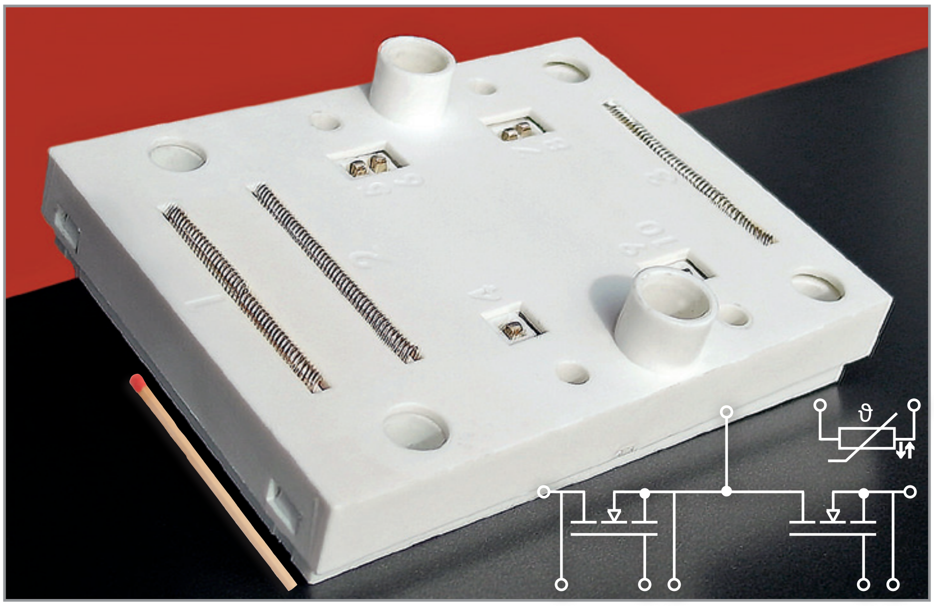
SEMIKRON

FlowCAD

SiC Power Modules



Silicon Carbide Power Module for 400 A and 1200 V with the dimensions of two match boxes side by side

SiC Power Module for Highest Power Output and Efficiency

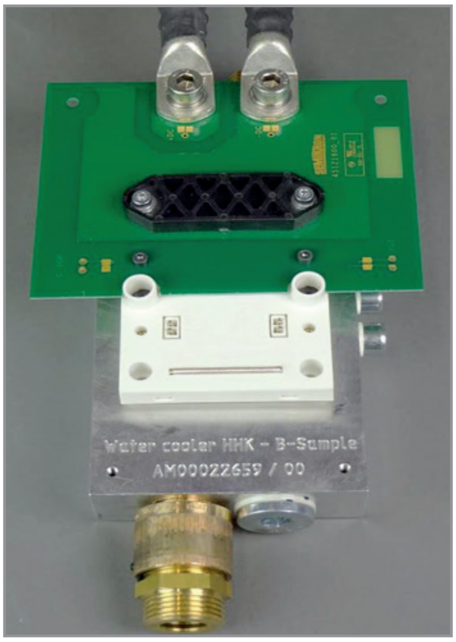
SEMIKRON offers full Silicon Carbide (SiC) Power Modules. They combine the latest packaging technologies for SiC MOSFETs. Several applications like solar, medical power supply as well as induction heating are asking for high current fast switching SiC MOSFET Power Modules.

Two main challenges arise from the design of such a high current power module: First, due to the high switching speed of SiC devices, the commutation loop inductance has to be significantly reduced to levels <<5 nH. Second, due to SiC chip size limitations many chips have to work in parallel what requires a very symmetrical layout of the circuit inside the power module.

Applying the Direct Pressed Die (DPD®) technology construction principle an ultra low inductance path is feasible. These SEMIKRON SiC MOSFET Modules enable highest output power and power densities in combination with high switching frequencies up to 100 kHz, lowest losses and maximum efficiency.

Through the increase of switching frequency the passive filter components can be reduced significantly and the electronic will have smaller dimensions. For example: additional snubber capacitors are not required.

Power losses are reduced at the same time which leads to smaller heat sinks and less cooling effort in general. Both benefits result in major decrease of system cost. This has enabled SEMIKRON to develop modules as small as a size of two match boxes side by side (95 x 50 x 15 mm) while covering power range up to 80 kW in 1200 V.



Connected power module without cover

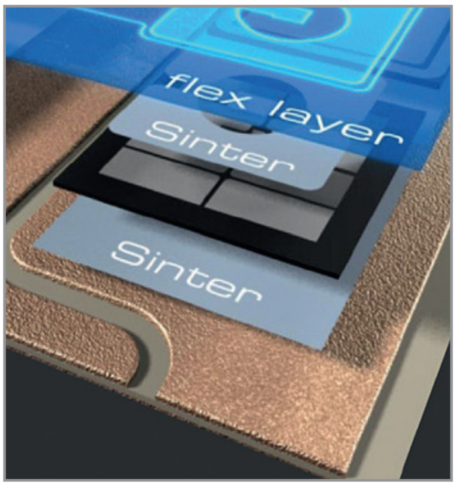
SEMIKRON headquarters in Nuremberg

Michael Schleicher, PCB Designer

Design Challenges

In high power applications there are multiple constraints like safety, current densities (above 100 A/mm^2) and operating temperatures ($T_{junktion\_SiC}$: 175°) which are different to low power applications. Common requirements like miniaturization and cost reduction apply in addition as well.

The new approach is to sinter a special flex pcb concurrently on TOP-side of bare dies and contiguos DCB layers to replace wire bond connections. Additionally the chips themselves are sinterted on the same DCB layer, too. While bond wires can only make contact to about 21 % of the total metallized chip surface, the sintered flex exhibits a die contact area of up to 85 %.
The increased contact surface and the thick metal layer (on flex) improve the heat distribution, the surge current capability (up to 400 A) and has next to the sinter process an impact on the greatly improved power cycling capability of such a device.



Stackup with two layer DCB and two layer flexible PCB

At the same time all spacings must be compliant for creepage and air gaps to prevent sparking at operating voltages of 1200 V. The stackup had to be adjusted to the available assembly technology which is completely inhouse at SEMIKRON in Nuremberg.

These design challenges were successfully mastered for preproduction development.
In a next step the new generation of SEMIKRON power modules will be launched.

Tools used for design

"Current density and thermal What-if simulations of those new stackups showed us, that we could reduce the thermal resistance Rth by 38 % in comparison with standard stackups and also reduce the inductivity about 10 times" said Michael Schleicher, PCB Designer at Semikron. "Prototypes of the evolutionary stackup verified the simulation by measurement results."

Prediction of current and thermal simulation is an iterative co simulation, because the conductivity of copper changes due to self heating when there is a high current density. With currents of 400 A thermal design has a major impact on placement of components and routing of wires and shapes.

Cadence Allegro PCB Designer and Allegro Miniaturization Option were used to design the Flex-PCB stackup and to implement the chip between the flexible printed circuit board and DCB. Safety simulations (air gap and creepage) for the flexible PCB were done in NEXTRA based on the Allegro design data. SolidWorks-format as based on NEXTRA-data used to exchange data on the mechanical CAD department or assembly simulations.

The final module consists of two designs (flexible layer and the DCB) which are manufactured by different suppliers. This process of multiple suppliers and internal assembly required additional manufacturing documentation including dimensions, fiducials and tolerances.

All tolerances were also implemented in Allegro PCB Editor as online design rule checks (DRC).

About SEMIKRON

SEMIKRON is one of the world's leading manufacturers of power modules and systems primarily in the medium output range (approx. 2 kW up to 10 MW). The products are at the heart of modern energy efficient motor drives and industrial automation systems. Further application areas include power supplies, renewable energies (wind and solar power) and utility vehicles. SEMIKRON's innovative power electronic products enable our customers do develop smaller, more energy efficient power electronic systems. These systems in return reduce the global energy demand.
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