2PAK-7L)	TO-247-3	TO-247-4	SOT-227	Bare Chip
1700 V SiC MOSFETs	13 mΩ				G3R13MS17N *December 2020*	G3R13MS17-CAL *December 2020*
	20 mΩ			G3R20MT17K *December 2020*	G3R20MT17N *December 2020*	G3R20MT17-CAL *November 2020*
	45 mΩ		G3R45MT17D *November 2020*	G3R45MT17K *December 2020*		G3R45MT17-CAL *November 2020*
	450 mΩ	G3R450MT17J *December 2020*	G3R450MT17D *December 2020*			
	1000 mΩ	G2R1000MT17J *Production*	G2R1000MT17D *Production*			

Availability Timeline

SiC Modules Under Development …

GeneSiC SEMICONDUCTOR

3300V – SiC MOSFETs

		TO-263-7 (D2PAK-7L)	Bare Chip
3300 V SiC MOSFETs	50 mΩ		G2R50MT33-CAL *Production*
	120 mΩ	G2R120MT33J *October 2020*	G2R120MT33-CAL *Production*
	450 mΩ	G2R450MT33J *December 2020*	
	1000 mΩ	G2R1000MT33J *Production*	

Availability Timeline

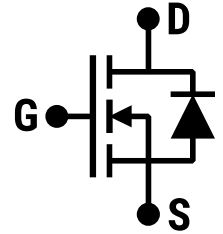
SiC Modules Under Development …

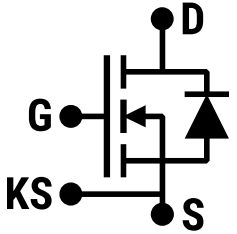
GeneSiC SEMICONDUCTOR

Nomenclature – SiC MOSFET

G	3	R	75	MT	12	D

- ***G3*** – GeneSiC Semiconductor 3rd Generation SiC MOSFET (G3R™)
- ***R/S*** – $R_{DS(ON)}$ Rating (mΩ) / Special Customizations
- ***75*** – Typical On-State Resistance ($R_{DS(ON)}$) at 25°C
- ***MT/MS*** – MT = Planar MOSFET; MS = Integrated-Schottky MOSFET
- ***12 , 17 , 33*** – Breakdown Voltage Multiplier * 100 (V)
- ***D*** – Industry Standard Package Code
  - ***J*** – TO-263-7 (D2PAK-7L)
  - ***D*** – *TO-247-3*
  - ***K*** – *TO-247-4*
  - ***N*** – *SOT-227*
  - ***CAL*** – *Bare Chip*





GeneSiC SEMICONDUCTOR

Nomenclature – SiC Schottky MPS™

G	C	2X	10	MPS	12	247

- ***G*** – GeneSiC Semiconductor
- ***B, C, D, E***– Technology Generation (B/C – Gen3; D – Gen4; E – Gen5)
- ***2X*** – Common Cathode or Dual Diode (or Blank if Standard Diode)
- ***10*** – Forward Current (A) Rating at Rated Forward Voltage (V_F)
- ***MPS , SLT , SHT*** – Schottky MPS™ Series (Merged-PiN-Schottky); SLT / SHT – Schottky JBS
- ***06 , 12 , 17 , 33*** – Repetitive Peak Reverse Voltage Multiplier * 100 (V)
- ***220 , A*** – Industry Standard Package Code
  - ***214*** – DO-214
  - ***252 , E*** – TO-252-2 (DPAK-2L)
  - ***263 , J*** – TO-263-7 (D2PAK-7L)
  - ***220 , A*** – TO-220-2 or TO-220-FP
  - ***247 , H / D*** – *TO-247-2 (H) or TO-247-3 (D) (Common Cathode)*
  - ***227 , N*** – *SOT-227 (Dual Diode - Module)*

Packages / Configurations

Standard

DO-214 (SMB)

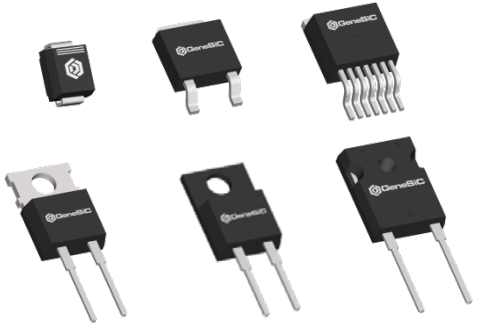
TO-252-2 (DPAK)

TO-263-7 (D2PAK)

TO-220-2

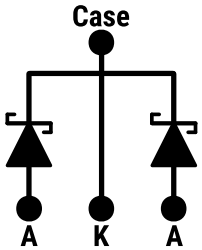
TO-220-FP

TO-247-2



Common Cathode

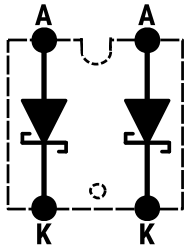
TO-247-3



Dual Diode

SOT-227

(Isolated Base-plate)



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