50% more power from SiC chips in high performance ceramic-isolated discrete packages

F. Perraud, Product Marketing Manager, Littelfuse

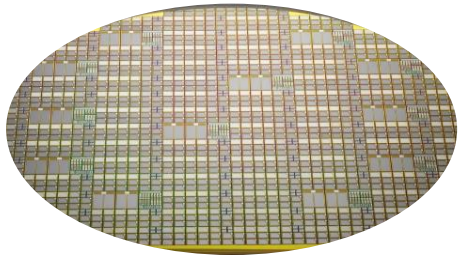
Bodo's Wide Bandgap Event 2024

Making WBG Designs Happen

SiC

Design challenges

- Increase power density, bring down system $/A
- Simplify mechanical, thermal design
- Simplify assembly, improve yield and quality



Can we get more power out of our SiC devices

We need to parallel too many devices in our current design

Our yield suffers from complicated assembly

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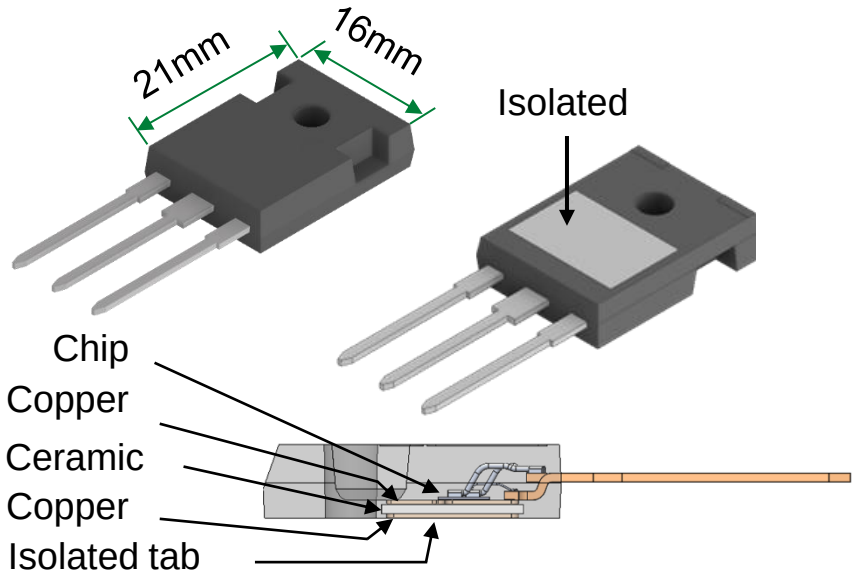
ISO247 package with AMB substrate isolation

- AMB* substrate using high performance ceramic
- 2.5kVrms (AC) 1min isolation**
- Follows JEDEC TO247-AD
- Ceramic‘s CTE matching SiC‘s
- Reduced Rth J-H
- Reduced chip to heatsink parasitic C
- Power cycling robustness

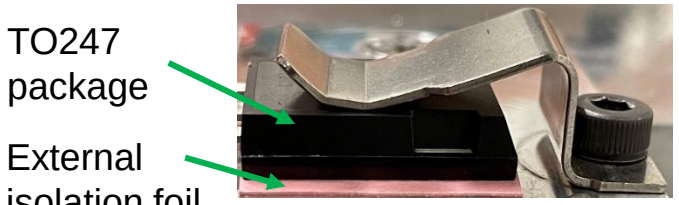


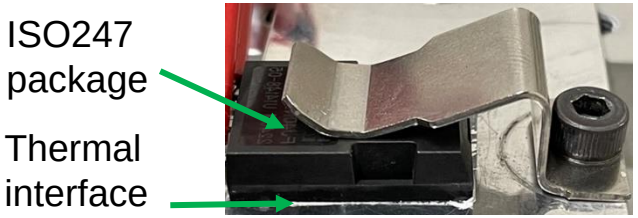
* Active metal brazing
** UL pending

Test Setup (I) - Thermal Performance Comparison

- SiC MOSFET, 1200V, 25mΩ
- Comparing thermal performance in 3 different setups

	TO-247	TO-247	ISO247
Isolation	External foil $1.8W.mK^{-1}$	External foil $6.5W.mK^{-1}$	Internal, AMB Thermal paste
Package R_{thJC} [K/W]	0.27	0.27	0.45

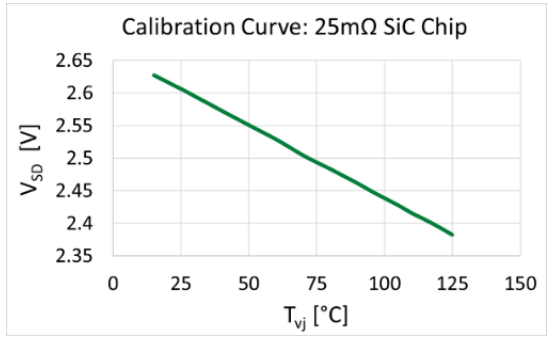


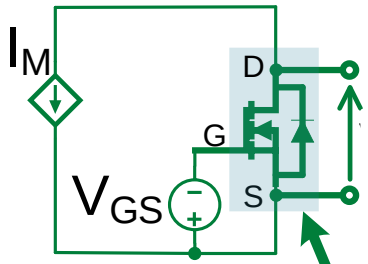


Test Setup (II) - Thermal measurement

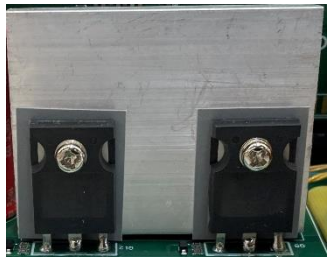
Z_{th}-measurement according to IEC 60747-8

1. Calibration Curve extraction

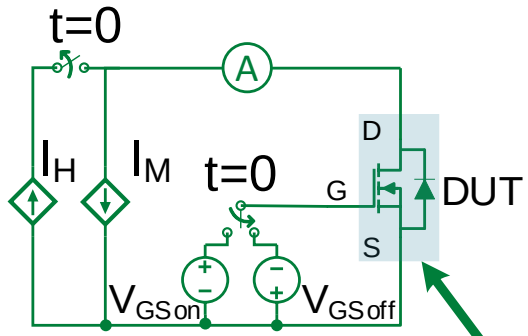




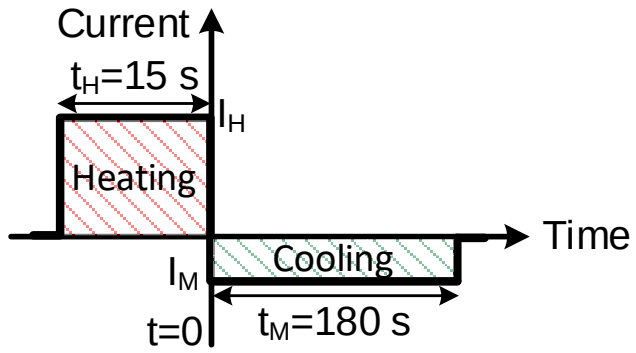
Temperature controlled heat plate



2. Thermal Impedance Measurement



Temperature controlled heat plate



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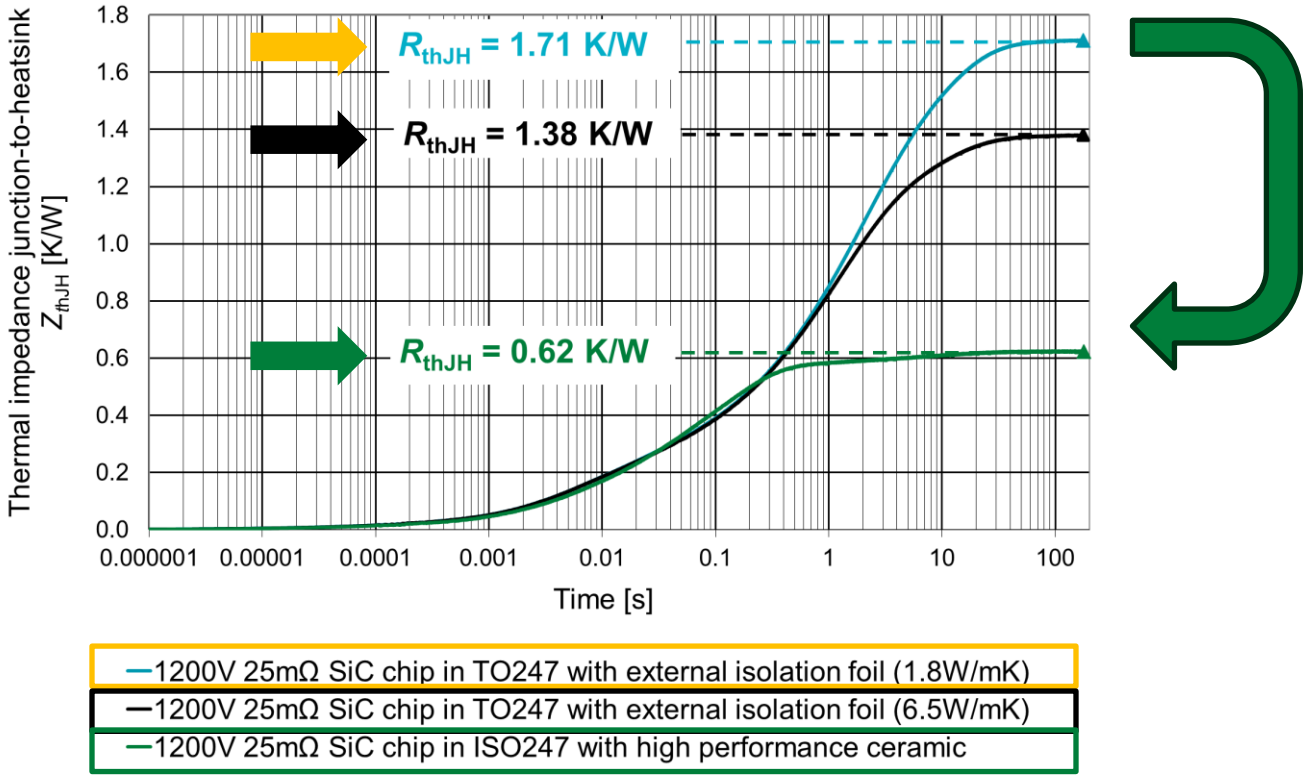
Thermal Performance Advantages – Rth J-H

- Comparing Rth J-H at identical heating current I_H= 40A
- 64% lower Rth J-H with the ISO247 package



64% lower Rth J-H with the ISO247 package

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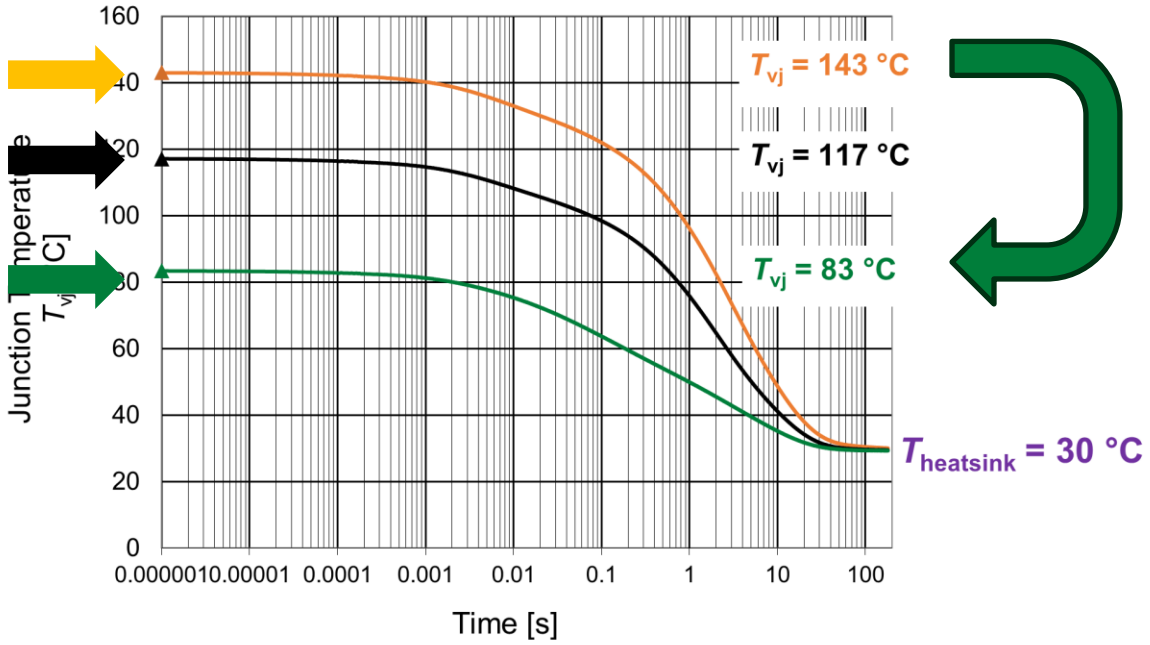
Thermal Performance Advantages - Tvj

- Comparing Tvj at identical heating current I_H= 40A
- Up to 60ºC reduction in T_{vj}



The ISO247 package keeps the SiC chip 60 °C cooler

—1200V 25mΩ SiC chip in TO247 with external isolation foil (1.8W/mK)
—1200V 25mΩ SiC chip in TO247 with external isolation foil (6.5W/mK)
—1200V 25mΩ SiC chip in ISO247 with high performance ceramic

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Application – increase the power output at same Tvj

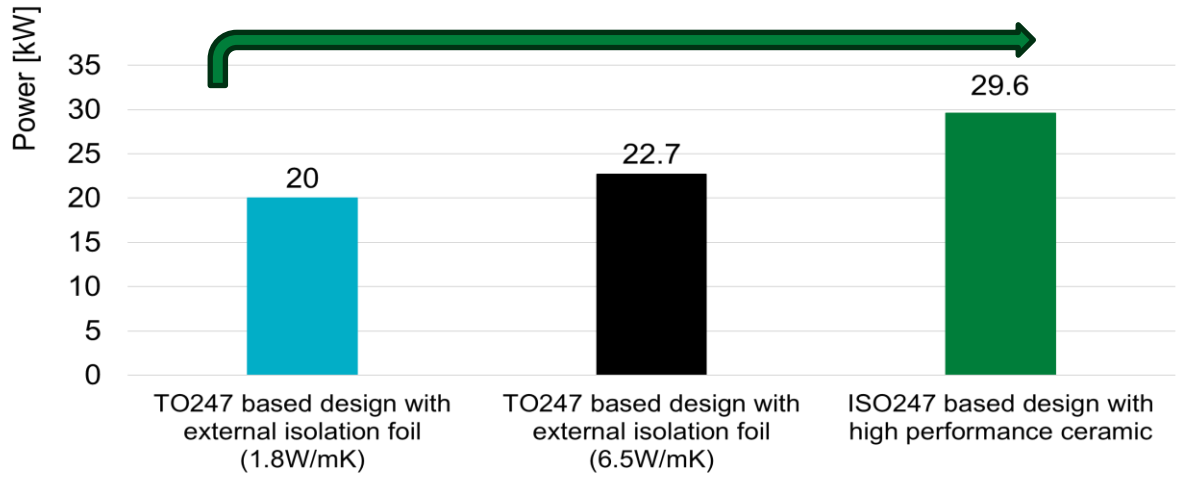
- In reverse - implied I_H to reach Tvj=130°C
- Theoretical 20kW (800V DC) power converter operating at T_{vj} = 130°C

30% higher drain current

170% higher power handling

	I_H [A]	R_{thJH} [K/W]	P_{DJH} [W]
TO-247 with 1.8 W/mK isolation foil	38.8	1.17	59
TO-247 with 6.5 W/mK isolation foil	42.2	1.38	73
ISO247 with high performance ceramic	**50.8**	**0.62**	**160**

48% increase potential in power output *



*Calculated based on the thermal measurement results@Tvj=130°C for theoretical 20 kW application with 800 V DC-link

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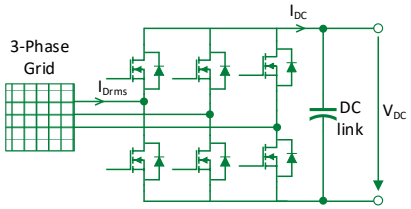
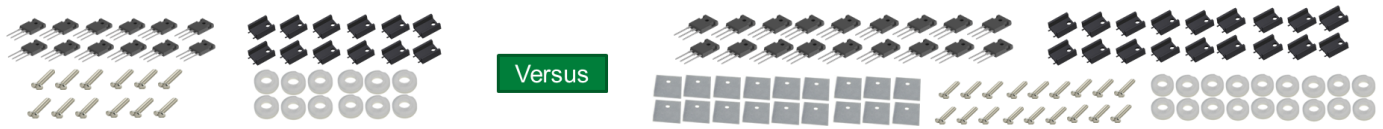
System simplification / cost saving opportunities

- **Illustrative example 50kW active front end converter**
  - Paralleled 1200V/30mΩ SiC MOSFETs





	ISO247 with AMB substrate	TO247
Total number of devices	12 (2 per switch position)	18 (3 per switch position)
No. of isolation pad	0	12
Mounting & assembly	No isolation pad	Place and assemble 18 isolation pads
Production yield improvement	+10 p.p. vs base case*	Base case

** Based on feedback from lead customer*

Littelfuse new SiC lineup

- **~50 new SiC diodes and MOSFET planned for release until Q2‘2025**
- **Commodity line: state of the art standard discrete devices**
- **Performance line: isolated, multichip devices**

Released **R&D**

	Commodity line					Performance line				
	MOSFETs			Diodes		MOSFET			Diodes	
	Single			Single	Common cathode	Single		Half bridge	1PH rectifier	Parallel
	TO247	TO263	TOLL	TO220, TO247, TO263	TO247	**ISO247-3L and ISO247-4L**	SOT227	SMPD	SMPD, i4	SOT227
650V										
1200V										
1700V										

1200V SiC MOSFETs - ISO247 new lineup

Non released devices‘ schedule and characteristics subject to change without notice

- **State of the art SiC trench MOSFET**
- **TO247-AD compatible isolated package, high performace AMB substrate**

			Q4 24	Q1 25
V_{DSS} (V)	R_{DSON} (mΩ)	I_D @ 25°C (A)	ISO247-3L (2500V~ isolation) 	ISO247-4L (2500V~ isolation w/ Kelvin source) 
1200	18	80	IXSJ80N120R1	IXSJ80N120R1K
	36	43	IXSJ43N120R1	IXSJ43N120R1K
	62	25	IXSJ25N120R1	IXSJ25N120R1K

Takeways – ISO247 with AMB substrate isolation

- Increased power output, up to 30% more current
- Decreased Rth J-C, chip up to 60° C cooler
- System level cost saving opportunities
- Simplified mounting and production yield improvement
- Littelfuse new SiC portfolio

Thank You

Related Materials

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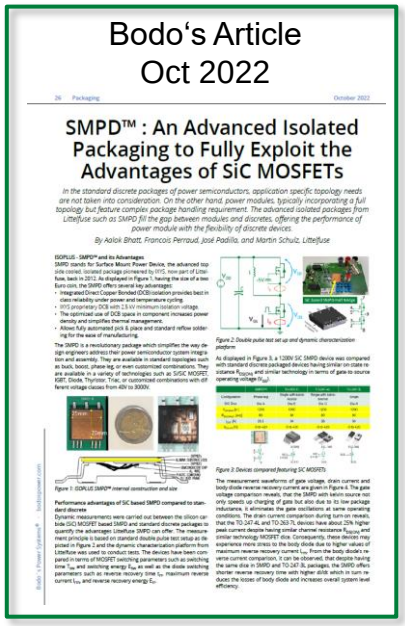
Oct 2022



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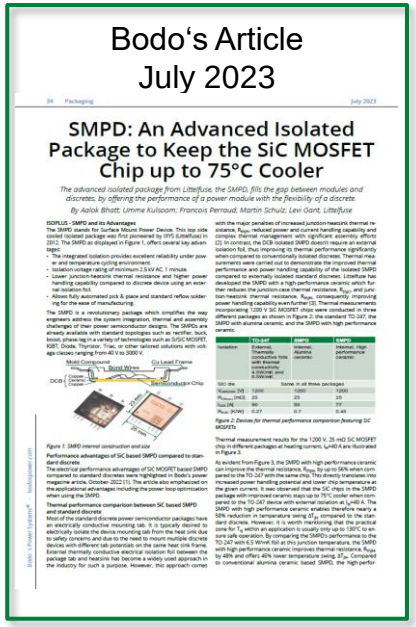

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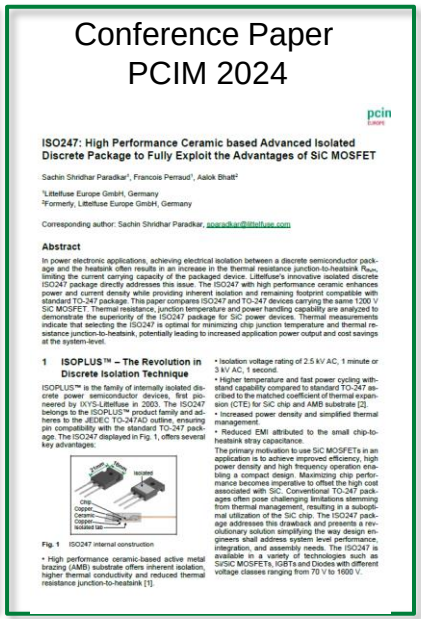

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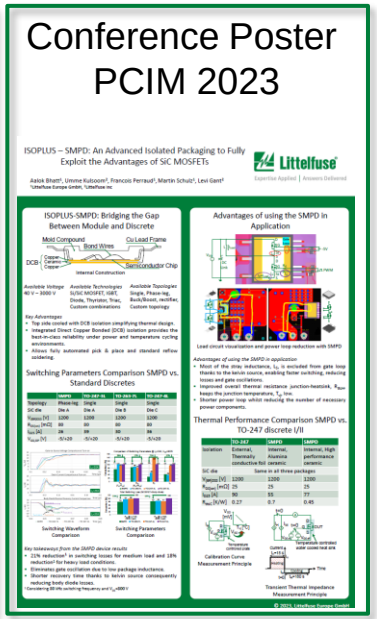

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