



G2S – The new all in one solution replacing Si and SiC

PCIM 2026

G2S™ Basics

G2S™ in Power Moduls



3-5 Power Electronics GmbH

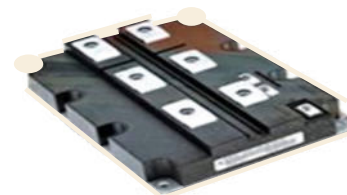
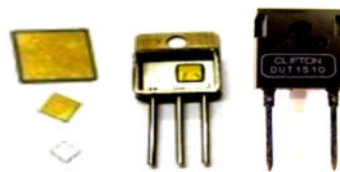
www.3-5pe.com



Profile 3-5 Power Electronics GmbH

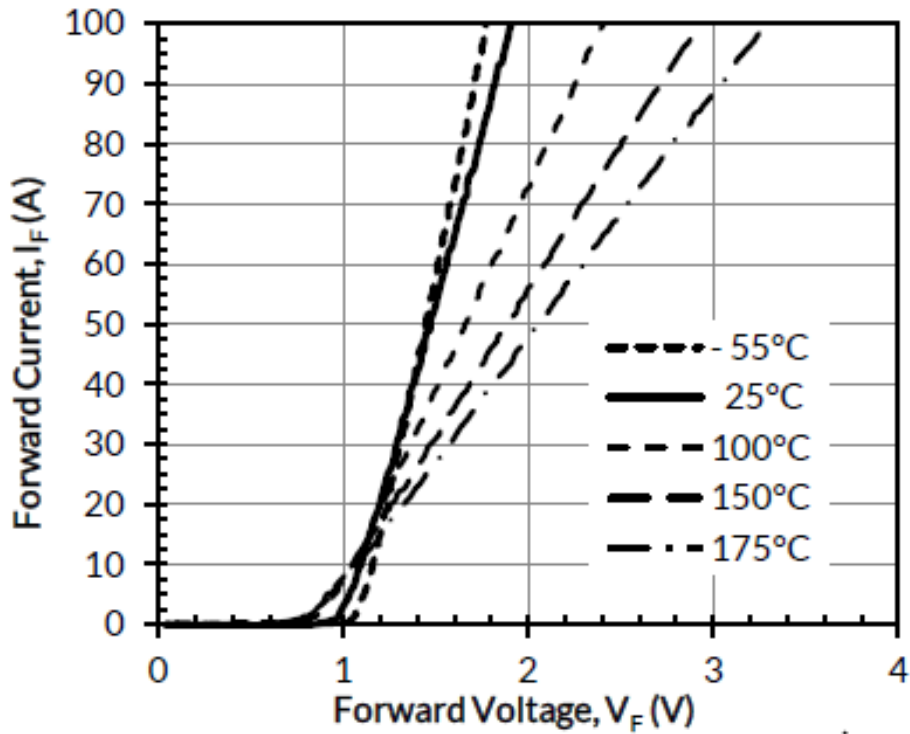


Company:	3-5 Power Electronics GmbH, founded 2016
Office:	Technologie Zentrum Dresden-Süd
Employees:	10
Business purpose:	Development, production (Fab-lite) and marketing of GaAs semi-finished products, chips and modules for power electronics
Target markets:	Industrial products, industrial plant construction, inverters for EV and renewable energies (solar and wind), EV battery charging stations, data centers, and industrial motor drives
Products:	Fast pn diodes, Schottky diodes and power transistors based on the GaAs semiconductor material
Invested:	€17.4 Million (€ 15,1 mm from Investors and € 2.3 mm in Grants from Germany, new Grants decisions €2.4 mm)
Shareholders:	Dr. Volker Dudek (founder, CTO), Dr. Gerhard Bolenz (founder, CFO), Richard J. Kulle (founder, adviser), Sturm Family Office (founder ebm-pabst, Germany)
Business model:	Development and production using proprietary GaAs technology based on a Fab-Lite model, according to which product design and proprietary manufacturing processes are carried out in-house and standard manufacturing processes are outsourced (Azurspace, Heilbronn)



**PCIM 2026,
Hall 9, Booth 529**

50A, 1200V SiC Schottky Diode



3-5PE
1200V, 60A GaAs PIN Diode

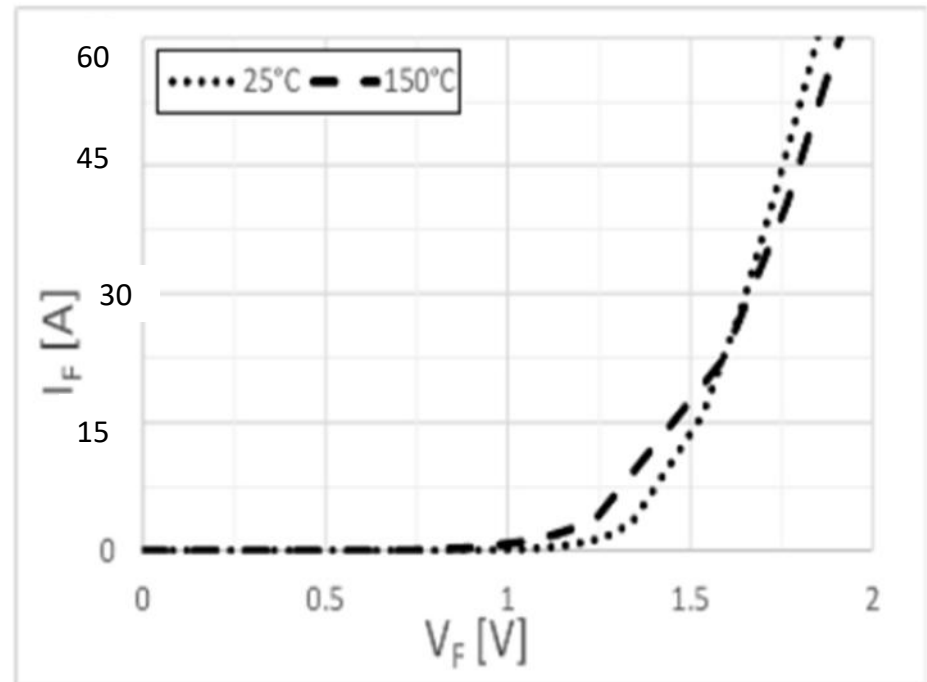


Fig. 1: Forward Characteristics

Figure 1. Typical forward characteristics

Comparing general performance and dynamic behaviour

	Si	G2S	SiC
Common Power Diode Types	(Schottky* <600V), pin	(Schottky* <600V), pin	Schottky*, Body**
Operating Current density [A/cm²] (for 1200V devices)	200-300	600-800	150-200
Junction capacitance ($C_j = \frac{\epsilon A}{d}$)	(moderate area, higher w_B)	(small area, moderate w_B)	(large area, thin w_B)
Dynamic Losses	<p>→ QRR very temperature dependent </p>	<p>→ QRR is temperature stable over wide range due to temp. dependent mobility </p>	<p>→ Temperature dependent QRR in bipolar mode and for body diodes </p>
EMI higher at	More EMI and lower switching speed at low temperatures → cold start drawback [1,2]	More EMI and lower switching speed at low temperatures → cold start drawback	More EMI and lower switching speed at higher temperatures → max performance drawback [1,2]
Total Switching losses	highest and temperature dependent Qrr, moderate Qj	moderate and almost temperature independent Qrr, lowest Qj	small, temperature dependent Qrr, very high Qj

* Schottky = MPS (merged pin Schottky) p-islands inject holes (bipolar mode) at high currents (accelerated at elevated temperature)

** Body-diodes = PN (bipolar) diodes

[1] O. Siwak et al. „SiC MOSFET im Antriebsumrichter für E-Fahrzeuge –eine eierlegende Wollmilchsau?“ Proceedings Halbleiterkolloquium Freiburg 2024
 [2] A. Maitra et al. „Body-Diode Robustness in SiC MOSFETs“ Proceedings Halbleiterkolloquium Freiburg 2024

Comparing general performance and dynamic behaviour

	SiC		GaAs	
1 High Breakdown Voltage (critical electrical Field)	10 time better as Si	● ●	2 time better as Si	●
2 Carrier Mobility	0,7 time of Si	●	6 time better Si	● ●
3 High Temperature robustness	Theoretical Up to 800 ° C , Si up to 200 °	●	300 ° C, Si up to 200 °	●
	(But Package Limit 200° in the future 300°)			
4 Switch off Power Loss	1/20 of Si	● ●	1/7 of Si	● ●
5 Switching Frequency	20 times faster than Si	●	7 times faster than Si	●
6 EMI Noise generation	higher than Si	●	Comparable to Si	● ●
7 Production efforts	much higher than Si	●	Defect level comparable to Si	●

The use of LOW COST GaAs will lead to reduced power losses and a reduction of passive devices, reduction of device size and cooling systems leading to WEIGHT and VOLUME REDUCTION of High Power Products



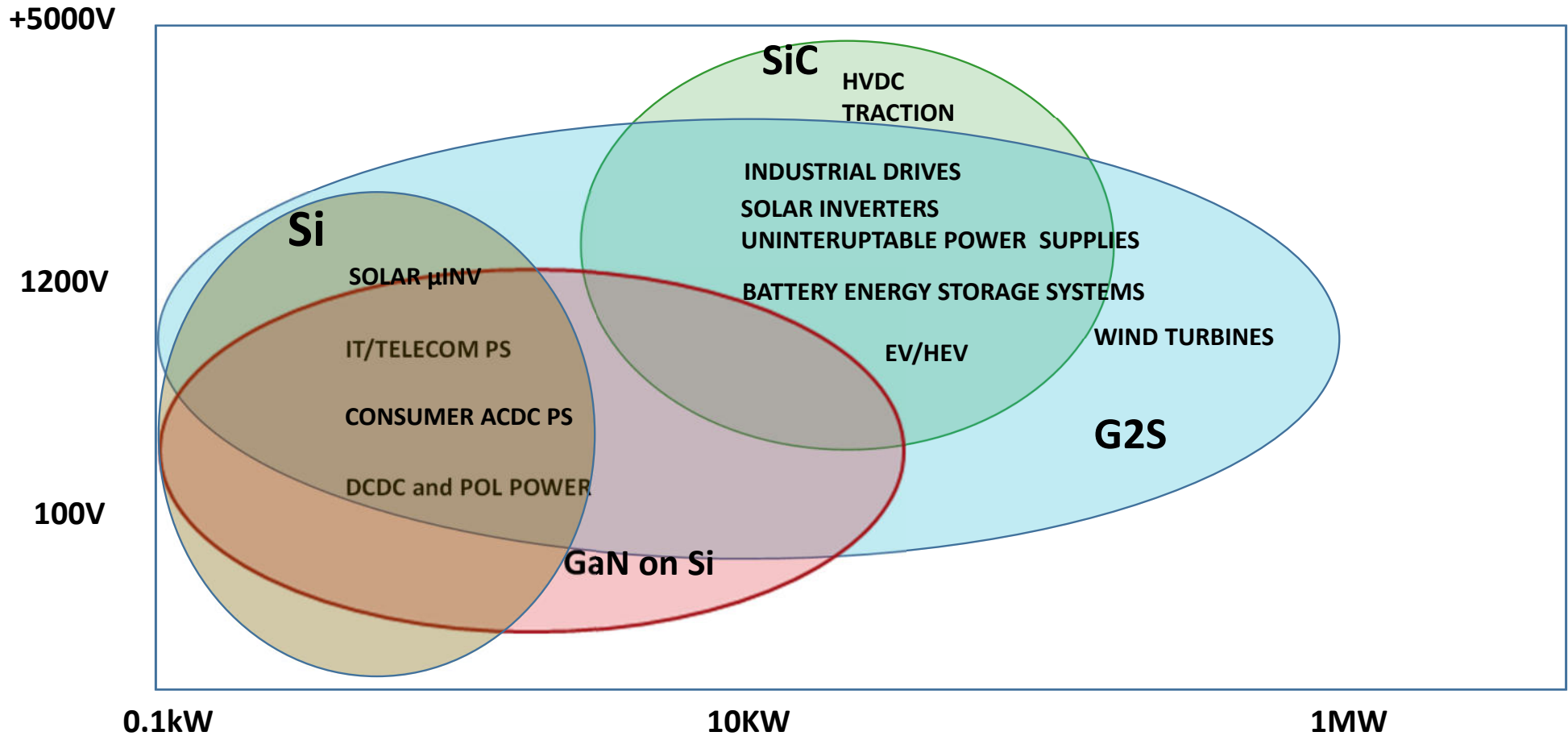
G2S Diodes



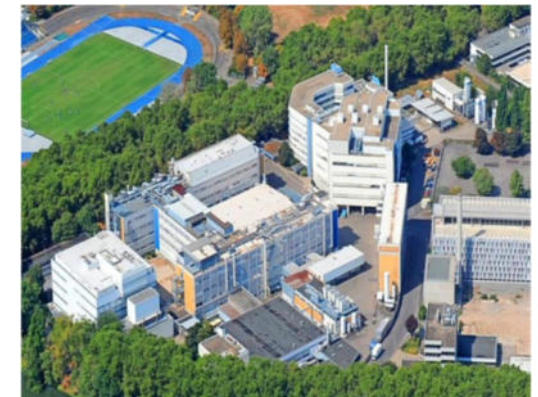
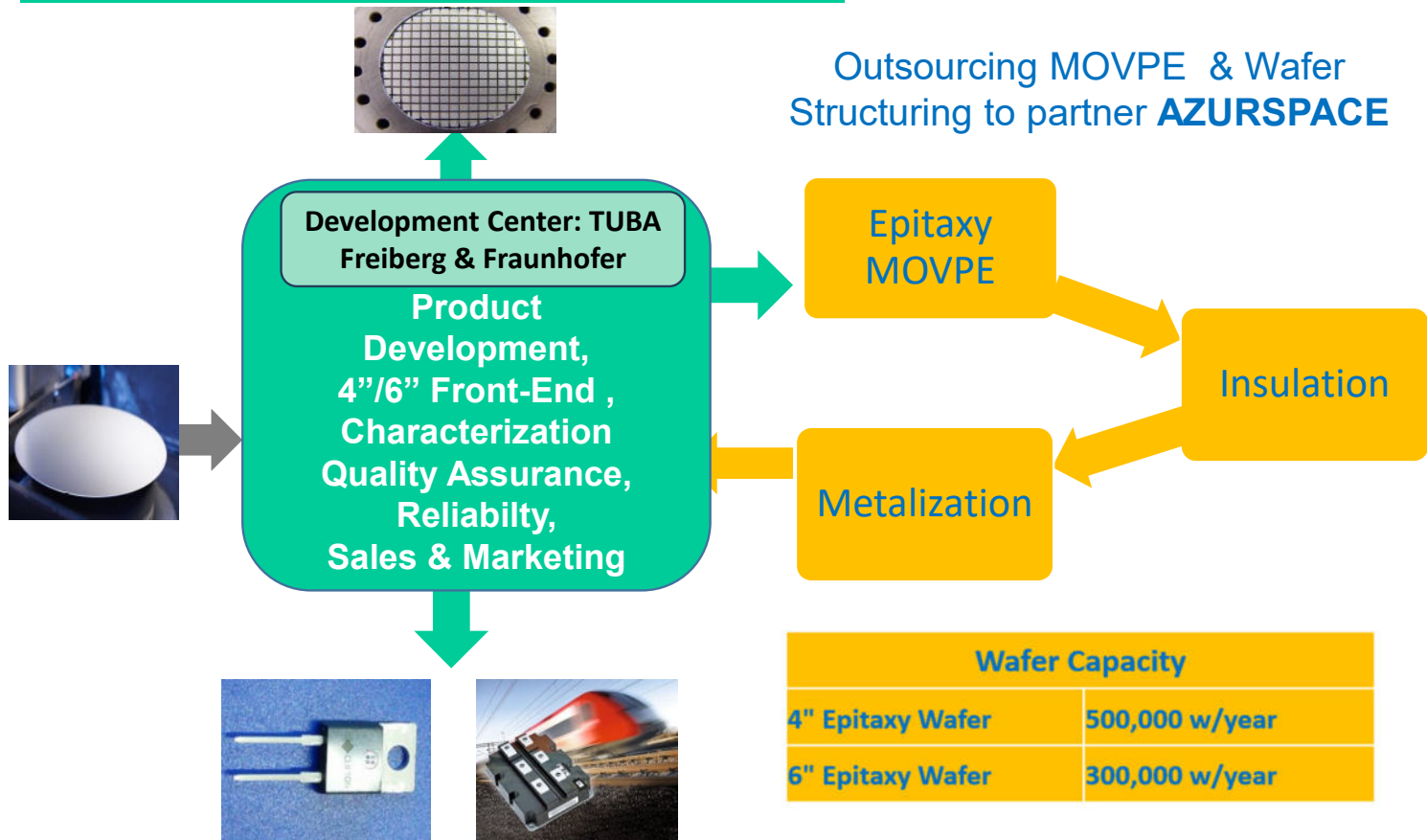
- 35PE has developed a new technology G2S for power semiconductors based on GaAs substrates
- This technology enables G2S PIN diodes with high breakdown voltage and high current density while also offering fast switching speeds comparable to Schottky diodes
- G2S PIN diodes perform better than Si PIN diodes and SiC Schottky diodes across a wide temperature range and voltage
- Manufacturing costs are approximately one-third lower, and in addition the chip size is a factor 2 smaller compared to SiC diodes
- G2S PIN diodes can be offered at Si prices even at high voltages (1200 V).
- High performance G2S PIN diodes including chip size reduction also allows for smaller module sizes, thereby reducing module costs and weight.
- G2S PIN diodes outperform comparable Si diodes at the same price.

Price and Performance Comparison





3-5 PE High Power Semiconductor Manufacturer



AZUR SPACE Solar Power GmbH, Heilbronn

GaAs Substrate



Wafer Foundry



GaAs Power Semiconductor Company



- Focus on R&D and product development
 - Step 1: standard diode module
 - Step 2: HBT transistors, IGBT's
- Development Center TUBAF & FhG
- Product qualification & reliability
- Technical product marketing
- Sales & Marketing

Second largest supplier ww of top-grade GaAs, InP and GaN wafers. (location Freiberg)

Independent from China in 2 y. because Al refineries will collect Ga as a waste product during their production

AZUR SPACE Solar Power European leader and a global player in development and production of multi-junction solar cells for space PV (location Heilbronn)

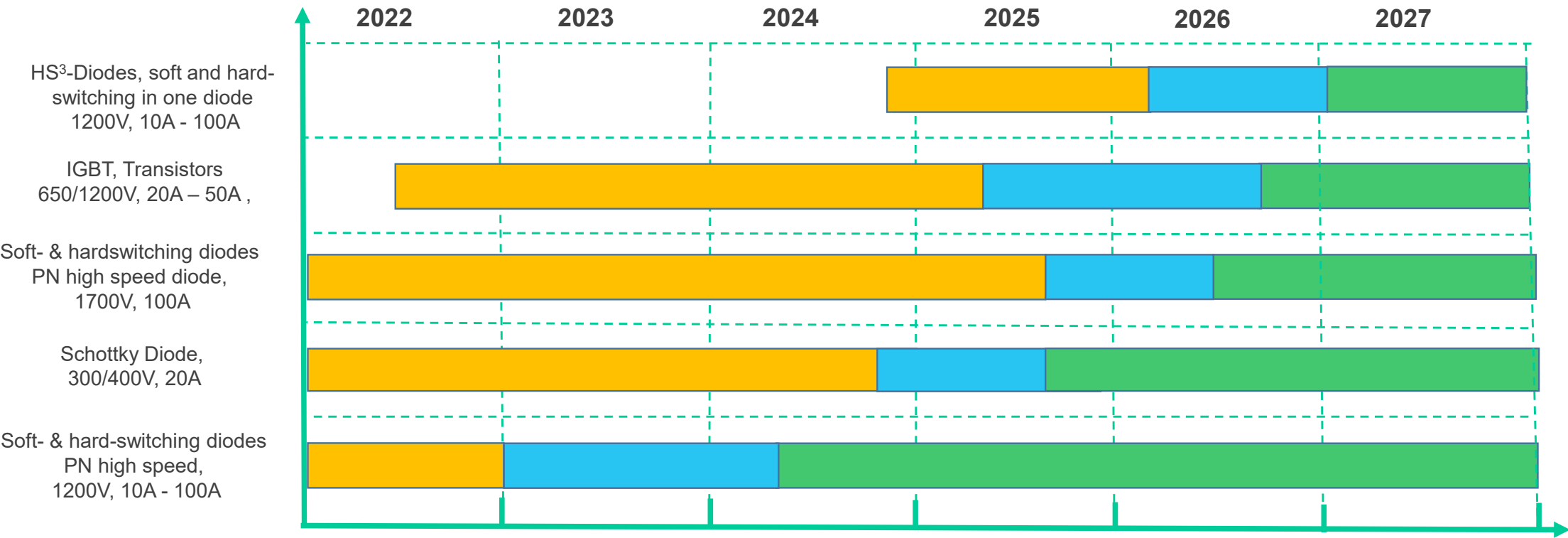
GaAs foundries as 2nd source are available in Germany, Europe, Taiwan and Malaysia

GaAs has been used for low-voltage applications with high yield for several decades.

Business model with external wafer fab foundries with low investment scalable



Roadmap & Patents



- 6" wafer from 2026 depending on volume of wafers
- On customer request mask customizing possible
- Continuous development of further high-power diodes
- First round reliability tests completed



Patent Portfolio

Patent Subject	File No. of German Patent Office	Patent Portfolio			
		Europe	Japan	China	USA
1 III-V(GaAs)-PIN-Diode	AKZ 10 2016 013 541.7	✓	✓	✓	✓
2 III-V(GaAs)-PIN-Diode plus N+ Substrate	AKZ 10 2016 013 540.9	✓	✓	○	✓
3 Staked GaAs Schottky-Diode	AKZ 10 2016 013 542.5	✓	✓	✓	✓
4 III-V(GaAs) PIN-Diode with special Defect Layer	AKZ 10 2017 002 935.0	✓	○	✓	✓
5 Staked III-V Diode	AKZ 10 2018 000395.8	✓	✓	✓	✓
6 Diode with Defect Layer	AKZ 10 2017 002 936.9	✓	○	✓	✓
7 GaAs Layer Structure p+; p and n-Layer	AKZ 10 2016 015 056.4	✓	✓	✓	✓
8 Liquid Phase Epitaxy Jig	AKZ 10 2017 009 110.2				
9 Liquid Phase Epitaxy Jig with feed line	AKZ 10 2017 003 638.1				
10 GaAs IGBT	AKZ 10 2016 015 475.6	✓	✓	✓	✓
11 Staked GaAs Diode	AKZ 10 2017 011 878.7	✓	✓	✓	✓
12 III-V(GaAs)-PIN-Diode	AKZ 10 2018 002 895.0	✓	○	○	✓
13 Scribing Frame	AKZ 10 2017 011 878.7	✓	○	✓	✓
14 Staked high blocking III-V Diode	AKZ 10 2019 001 459.6	✓	✓	✓	✓
15 Staked high blocking InGaAs Diode	AKZ 10 2019 003 068.0	✓		○	✓
16 Staked III-V Diode	AKZ 10 2021 000 609.7	✓	✓	✓	○
17 Staked III-V Diode	AKZ 10 2021 000 611.9	○	○	○	✓
18 Staked III-V Diode	AKZ 10 2021 000 610.0	○	✓	○	✓
19 Package with water cooling	AKZ 10 2021 001 968.7	✓	✓	✓	✓

○ = Patent filed

✓ Patent granted

Proof-of-Concept



Proof of Concepts from different users



Wireless Charging System tested
SiC diodes replace by G2S-diodes

20% lower power loss compared to SiC diodes

GaAs Power Rectifier Diode Module
for Ultra-Fast EV Charging by

1,6% higher system efficiency vs SiC diodes, considerable
module cost reduction

G2S soft-switching diodes used in
10kW LLC Converter

Performance with GaAs is very close to that of SiC at lower cost

GaAs soft-switching diodes used in
Phase Shift Full Bridge Converter

GaAs and SiC have very similar performance, especially as load current/
power increases. At higher power GaAs is better compared to SiC

G2S hard-switching diodes used in
Power Factor Correction Apps (PFC)

Out of the evaluation report: ...That GaAs Diode perform better
than the SiC Schottky diode under all power levels under study.

IGBT Bridge Rectifier and Free
Wheeling Diode

1.33% higher efficiency compared to Si

Ultra-fast EV batterie storage / charging
systems with G2S diodes in IGBT modules

Switch-on and reverse recovery losses savings against Si Diodes

Test of G2S diodes in 1200V, 225A
Standard IGBT Module

Total module switching losses are 22% lower at nominal operating
point and 34% lower at typical operation of 100A

Advanced characteristics leading to higher energy savings & reduced costs.

Wireless Charging System

- Performance comparison of SiC & GaAs diodes applied in a wireless charging solution. B2U-rectification at constant output voltage & sinusoidal input current.

System performance: 3.3 kW, primary-side power control, measured at 9.1A, 142 kHz and 356 V output voltage

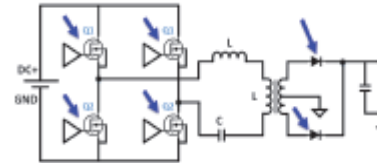
- 20% lower loss performance with GaAs pin-diode compared to SiC Schottky diode.

20% lower power loss compared to SiC diodes

GaAs Power Rectifier Diode Module for Ultra-Fast EV Charging

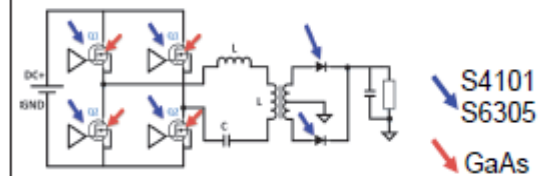
Efficiency of air-cooled LLC converter

Configuration A – All SiC

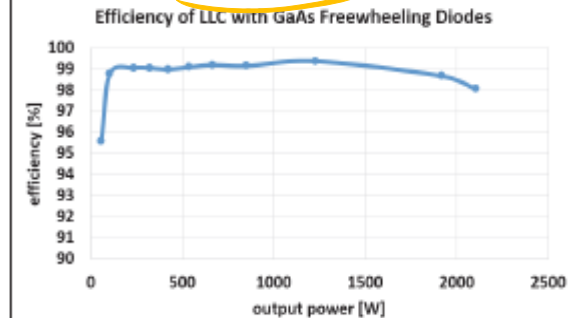


→ Max. efficiency at 850 W Output: 97,7%
 ↘ S4101 (Rohm)
 S6305 (Rohm)

Configuration C – GaAs free wheeling



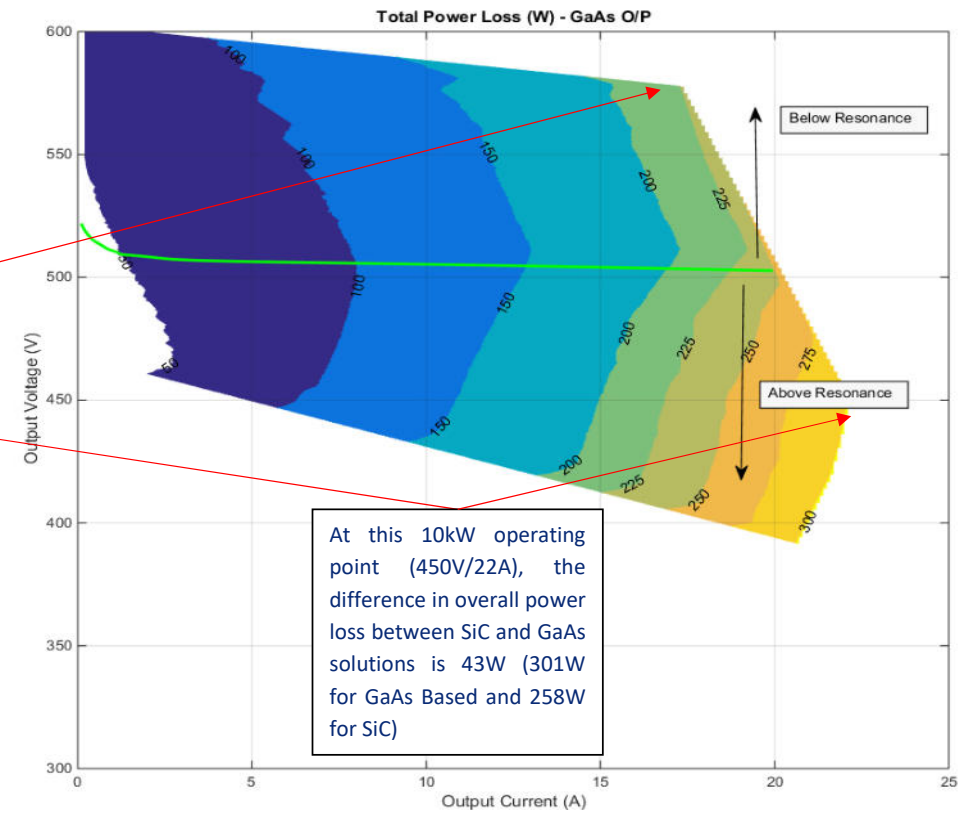
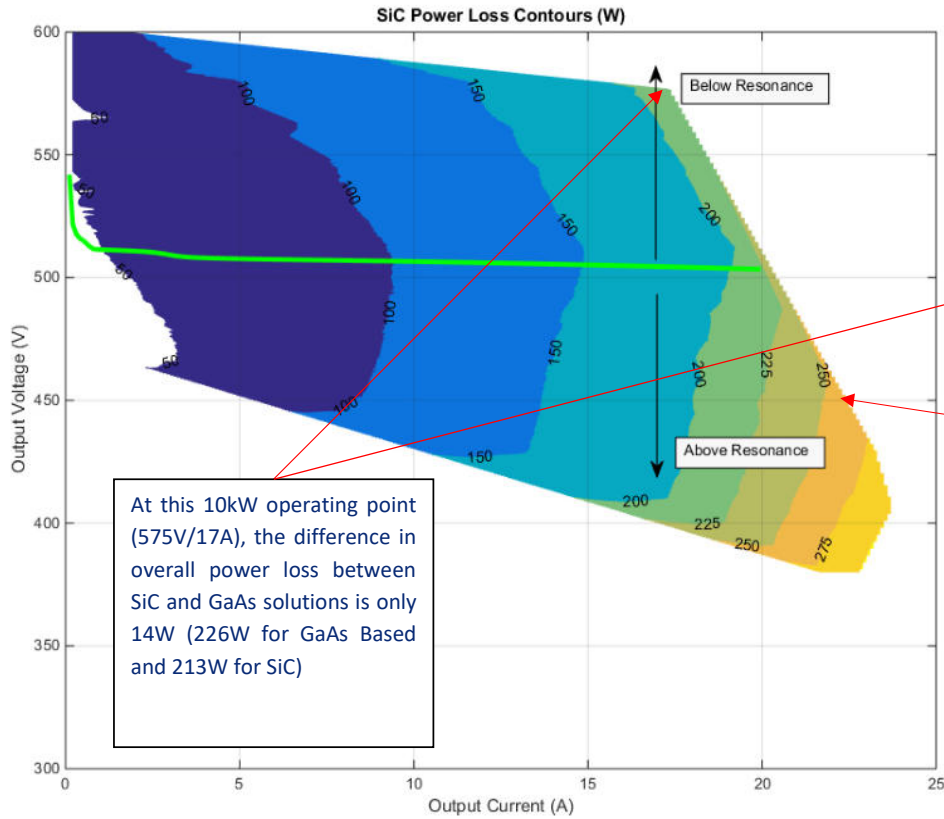
→ Max. efficiency at 1200 W Output: 99,3%



1,6% higher system efficiency vs SiC diodes

G2S soft-switching diodes used in 10kW LLC Converter

LLC converter is a one of the two most used switching topologies for EV loading stations



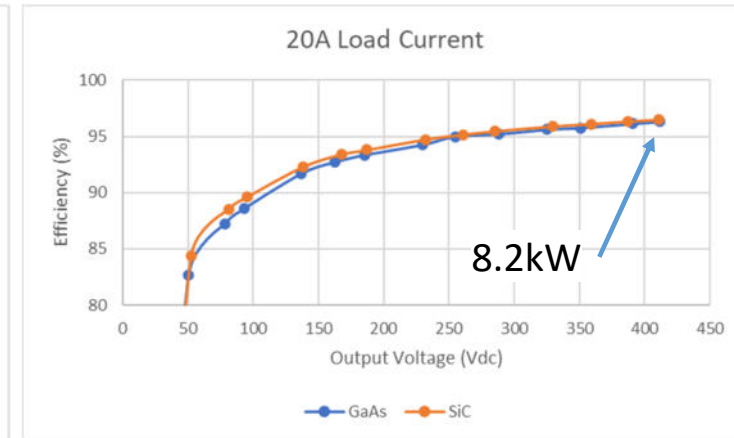
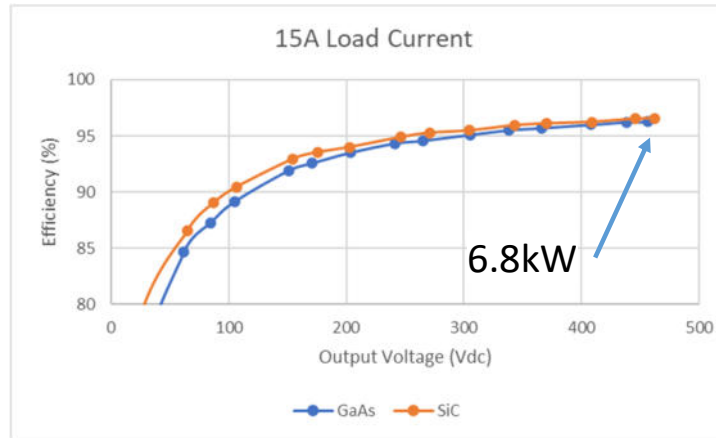
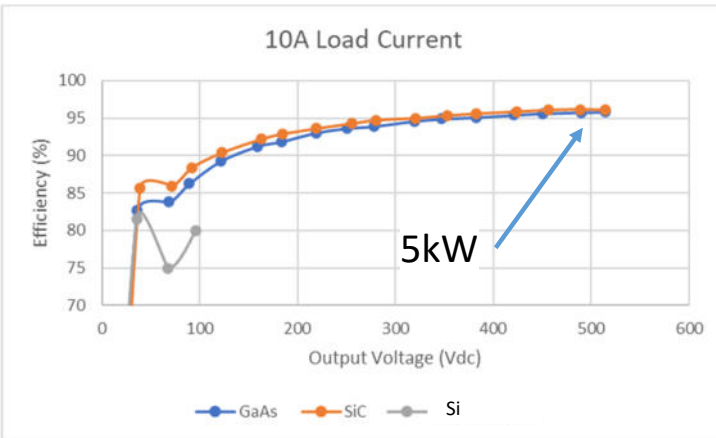
SiC

Performance with GaAs is very close to that of SiC at lower cost.

G2S (GaAs)

G2S soft-switching diodes used in Phase Shift Full Bridge Converter

Phase Shift Full Bridge converter is a one of the two most used switching topologies for EV loading stations

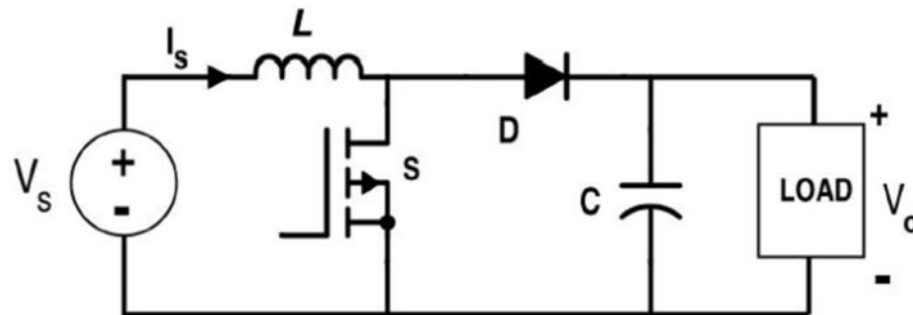


Hyperfast Silicon performance is very poor and this technology is not viable for use at this power level due to T_{rr} induced losses. Limited data capture was possible due to very high clamp losses.

GaAs and SiC have very similar performance, especially as load current/power increases. At higher power GaAs may be better compared to SiC.

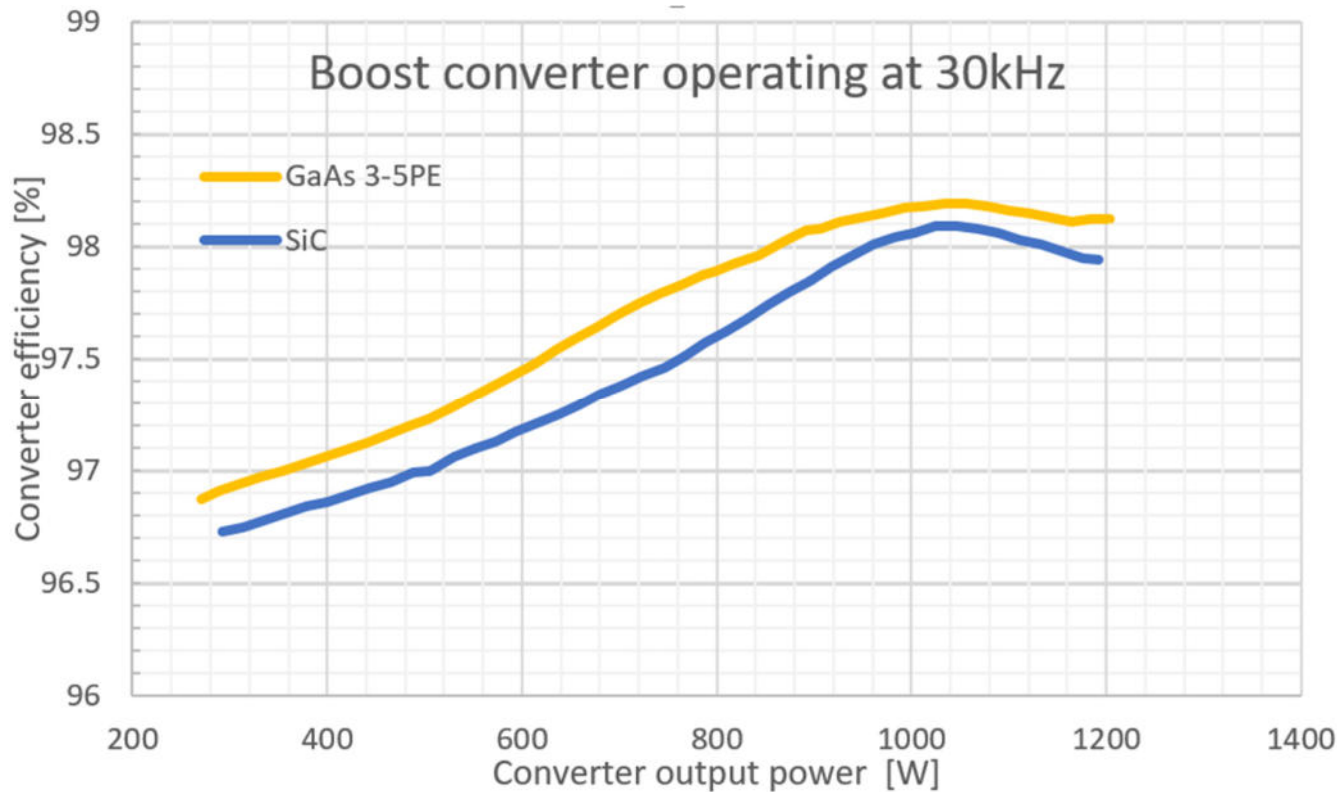
PFC is the most used applications in power electronics. A large discrete power semiconductor manufacturer intensively investigated our GaAs diodes with 4 different types of GaAs diodes with its SiC diodes in PFC application.

Circuit:



- $V_s = 370 \text{ V}$, EA-PSI9750-06 power supply
- $V_o = 740 \text{ V}$, Load = EA-EL9750-20 electronic load
- $L = 1 \text{ mH}$ (25 A max)
- $C = 100 \mu\text{F}$ (900 V max)
- $S = \text{WN8CM80120W}$, PWM driven, $V_g = 20 \text{ V}$ (on state), $V_g = -5 \text{ V}$ (off state)
- $D =$ all of the diodes mentioned above

GaAs hard-switching diodes used in Power Factor Correction Apps (PFC)

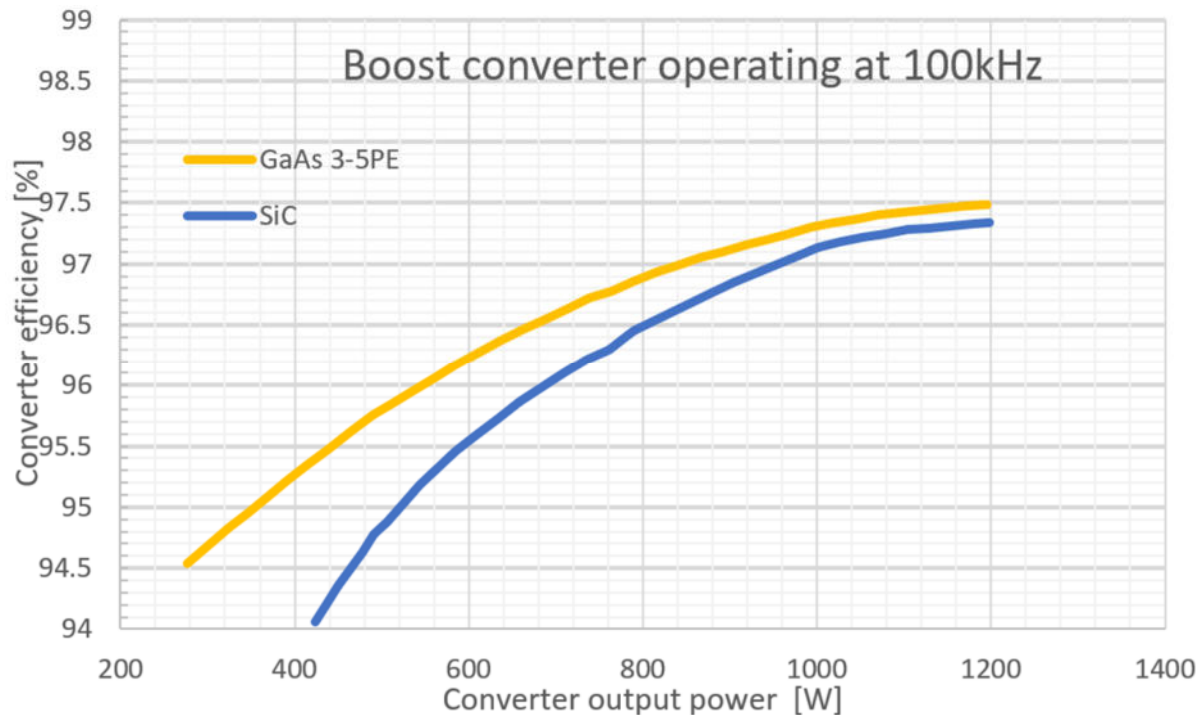


At 30k all GaAs Diode Profiles are better in all measuring points than SiC diodes.

At 30kHz switching frequency the boost converter operates in continuous mode up to approximately 800W output power level. Above that level the converter operates in discontinuous mode.

GaAs hard-switching diodes used in Power Factor Correction Apps (PFC)

The 3-5PE G2S hard switching diode is optimized for PFC and in all measuring points better than SiC diodes.



At 100 kHz switching frequency the boost converter operates in discontinuous mode up to approximately 250W output power level. Above that level the converter operates in continuous mode.

Out of the evaluation report:

...That GaAs Diode ... perform better than the SiC Schottky diode under all power levels under study.

Additional Customer also evaluated our G2S diodes and „performance is as good as SiC diodes, in terms of efficiency it will be better than SiC diodes“. Customers wants to switch to G2S.

Test data from a Chinese Customer

➤ Dynamic and static testing

chip	FWD static test		FWD dynamic test				
	If (A)	Vf (V)	IFM (A)	Vcc (V)	di/dt (A/uS)	trr (uS)	Qrr (uC)
陆芯IGBT+华微FRD	30.4	2.859	31	595	1863	0.033	0.792
陆芯IGBT+华微FRD	30.4	2.896	31	591	1865	0.033	0.787
陆芯IGBT+华微FRD	30.4	2.872	31	595	1852	0.033	0.782
陆芯IGBT+华微FRD	30.4	2.885	31	595	1990	0.033	0.782
陆芯IGBT+35PE FRD	30.3	1.739	50	596	1464	0.04	1.205
陆芯IGBT+35PE FRD	30.3	1.747	51	594	1422	0.04	1.191
陆芯IGBT+35PE FRD	30.3	1.736	49	596	1509	0.04	1.192
陆芯IGBT+35PE FRD	30.3	1.729	51	595	1417	0.04	1.241

➤ Welding machine platform test

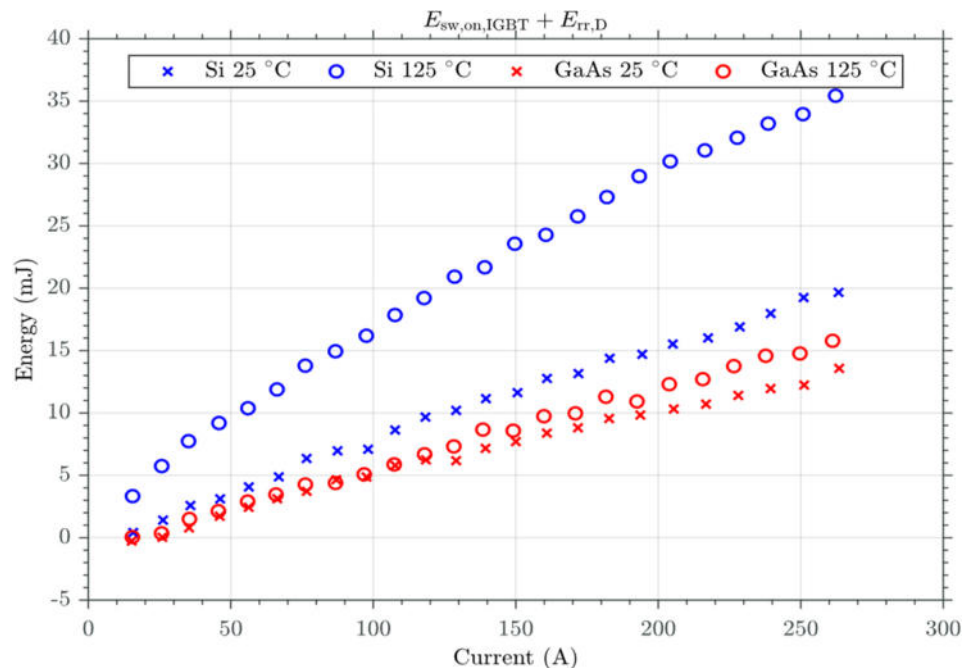
chip	test frequency	input voltage	input current	output voltage	output current	efficiency
陆芯IGBT+华微FRD	25KHz	452V	4.3A	23.1V	76.6A	91.04%
陆芯IGBT+35PE FRD	25KHz	452V	4.19A	22.9V	76.4A	92.37%

G2S diodes in ultra-fast EV batterie storage / charging systems

Application ultra-fast EV charging system in conjunction with battery energy storage systems:

- Switching topology: Auxiliary Resonant Commuted Pole Inverter
- 1.2kV Si diodes replaced by 1.2kV G2S Diodes
- Tests performed at different currents and chip temperatures
- Tests have been made at **University of Applied Sciences Georg Simon Ohm Nuermberg**, Germany

Loss savings: sum of switch-on and reverse recovery losses:

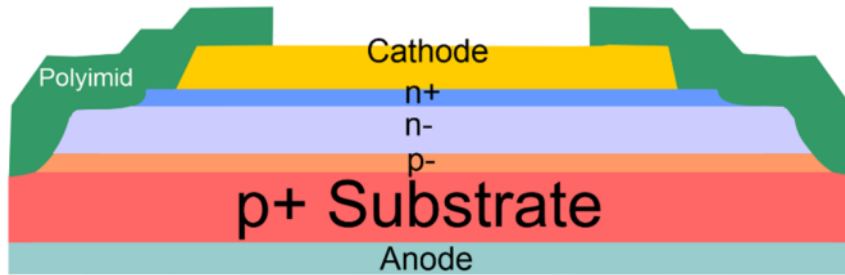


Significant reduction of losses (factor 3.5 (55A) and 2.0 (250A)) are possible by replacing the diodes, especially at higher chip temperatures to be expected in periodic operation



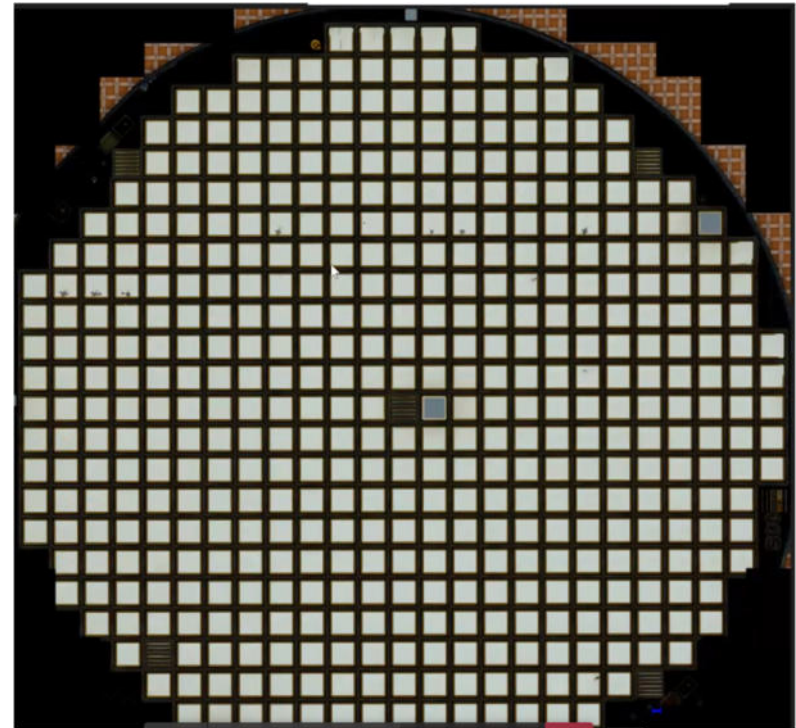
G2S for Power Modules

Crosssection of the G2S pin Diodes

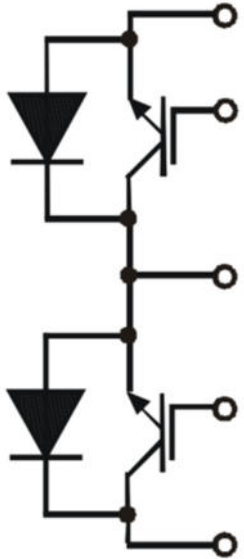


G2S Diode metallization options

	Discrete	Module Type Clip	Module Type Bond
Anode	Ag	Ag	Al
Kathode	Ag	Ag	Ag



GaAs wafer Topview, 60A 1200V per bare die



Total module switching losses (Eon+Eoff+Err) are >20% lower at nominal operating point compared to Si-Diodes. At typical operation of 100A the swiching losses are **>30% lower**

Cost structure



Die Size of SiC & GaAs



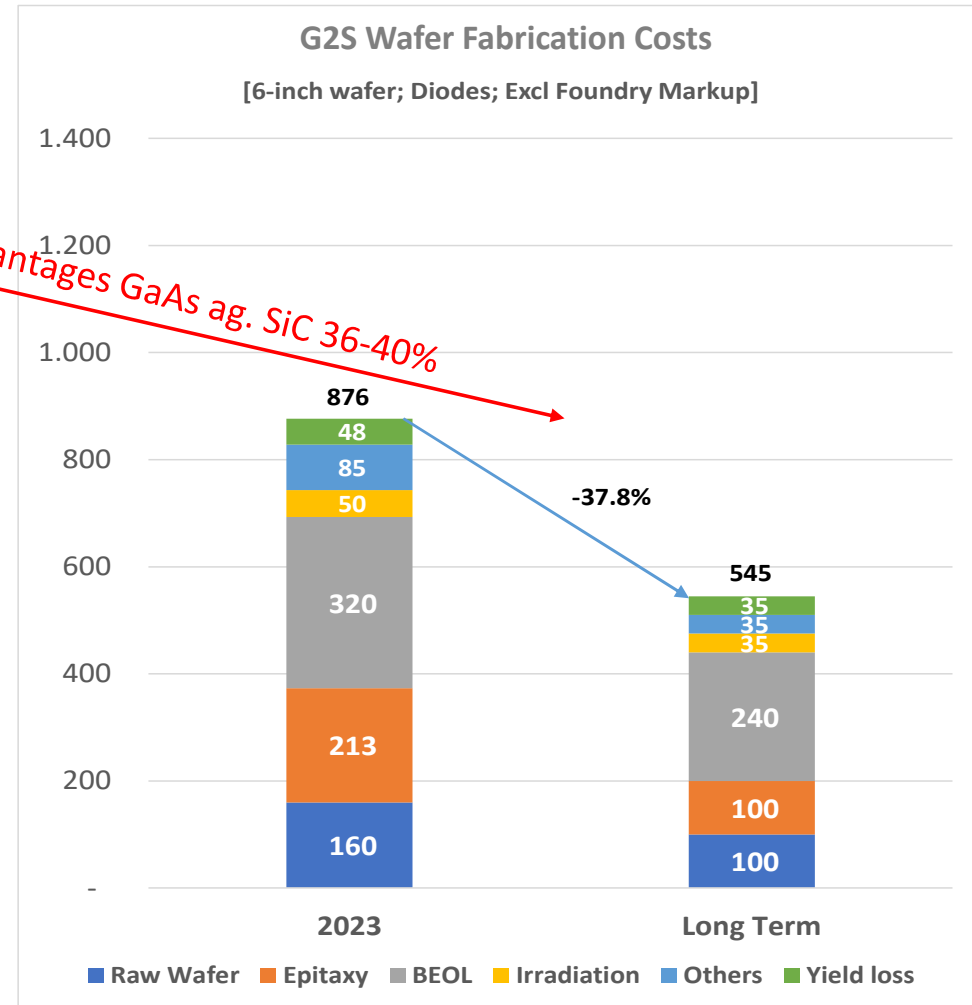
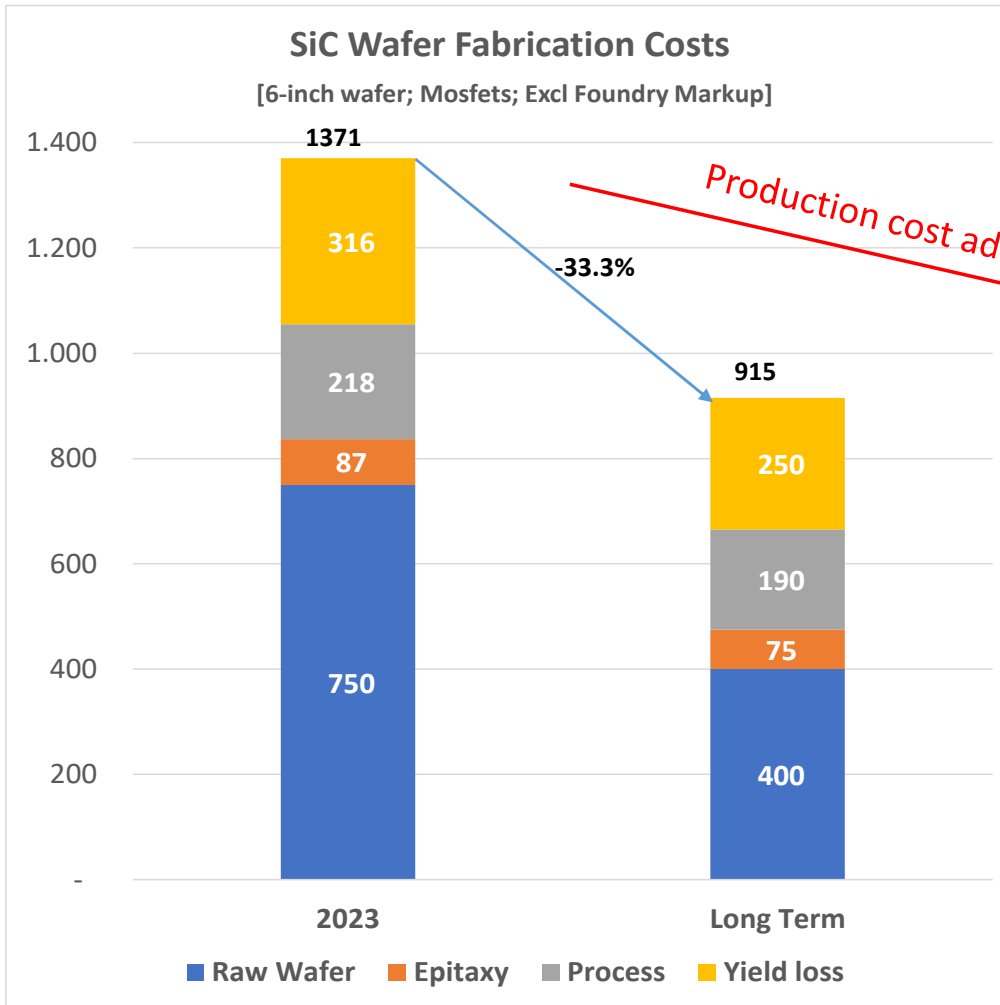
Cost advantages:

- Die size of G2S is 35% up to 50% smaller than SiC. On a 6 inch wafer are as many dies as on a 8 inch SiC wafer.
- 8 inch G2S substrate wafers are already available.

Competitor's bare die sizes compared with GaAs dies

Current (A)	SiC		G2S (GaAs)		Die size factor
	Die Size (mm)	Die area (mm ²)	Die Size (mm)	Die area (mm ²)	G2S smaller than SiC
10	2,26 * 2,26	5,1076	1,58 * 2,18	3,4444	1,5
15	2,7 * 2,7	7,2900	2,62 * 1,72	4,5064	1,6
20	3,08 * 3,08	9,4864	2,62 * 2,12	5,5544	1,7
30			3,62 * 2,12	7,6744	
50	4,9 * 4,9	24,0100	3,34 * 3,34	11,1556	2,2
60			3,6 * 3,6	12,96	>2,2

G2S Production Cost advantage against SiC Production Costs



Production cost advantages GaAs ag. SiC 36-40%

38% manufacturing cost advantage GaAs power diodes compared to SiC diodes in addition die size of G2S is a factor 2 smaller.

SiC Reliability issues

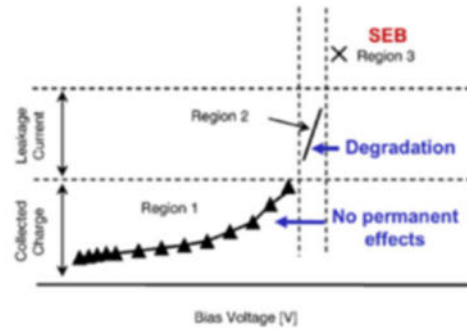


Figure 1. SiC Schottky diode responses to heavy-ion irradiation range from no permanent effect to leakage current degradation to sudden catastrophic single-event burnout (SEB) depending on the reverse bias voltage (V_R) during irradiation.

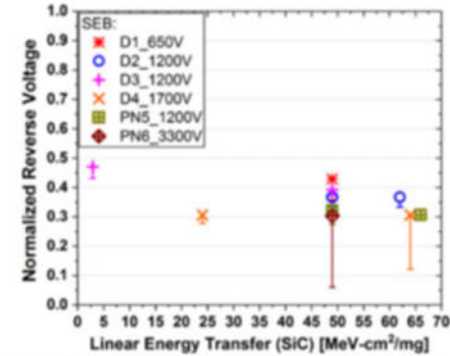
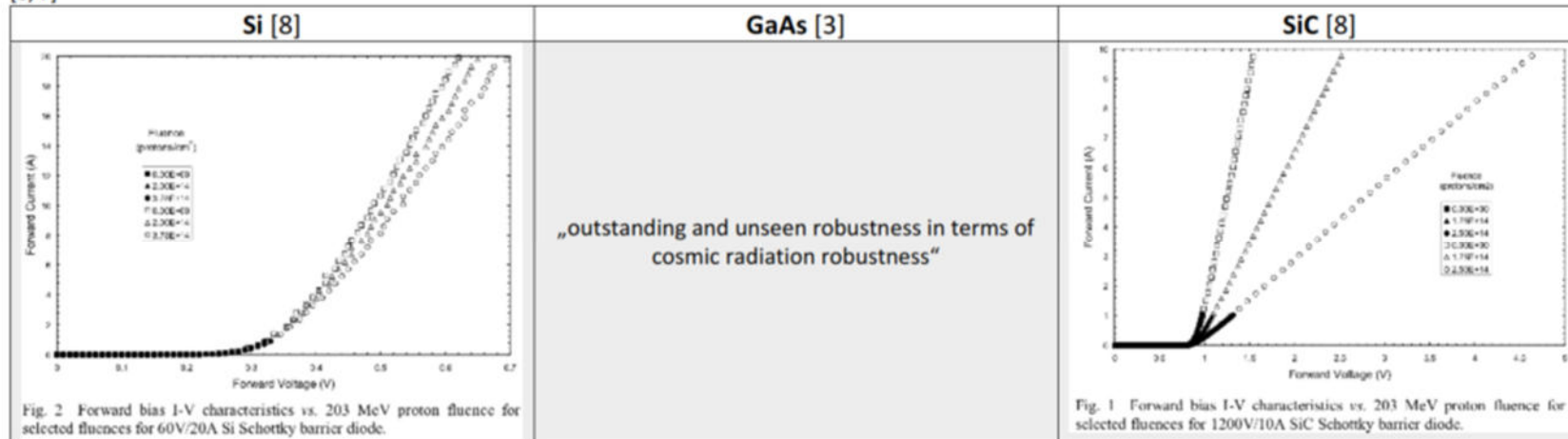


Figure 3. SiC diode V_R at which immediate SEB occurs, normalized to measured breakdown voltage, as a function of LET. Error bars extend down to the highest voltage evaluated at which immediate SEB did not occur.

[6, 7]



[3] customer report

[6] S. Kuboyama et al. "Anomalous Charge Collection in Silicon Carbide Schottky Barrier Diodes and Resulting Permanent Damage and Single-Event Burnout" IEEE Transactions on Nuclear Science, vol. 53, no. 6, pp. 3343-3348, Dec. 2006,

[7] J.M. Lauenstein et al. „Space Radiation Effects on SiC Power Device Reliability“ 2021 IEEE International Reliability Physics Symposium (IRPS), Monterey, CA, USA, 2021, pp. 1-8

[8] R. D. Harris, "SiC vs. Si for High Radiation Environments," 2007 IEEE Radiation Effects Data Workshop, Honolulu, HI, USA, 2007, pp. 63-67,

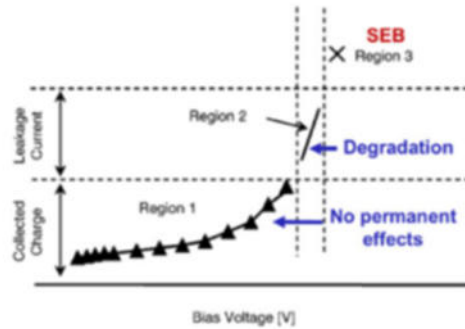


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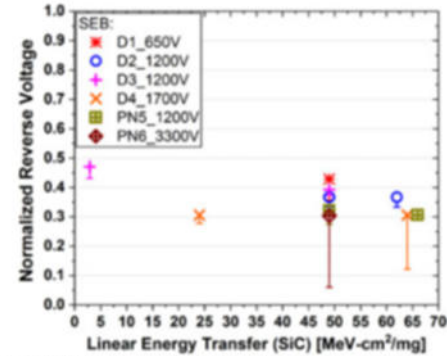
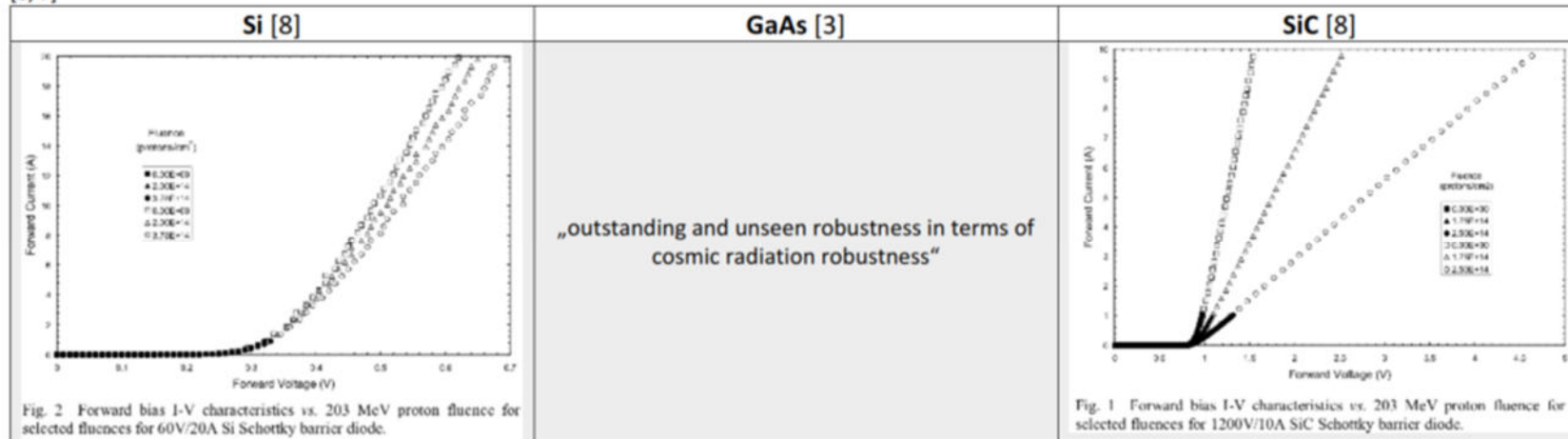


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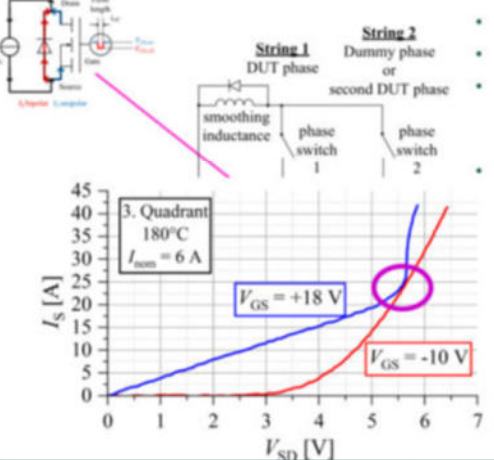
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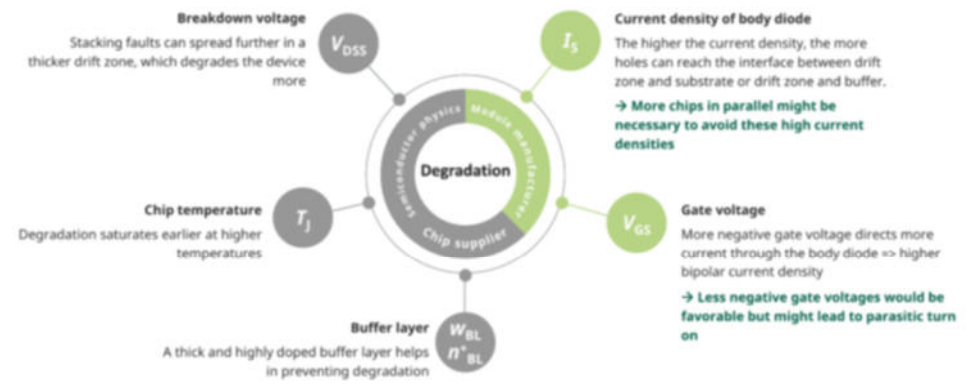
Reliability SiC Bipolar Degredation

i The current density of the integrated body diode is limited by basal plane dislocations in the crystal

Occurrence	Exposure with bipolar current	Consequences
<ul style="list-style-type: none"> Thermal stress during bulk growth leads to basal plane dislocations within substrate (BPDs) During epi-growth: <ul style="list-style-type: none"> 99% of BPDs are converted into Threading Edge Dislocations (TEDs) in the first μm (n^+ buffer) 1% of BPDs continue in the epi-layer BPDs could also be induced by p+ implantation 	<ul style="list-style-type: none"> Recombination of electrons and holes leads to the splitting of the BPD into two partial dislocations (PDs) This results in stacking faults (SFs) in the crystal layers between the PDs High current density also reaches BPDs deep in the crystal No degradation from TEDs 	<p>Spread of stacking faults leads to:</p> <ul style="list-style-type: none"> Increase in diode voltage V_f Increase of the MOSFET's $R_{DS,ON}$ Increase of drain leakage current I_{OSS} <p>=> higher losses</p>

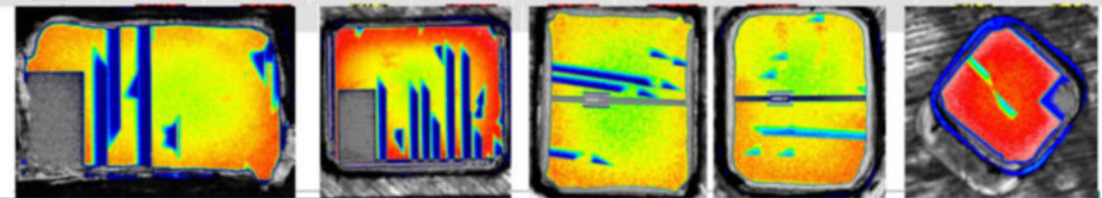


Factors influencing bipolar degradation



DC-Tests – Ergebnisse H1/2/3, $V_{GS} = -10\text{ V}$, $T_J = 120-170^\circ\text{C}$, $t_{akk} = 20\text{ min}$

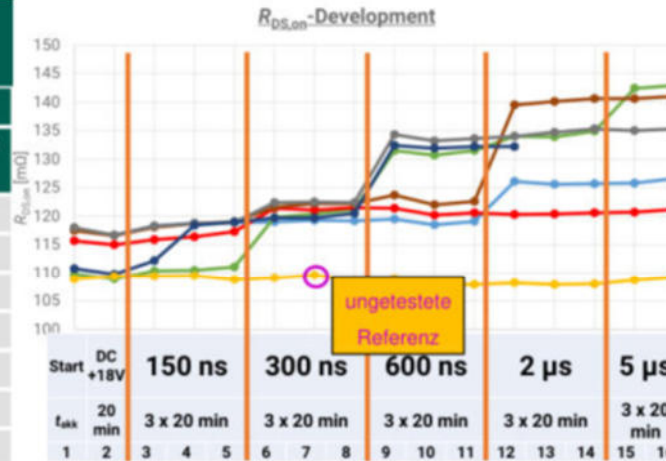
$I_{S,Test}/I_{nom}$	H1				H2			H3		
	$2,0 \cdot I_{nom}$	$2,7 \cdot I_{nom}$	$3,0 \cdot I_{nom}$	$3,3 \cdot I_{nom}$	$1,3 \cdot I_{nom}$	$1,8 \cdot I_{nom}$	$2,3 \cdot I_{nom}$	$3,5 \cdot I_{nom}$	$4,0 \cdot I_{nom}$	$5,0 \cdot I_{nom}$
Prozentualer $R_{DS,on}$ drift	+4% bis +46%	+4% bis +28%	+3% bis +8%	+4% bis +14%	+3% bis +14%	+3% bis +21%	+3% bis +38%		+7% bis +8%	+3% bis +5%



Cristal defects grow, starting from the substrates, through the epitaxial layers and destroy large amount of the active areas leading to significant increase of the on-state resistance and leakage current.

Kurzpulstests mit 500 ns Pulslänge: $V_{GS} = -10/+18 V$, $T_j = 170^\circ C$, $t_{akk} = 20 min$

		H1		H2	
		Totzeit 500 ns		Anschließender DC Test	
$I_{S,Test} / I_{nom}$		3,3		2,3	
$\Delta R_{DS,on}$	DUT1	+3.67%	+3.9%	+18.3%	
	DUT2	+14.9%	+1.4%	+6.4%	
	DUT3	+3.2%	+0.3%	+3.1%	
	DUT4	+4.3%	-	-	
	DUT5	+4.4%	-	-	
	DUT6	+4.9%	-	-	



Bipolar degradation occurs even with short dead times of 500 ns.

Continuing defect growth is observed in the DC test.

Bipolar degradation occurs gradually, depending on the pulse length, even with short pulse lengths.

[1] O. Siwak et al. „SiC MOSFET im Antriebsumrichter für E-Fahrzeuge –eine eierlegende Wollmilchsau??“ Proceedings Halbleiterkolloquium Freiburg 2024

[9] C. Herrmann et al. „Bipolardegradation bei SiC MOSFETs während kurzer Totzeiten“ Proceedings Halbleiterkolloquium Freiburg 2024