POWER AND MOBILITY

HIGH TEMPERATURE (250 °C) SIC POWER MODULE FOR MILITARY HYBRID ELECTRICAL VEHICLE APPLICATIONS

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GVSETS

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14. ABSTRACT
These newly developed high performance SiC power modules can provide substantial system benefits, including Increased efficiency, power density Reduced volume, weight Higher junction temperatures, ambient temperatures

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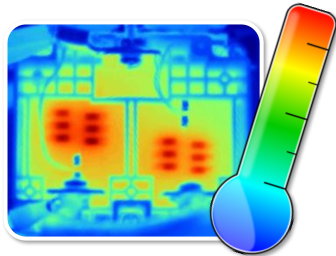
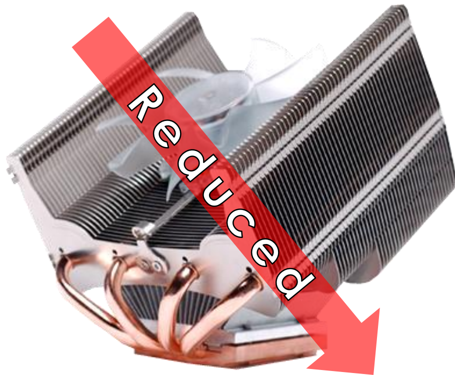
Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Why High Temperature?



What if temperature was *not a limitation*?

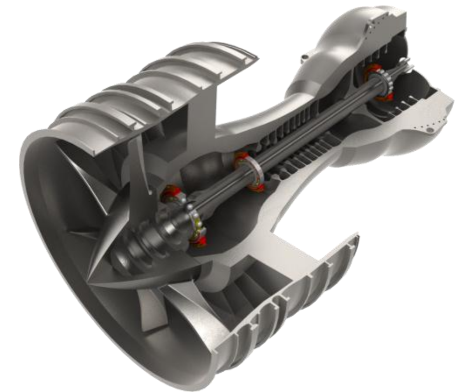


Cooling Systems

Thermal Shielding

- *Efficiency*
- *Power Density*
- *Size & Weight*
- *Complexity*
- *Cost*

Design Tradeoffs



Extreme Environments

Wide Band Gap Semiconductors

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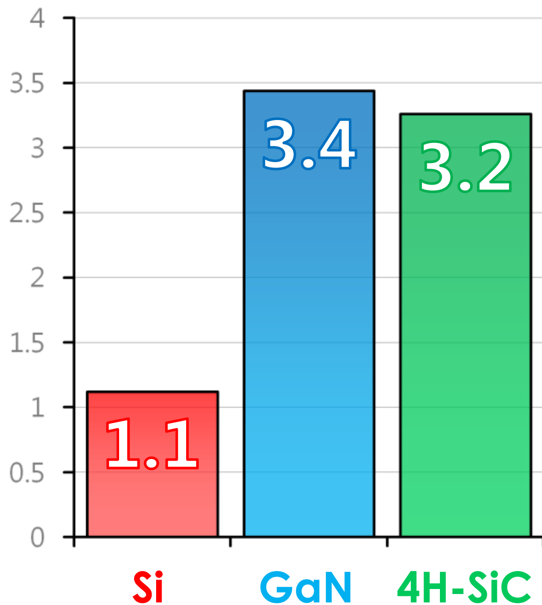
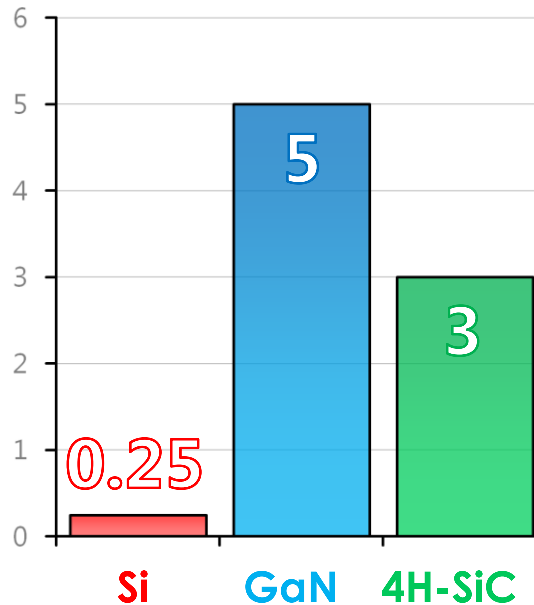
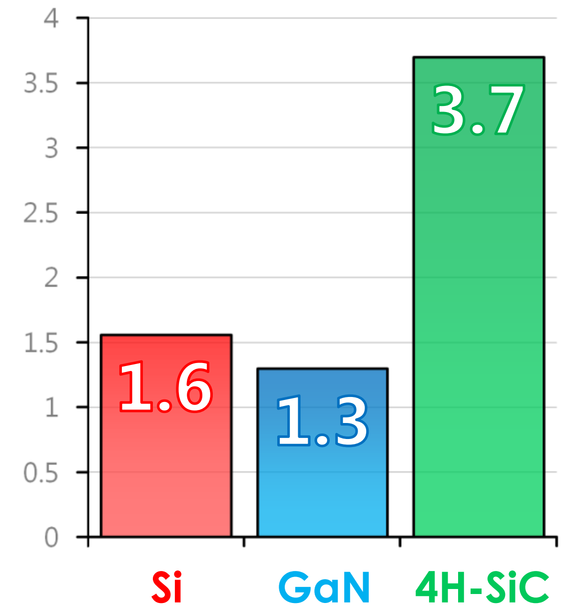






larger band gaps mean...

- ↓ **Intrinsic Carriers**
- ↑ **Operating Temperature**

higher critical fields result in...

- ↑ **Blocking Voltages**
- ↓ **On-Resistance**
- ↑ **Switching Speed**

increased thermal cond. allows...

- ↑ **Heat Dissipation**
- ↑ **Power Density**

Applications

Motor Drives

Military
Hybrid / Fully Electric Vehicles

Commercial
Hybrid / Fully Electric Vehicles

Aerospace
More Electric Aircraft

Power Converters

Solar / Wind
Grid-Tie Inverters

Geological
Down Hole Instrumentation

Aerospace
Power Conversion

High Voltage

Industrial
Modernized Power Grid

Commercial
Fault Current Limiter

Military
Advanced Warships

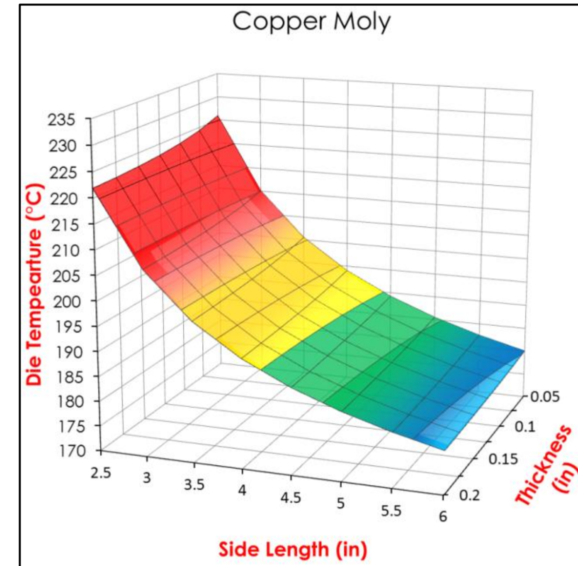
Wireless Telemetry

Industrial
Power Turbine Sensors

Aerospace
Jet Engine / Turbine Sensors

Design

philosophy and processes



Device Neutrality

Use the most suitable device for a given application

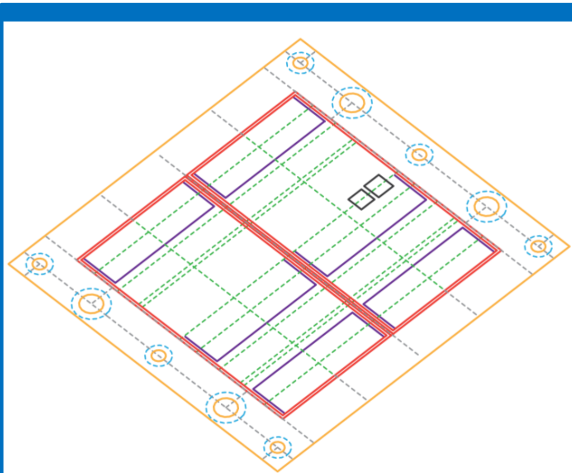
JFETs
SemiSouth
Infineon
Microsemi

MOSFETs
CREE
ROHM SEMICONDUCTOR

BJTs
CREE
TranSiC

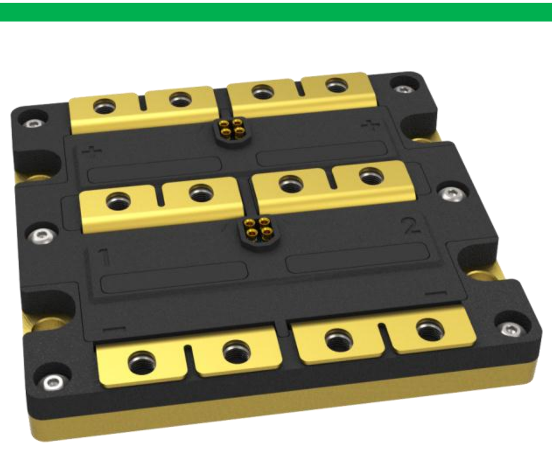
Diodes
CREE
SemiSouth
Infineon
GeneSiC SEMICONDUCTOR
IXYS
Microsemi
ROHM SEMICONDUCTOR

Technique which allows for rapid configuration of a design with minimal user input



Reference Sketches

Geometry is driven by relationships, equations, and named variables.



Assembly

Components are defined in context and driven by the referenced design variables.

Configurations

Thousands of variations may be rapidly analyzed with this process.

Using an adaptive CAD model and FEA simulation software, thousands of configurations may be investigated

Base Plate
material
geometry

Power Substrate
ceramic type
ceramic thickness
metal type
metal thickness

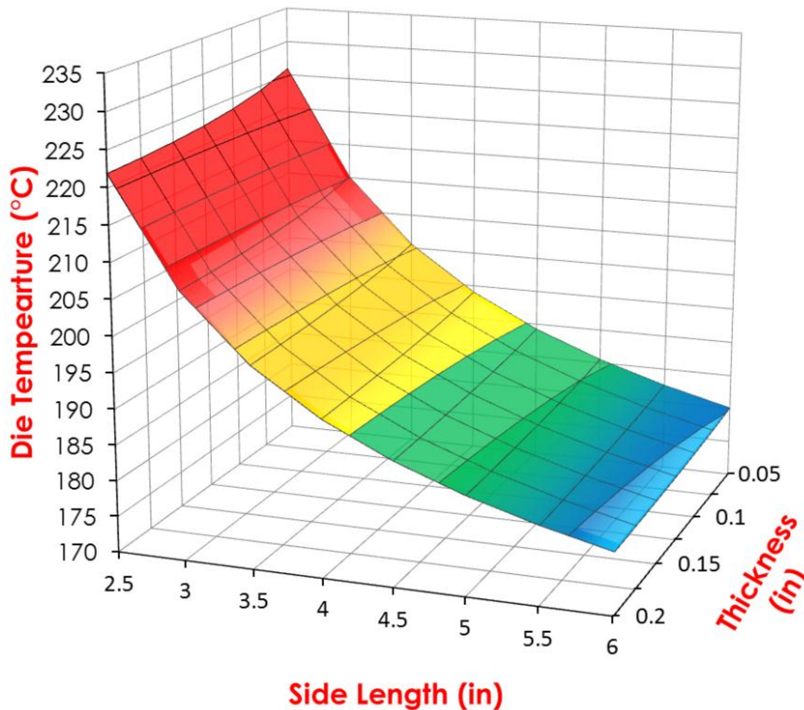
Die Attach
material
thickness

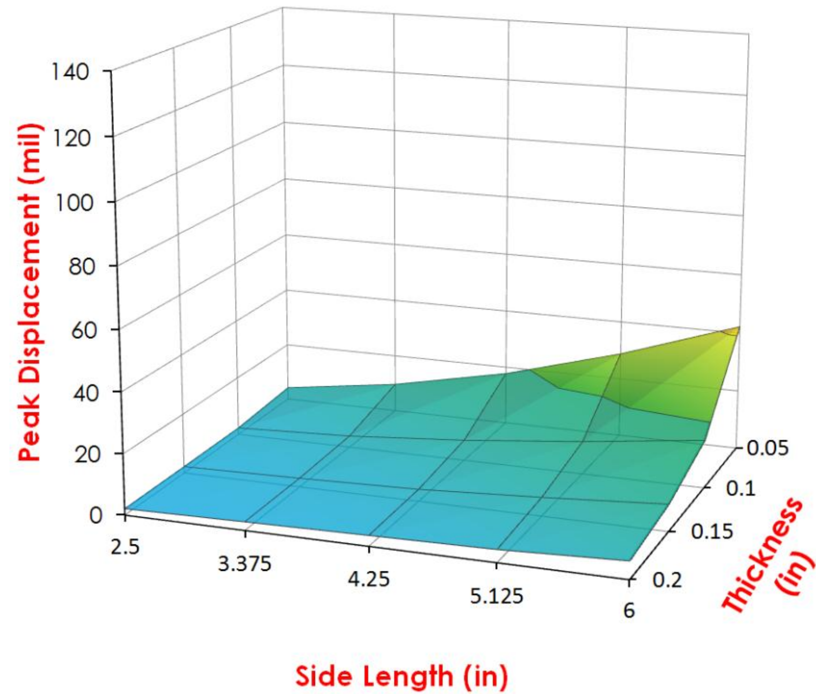
Spacing
die to die
die to edge
substrate to base plate
substrate etch lines
clearances
tolerances

Tradeoffs
thermal performance
stress & displacement
weight vs. performance
volume vs. performance
plastic reinforcements

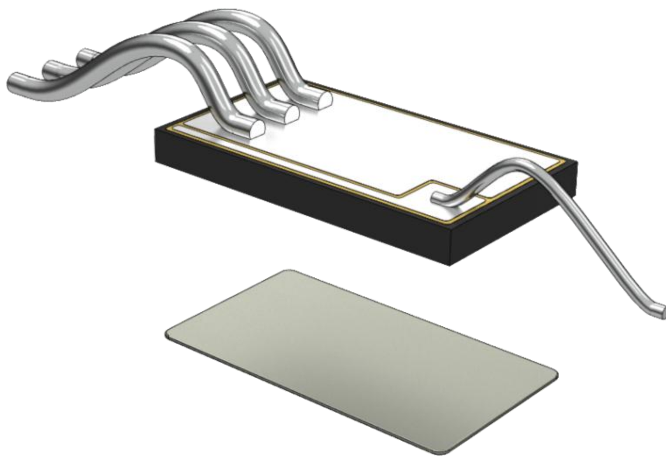
Example Base Plate Analysis

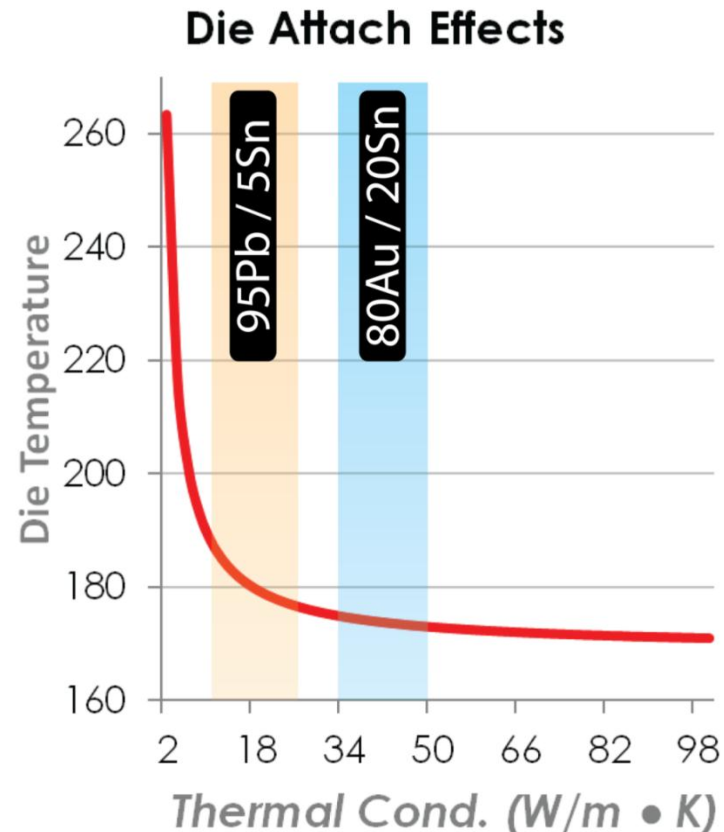
Simulation data is extracted and organized into design surfaces. Tradeoffs are identified and visualized





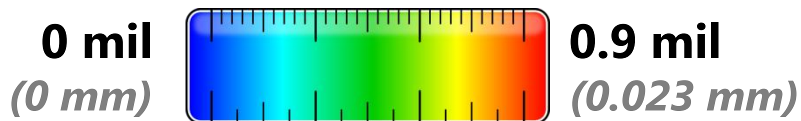
The thermal conductivity of the die attach exhibits diminishing returns

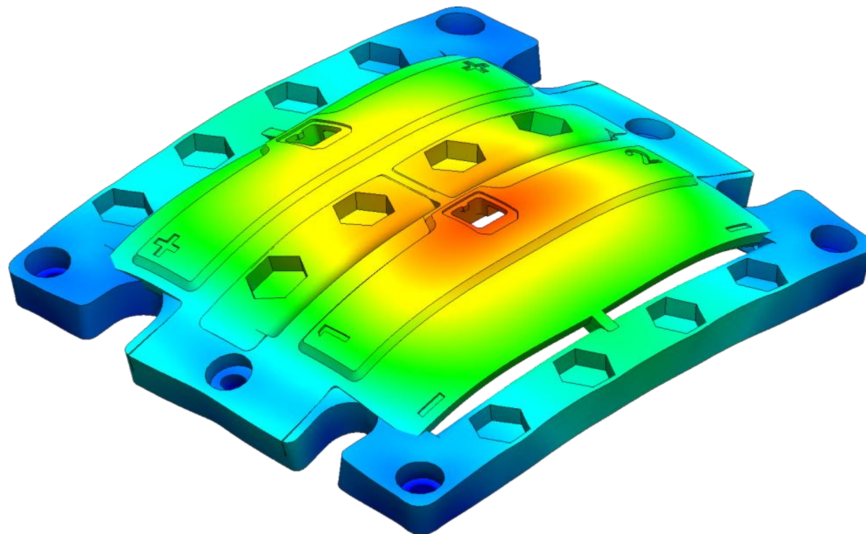




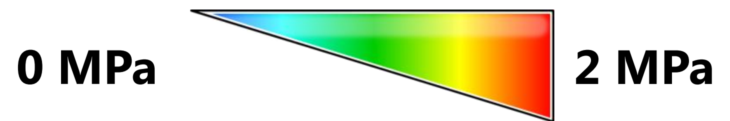
Plastic reinforcing features are carefully designed for minimal stress & displacement

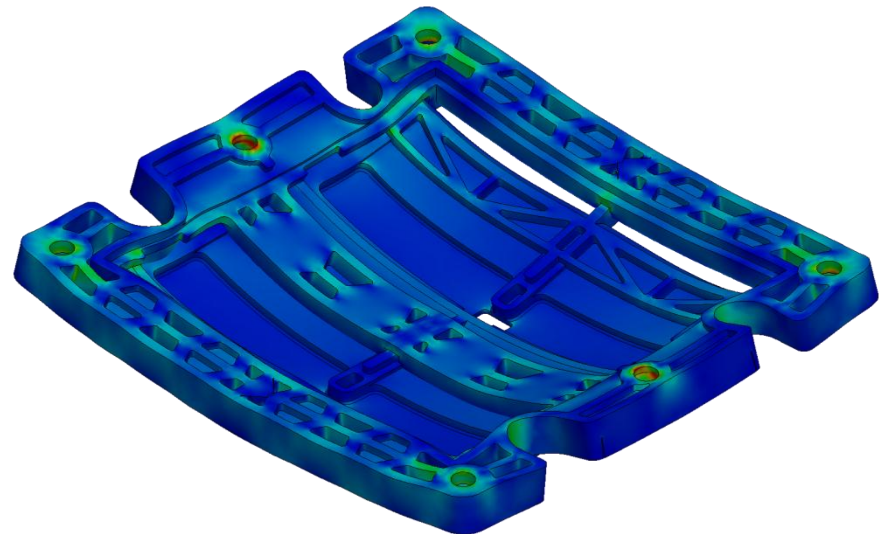
Displacement @ 200°C





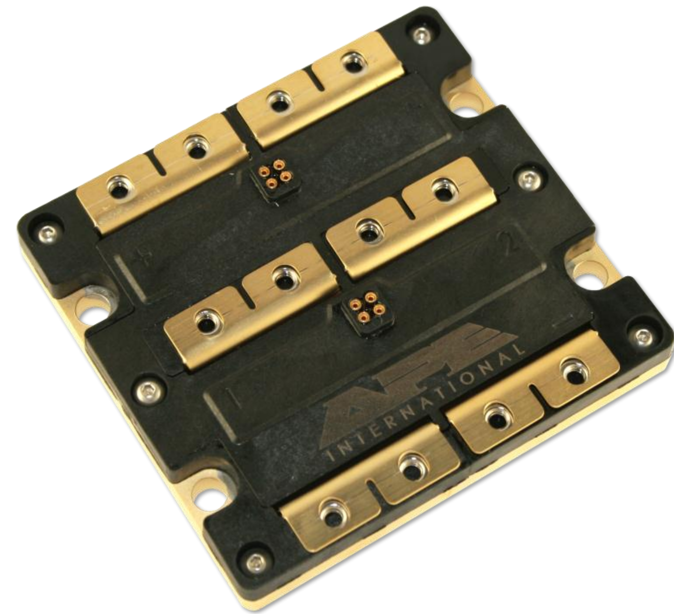
Von Mises Stress @ 200°C





HT-2000

design and features



HT-2000 Series

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High temperature, high frequency, high power density all SiC half or full-bridge power stage.

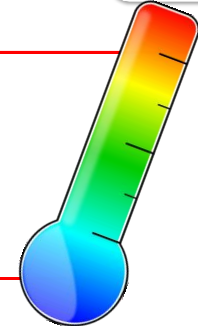
Ratings

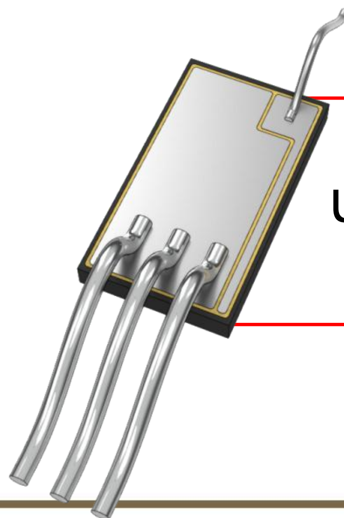
1200V

>150A

Temperature

250°C peak (packaging)





Devices

up to 16 die in parallel per switch position

**** pictured:*** ***SemiSouth 50mΩ JFET (SJEC120R050)***

Packaging

Multiple Material Choices Based on Application

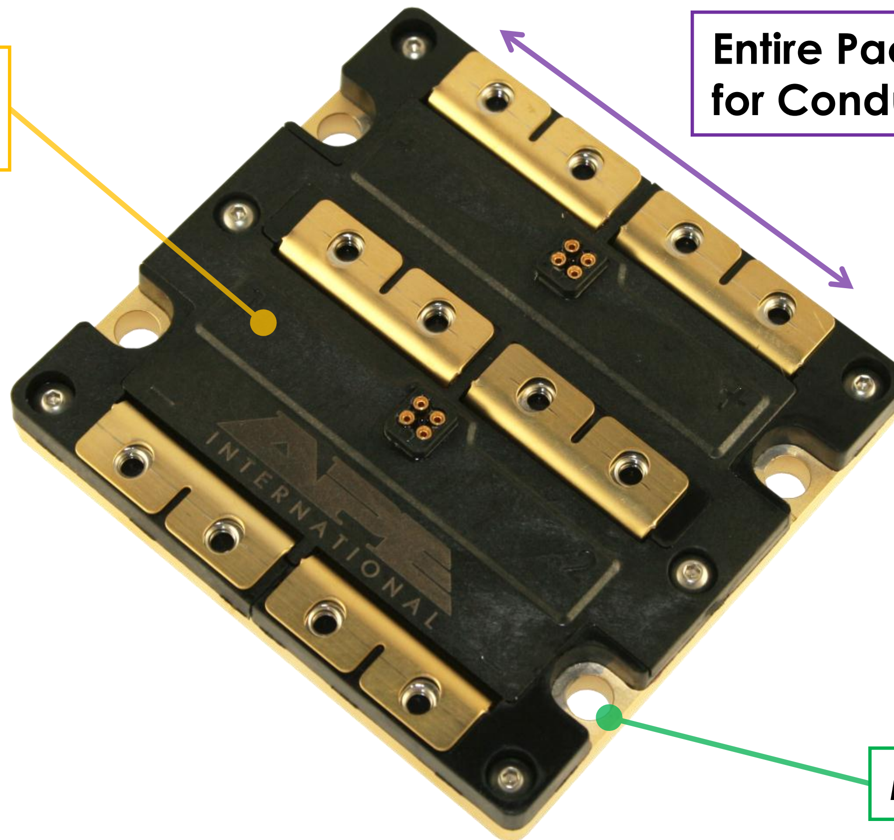
High Temp. Plastic Housing

Entire Package Width Used for Conduction

Very Low Profile
0.43 in (10.9 mm)

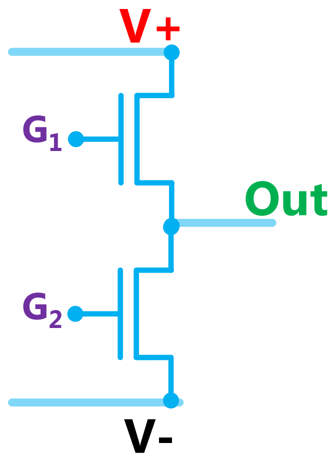
Completely Flux Free Assembly

MMC Base Plate

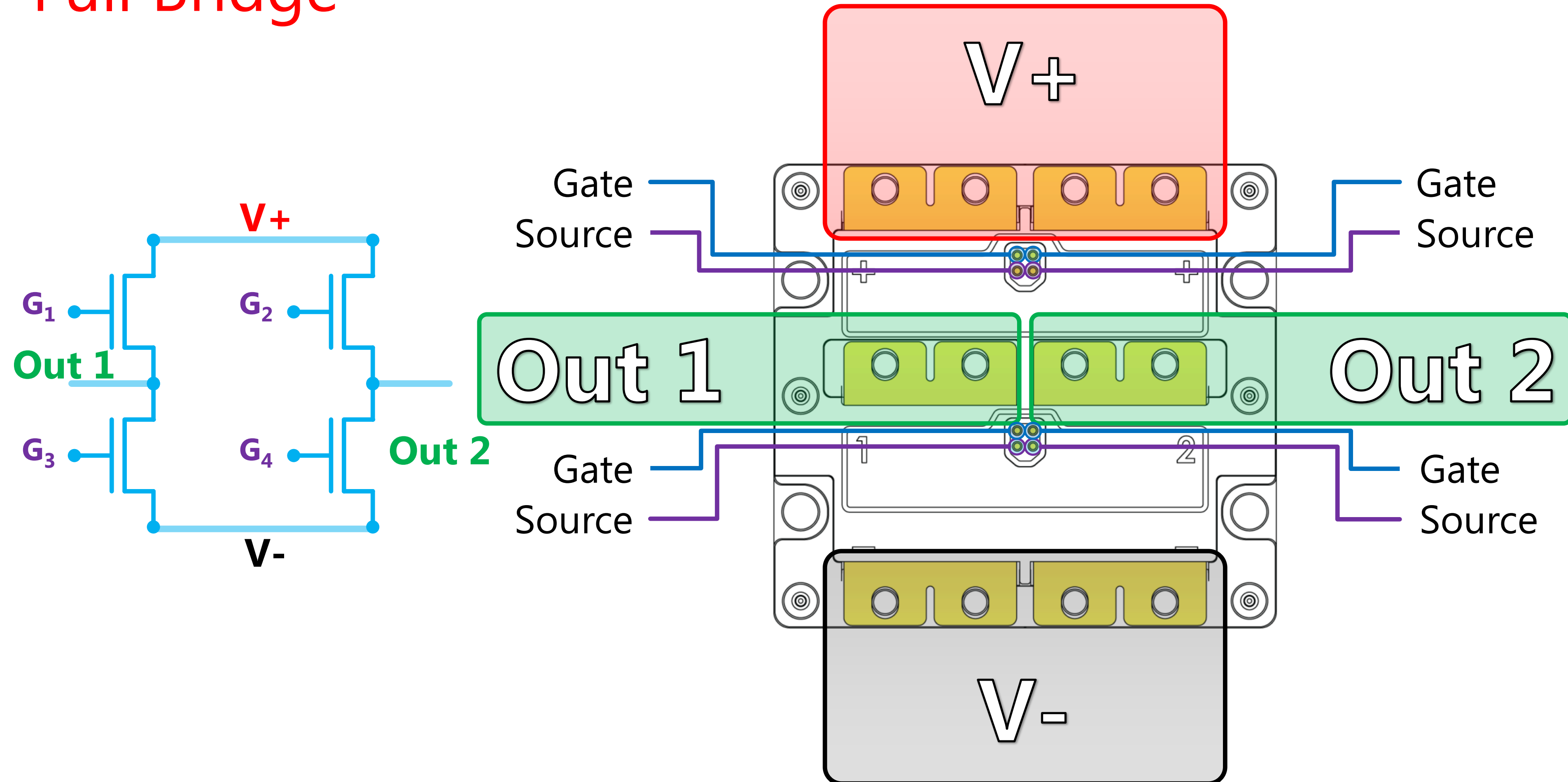


Each module contains four switch positions. Multiple configurations are possible through external bussing

Half Bridge

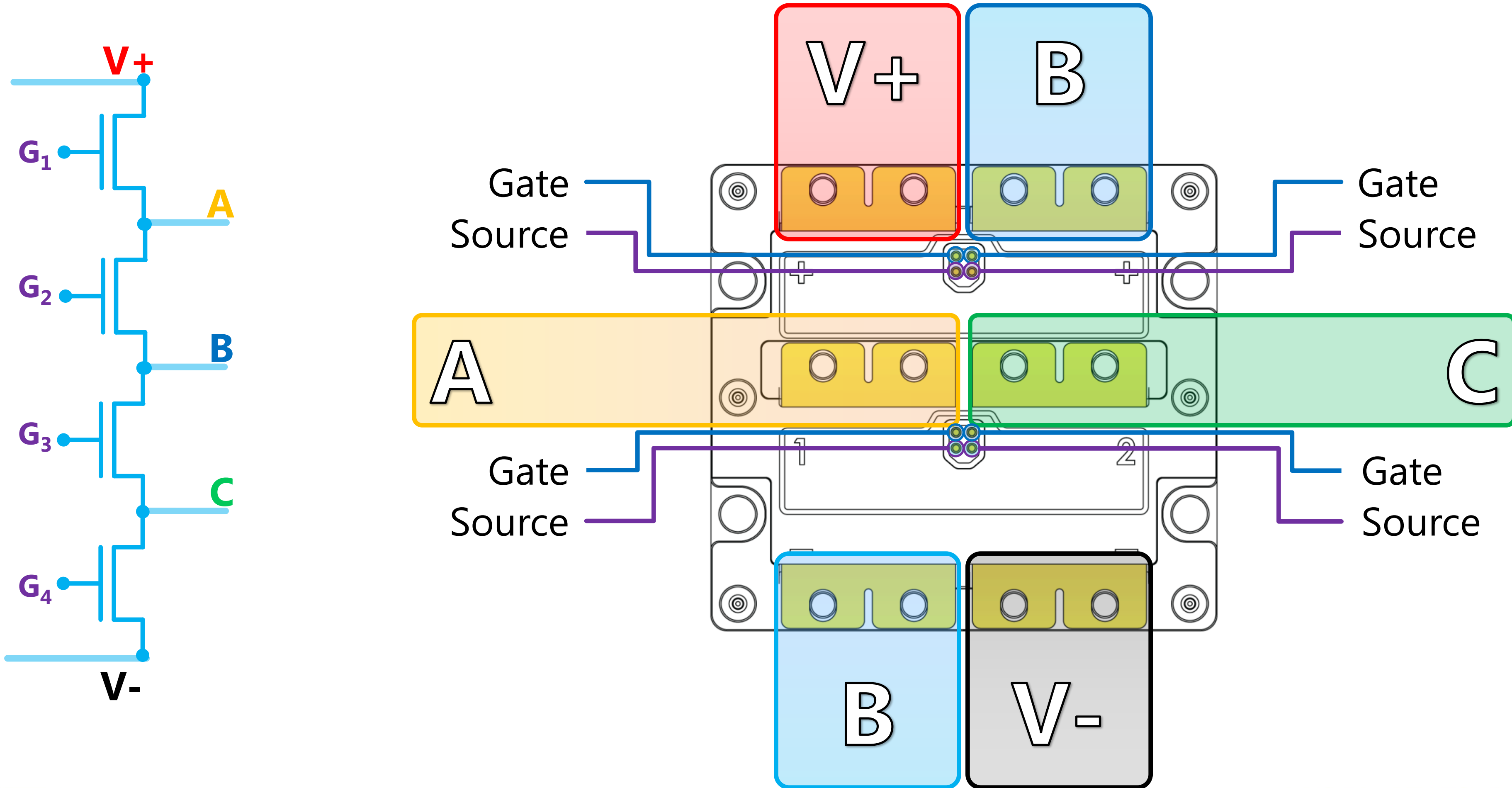


Full Bridge

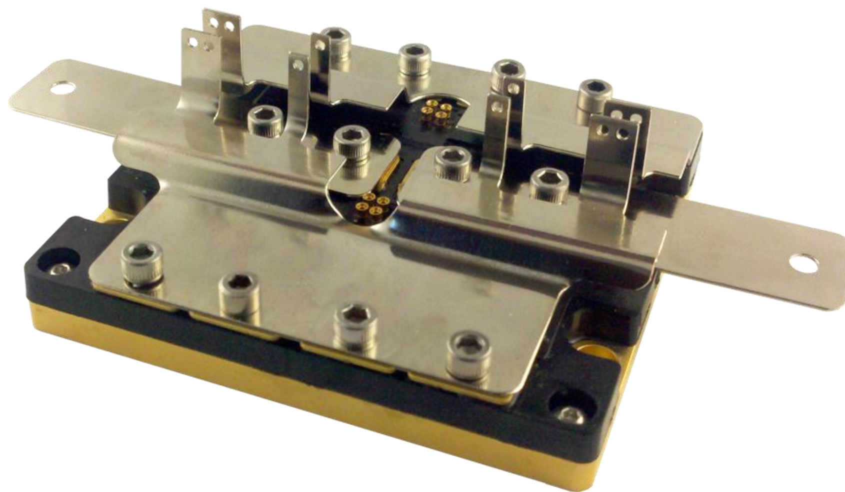


External Connections

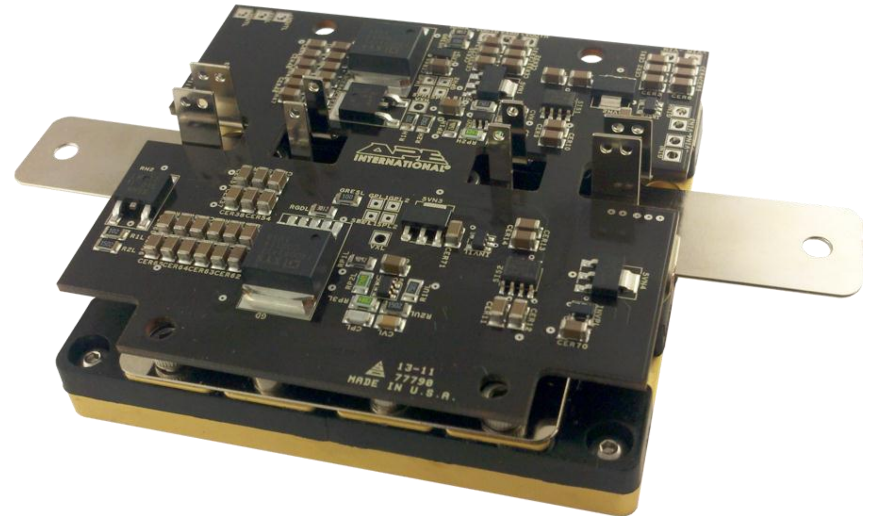
Series



HT-2000 modules are available with custom bussing and gate drives for rapid evaluation



Etched
Copper Bussing



High Frequency
Gate Drive

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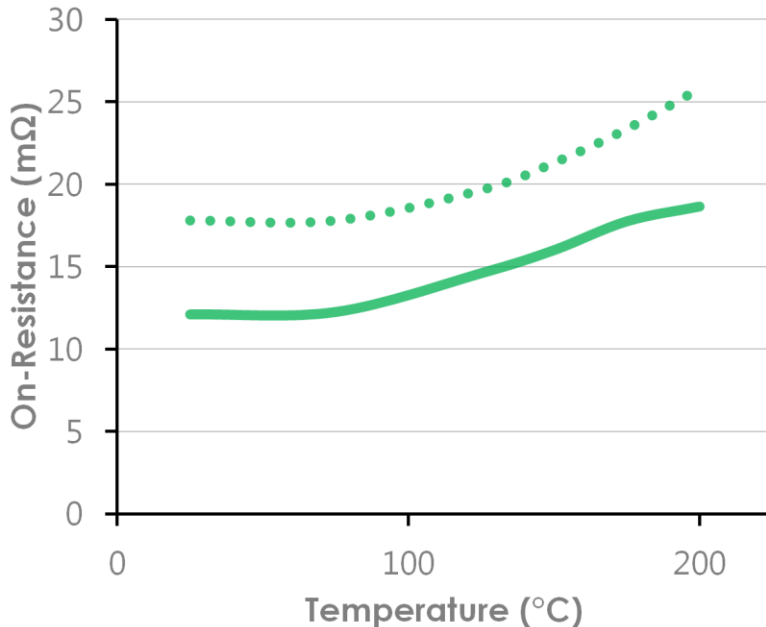
The paralleled switch positions exhibit very low on state resistances, even at high temperature

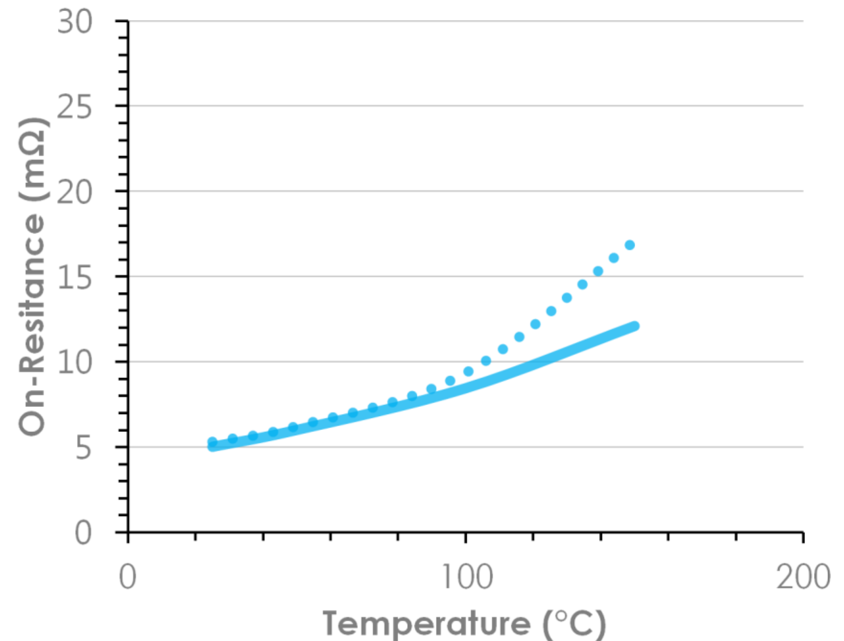
MOSFET Configuration

6 MOSFETs per switch position



JFET Configuration

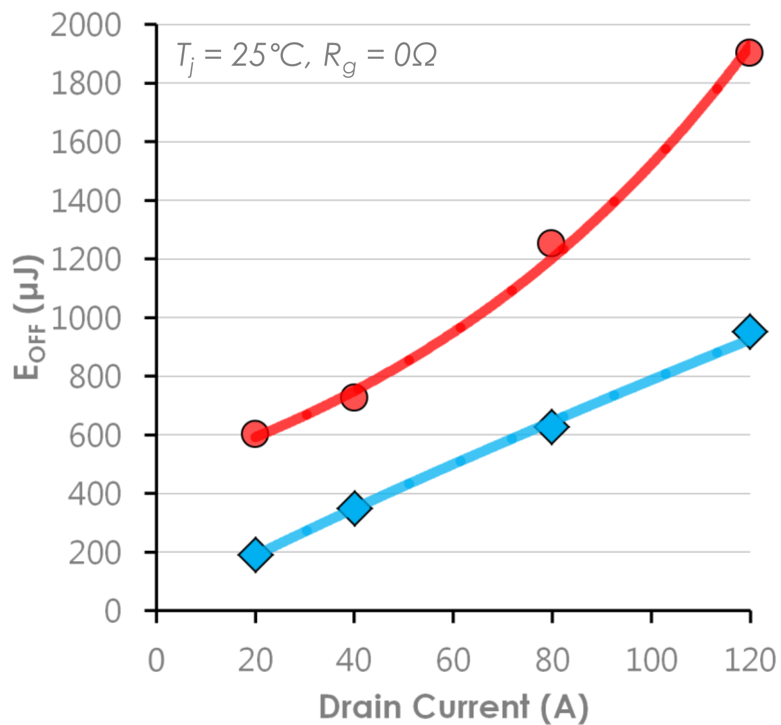
8 JFETs per switch position

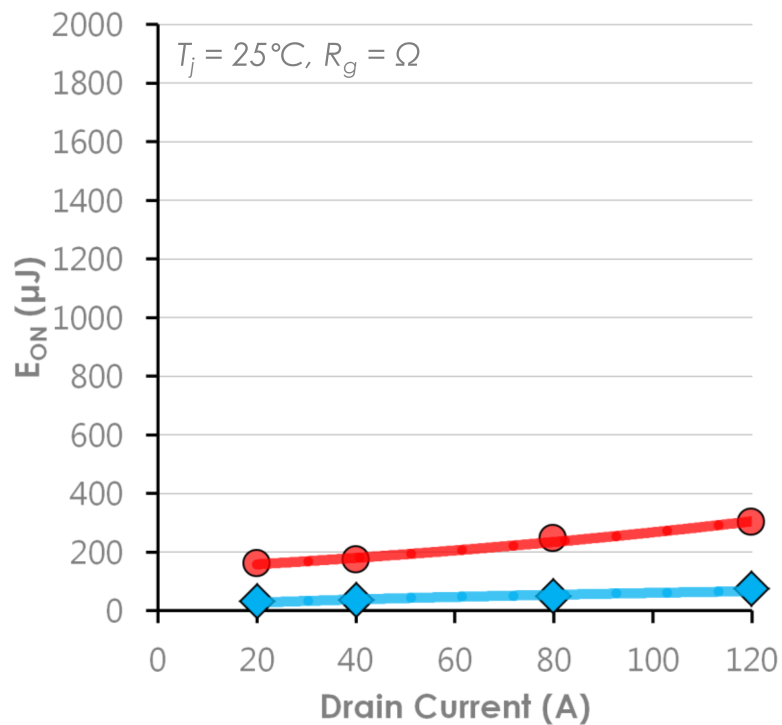


200 A (dotted) · 20 A (solid) — MOSFET

160 A (dotted) · 80 A (solid) — JFET

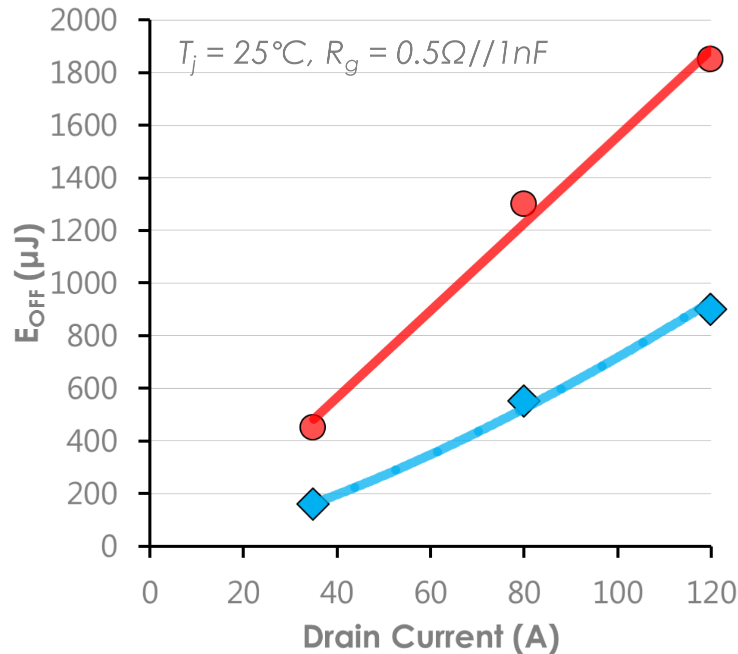
Switching Energy MOSFET Module

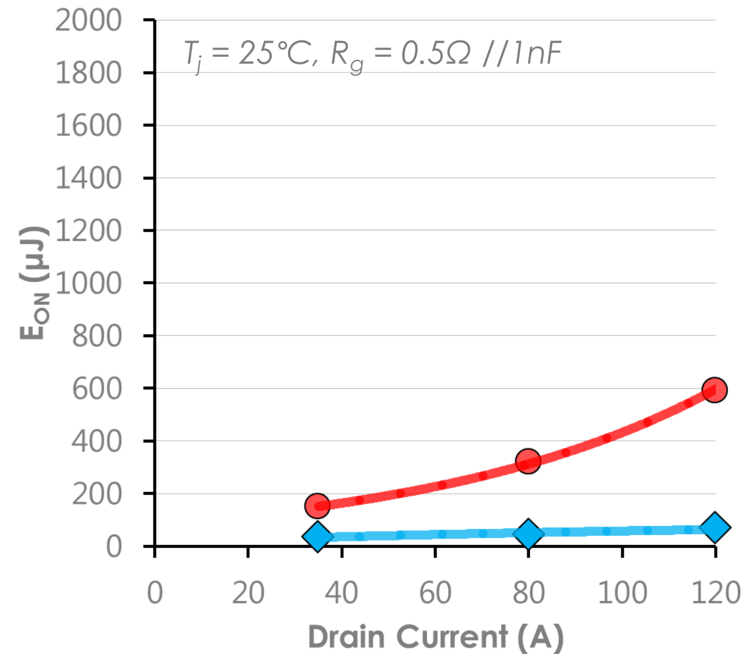




300 V 600 V

Switching Energy JFET Module





300 V   600 V

Summary

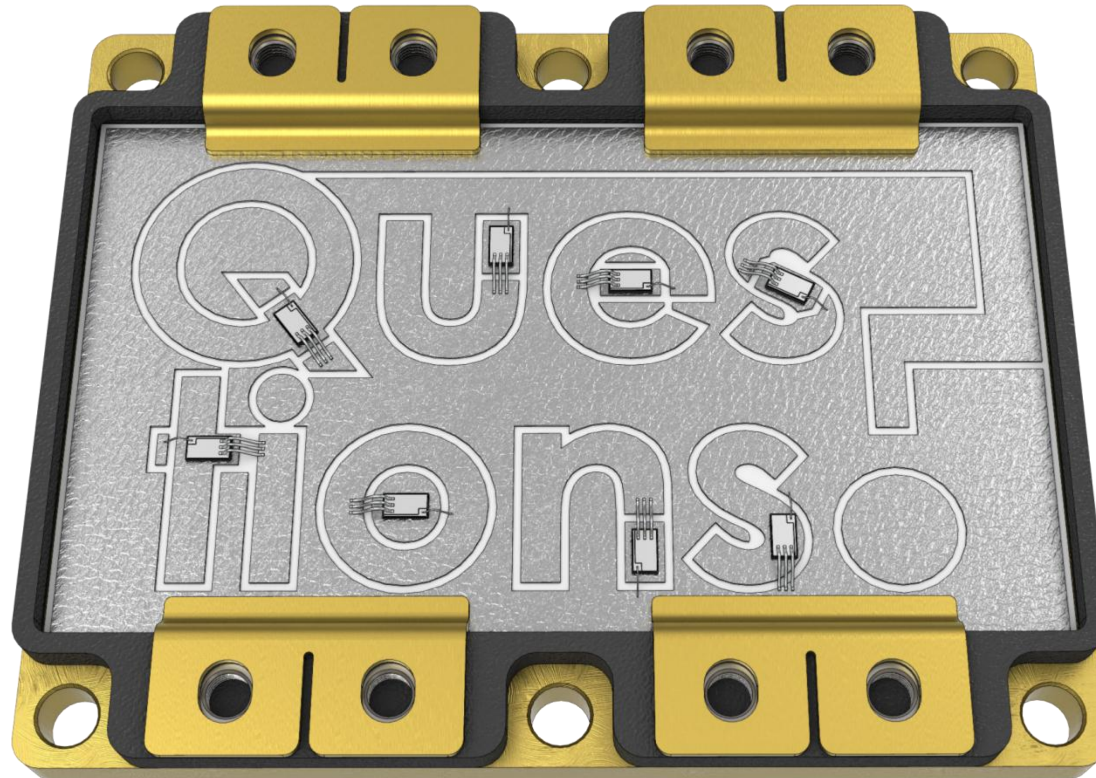
These newly developed high performance SiC power modules can provide substantial system benefits, including:

Increased
- efficiency
- power density

Reduced
- volume
- weight

Higher
- junction temperatures
- ambient temperatures

Thank You!



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