E L E C T R O N I C S

Informationpaper

# Ceramic heatsink in e-mobility

C E R A M I C E X P E R T S

# Ceramic heatsink for power electronics in e-mobility

E-mobility is a collective term for vehicles powered by electric energy. This group of vehicles includes electric cars, electric rail transport, e-bikes, electric scooters, trolley buses and other vehicles powered by electric energy. The main focus is on electric cars. Here, the need for innovative solutions is very high in many areas: starting with the transmission of electricity from the power grid to the car, the storage of electrical energy in batteries, to the reconversion to alternating current to drive the electric motor.

The biggest differences between conventionally powered and electric vehicles are mainly in the areas of propulsion and energy storage.

Normally, an electric vehicle has two DC power trains with associated DC/DC converters. The electric powertrain comprises the HV battery, the inverter and the electric motor. This increa-sed complexity poses new challenges for the coordination of all components.

Depending on the vehicle, these can vary depending on the on-board network topology and voltage level on the low and high voltage side. Rising vehicle electrical system voltages and increasing power levels of the drive system with corresponding load fluctuations from driving dynamics result in the highest demands on the system.


**1 Electric motors**
In today's all-electric cars, a wide variety of motor outputs can be found, depending on the supplier. For all operating modes, the drivetrain must provide the power dynamically and safely. For electric motors, for example, CeramTec offers isolations and bearing solutions.

**2 Power electronics**
Power electronics is one of the most important components of an electric car. These include controllers for motor control, DC/DC converters. CeramTec offers innovative solutions with ceramic coolers and substrates for circuit carriers. The topic of cooling is examined in more detail below. CeramTec has developed innovative and leading solutions for this.

**3 HV battery**
The vehicle battery is at the heart of e-mobility. It is available in a wide variety of forms, ranging from small cars to high-performance batteries for sports cars. Here, too, technical ceramics can open up further potential, as in the case of insulation for cell separation in solid-state batteries.

**3.1 HV battery management system**
The battery management system protects the battery against overvoltage, overheating and deep discharge. Ceramic components, coolers and substrates are available for the power circuits.

**4 Vehicle electrical system**
This is where the electronic engine management system is connected to the vehicle electronics and the can bus. In this way, assistance systems such as ESP and ABS can be controlled and supplied with energy. When it comes to cooling, substrates as circuit carriers and electrical components, technical ceramics also provide support in this area.

**5 Heating + air conditioning**
The passenger compartment is supplied via PTC direct heating or electric air-conditioning compressors. Insulators, heating elements and circuit carriers made of technical ceramics can provide support here.

**6 Charger**
Whether the HV battery needs to be charged quickly in an hour or in 6 hours, as is the case with normal charging, technical ceramics provide support here with insulators, circuit carriers and electrical components.


# The use of ceramic heatsinks

High voltages and currents are used in e-mobility to provide the required motor outputs. Road traffic and the rapidly changing different speeds associated with it require a highly dynamic energy supply. This places correspondingly high demands on the powertrain and all its supplying and controlling elements. Electronic powertrain control plays a key role in ensuring that the electrical energy provided is used efficiently. For this purpose, the DC voltage provided by the HV battery must be converted into AC current for the electric motor. The efficiency of the main inverter has a significant influence on the range of the electric vehicle and on how many kilometers can be driven with an HV battery charge.

The structure of the inverter's electronics is designed for minimal switching losses. The heat dissipation of the electronics in the inverter plays a central role. The higher the amount of heat that can be dissipated, the higher the power density of the electronics can be. The size of the electronics design can also be minimized, and the total number of electronic components can be reduced. With good heat dissipation, the potential of modern SIC semiconductor chips, which have a high switching frequency and improved thermal properties, can be better exploited.

# The SiC inverter power module on ceramic heatsink

The figure below shows the power module for the inverter.
This is subject to the following requirements:

**Dieser unterliegt folgenden Anforderungen:**

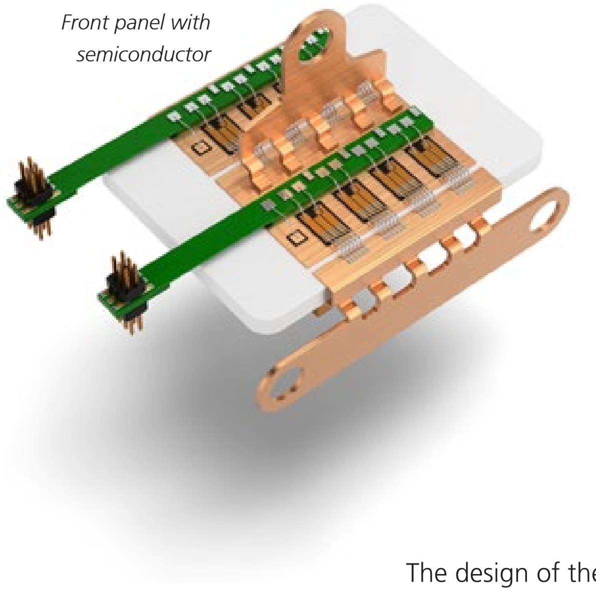
- 1200V full SiC half bridge with sintered semiconductor devices.
- Low Rth'= 0.15 K * cm²/ W for high current capability
- Low module inductance due to module integrated ceramic capacitor on the backside of the ceramic heatsink
- Non-critical interfaces for easy system application
- Module design scalable according to current requirements

# Chip-on-heatsink technology using the example of a drive inverter

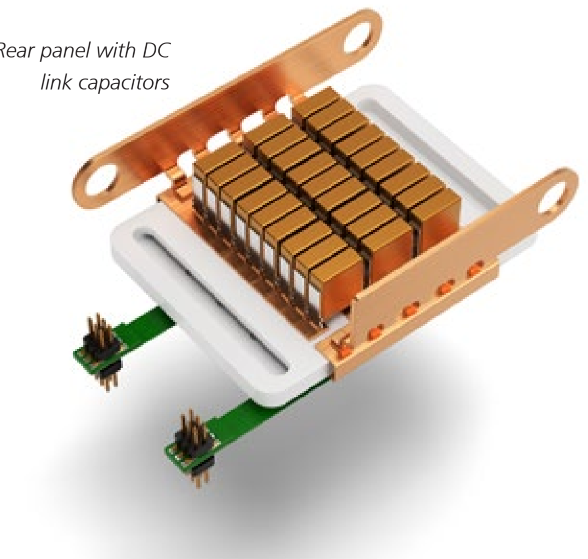
At the power electronics trade show PCIM Europe 2021, CeramTec's chip-on-heatsink cooling technology was presented, which is used for inverters in the e-mobility powertrain.

Based on the previously described requirements, the requirement profile for the cooler is to generate the maximum electrical power and provide it efficiently: low weight, compact design and maximum heat and maximum heat dissipation are the required properties. CeramTec has developed a cooling body made of aluminium nitride (AlN) with chip-on-heatsink technology that meets these requirements. The heat sink is a circuit carrier and cooling structure in one component.  This leads to a significant increase in power density and a significant reduction in power module size.

*Front panel with semiconductor*



*Rear panel with DC link capacitors*



The design of the ceramic heatsink enables optimized heat dissipation of the SiC semiconductors on the upper side of the heat sink, while the DC link capacitor is integrated low-inductively in the power module on the underside of the heat sink via metallization that encompasses the cooler.

# The cooling structure

The ceramic heatsink has an internal cooling structure. This is designed as a pin-fin structure, whereby the base body already has corresponding inlets and outlets for the cooling fluid. The pin-fin structure fulfils several main functions. It significantly increases the heat transfer surface of the heat sink. The surface of the pin-fin is optimally flushed due to its arrangement and thus enables good heat dissipation. At the same time, the pin-fin structure ensures high mechanical strength of the heat sink, which can therefore absorb compressive, torsional and bending forces well.

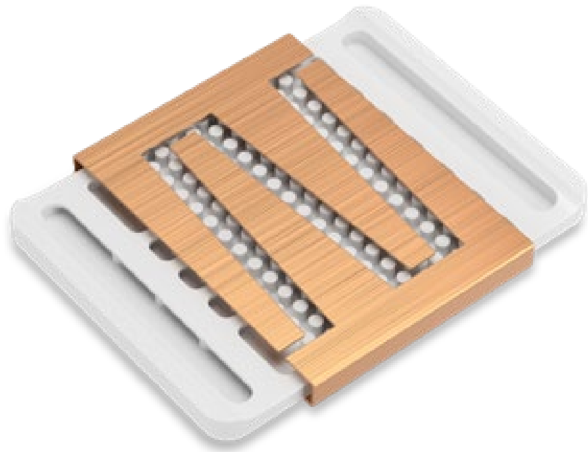
# The structure of the heatsink

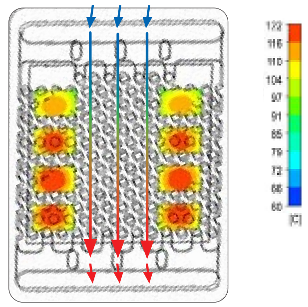
The structured copper sheets are applied directly to the ceramic cooler. Dimension and arrangement correspond to the requirements of the components and the electrical power to be provided.
The structure of the heat sink allows both sides to be used as circuit carriers and both sides to be cooled.

- Cooler consists of two layers
- Inlet and outlet on the back of the ceramic
- Easy connection to the cooling circuit via gaskets.
- Free choice of cooling liquid
- Resistant to electrochemical or mechanical corrosion.

The structure of the heatsink allows both sides to be used as circuit supports and both sides to be cooled.

*- Dimensions: 48 x 36 mm*
*- Metallization thickness 0.3 mm*
*- Weight of the heatsink ~ 10 g*





Another major advantage is that the pin-fin structure can be matched to the footprint of the SiC semiconductors in that there are the same number of cooling pins below the cooling lug. This allows optimum cooling of all chips.

With CeramTec's chip-on-heatsink technology, the direct metallization of the cooler and the cooling structure, CeramTec provides a cooling system for e-mobility that can be used efficiently and effectively in many areas for cooling power modules.


CeramTec
THE CERAMIC EXPERTS

CeramTec-Platz 1-9
73207 Plochingen
Germany

Phone +49 (0) 7153.611-0
Fax +49 (0) 7153.25421
E-mail myceramtec@ceramtec.de


YouTube Channel
CeramTec

**LinkedIn**
www.linkedin.com/ceramtec