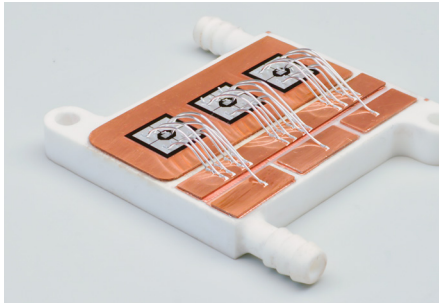


Ceramic Liquid-Cooled Heatsink for Bare Semiconductor Dies

Additively manufactured ceramic heat sink with liquid-cooling channels and thick copper layers (300 µm) as a substrate for power electronics

The Dyna-HOPE demonstrator is a compact, liquid-cooled ceramic heat sink made from 3D-printed aluminium oxide (Al_2O_3), sintered at 1,650 °C. The cooling plate is metallised with copper thick-film paste at 900–950 °C, followed by copper or copper composite foil sintered at approximately 300 °C and 10 MPa with a copper sintering paste. Finally, the IGBTs are sintered with similar boudarx conditions onto the foil and electrically connected on the top side using AlSi thick-wire bonding.



The proposed ceramic heatsink is a compact and lightweight cooling solution for high-power-density inverters using discrete semiconductor devices or bare dies. It is designed to achieve low overall thermal resistance, reduced system size and weight, and efficient heat dissipation.

The heatsink is currently additively manufactured from alumina (Al2O3) with focus on aluminum nitride (AlN) in the future, combining high thermal conductivity with excellent electrical insulation. Additive manufacturing enables a high degree of design freedom for cooling paths and geometries. Connections for cooling hoses and mechanical screw connections can be integrated directly into the component. The short distance between the semiconductor and the coolant eliminates the need for thermal interface materials, metallic baseplates and conventional aluminium or copper heatsinks. This makes it possible to build extremely lightweight inverters with very high power density in the least amount of space.

The ceramic surface can be functionalized with a structured or full copper or silver thick-film layer. This layer enables the direct mounting of Si-IGBTs, SiC-MOSFETs and bare semiconductor dies. An optional copper or copper-composite buffer layer can reduce mechanical stresses caused by different coefficients of thermal expansion and enables the conduction of high currents. Assembly can be realised by soldering or pressure-assisted, low-temperature silver or copper sintering. Electrical connections on the top side of the chips can be made using AlSi thick-wire bonding.

The scalable design supports H-bridge configurations for low-power applications, half-bridge topologies for medium-power three-phase systems, and parallel connection of up to four devices for high-power applications. High creepage distances between the top and bottom sides enable operation in polluted or high-altitude environments.

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exhibit overview