Electric Vehicles Could Benefit from 50% Improvements in Packaging Thermal Resistance

Enhanced surfaces lead to increased heat transfer and power density.

Inverters are used in hybrid electric vehicles (HEVs) and electric vehicles (EVs) to convert DC battery power into a form that can be used by electric motors. Aggressive thermal management is essential in boosting power density and specific power of these power electronic devices to the levels needed to meet program targets and goals.

The National Renewable Energy Laboratory's (NREL's) Advanced Power Electronics Task in the Center for Transportation Technologies and Systems, in collaboration with 3M and Wolverine Tube, Inc., has demonstrated significantly increased heat-transfer rates for single-phase and two-phase flows using surface enhancements. In heat transfer experiments on a 1 square cm area chip surface, the 3M microporous coating resulted in up to a 500% enhancement in pool boiling heat-transfer coefficients with respect to the case where there was no coating. Up to a 100% enhancement in heat-transfer coefficients was demonstrated for submerged single-phase jets of liquid impinging on a Wolverine MicroCool enhanced surface with respect to the case where the liquid impinged on a non-enhanced surface. These results have significant implications for reducing the overall thermal resistance in power electronics packages/modules.

Immersion boiling combined with enhanced surfaces can decrease the total semiconductor junction-to-liquid (or coolant) thermal resistance of an automotive power module by over 50% compared to a traditional single-phase water-ethylene glycol cooling system. This reduction may have significant impacts on the cost, weight and volume of power electronics components. It is estimated that improved thermal performance can reduce the number or area of the insulated-gate bipolar transistor (IGBT) devices by more than half, with potential cost savings exceeding 50%.

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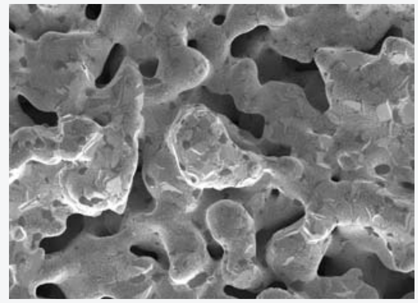

Scanning electron microscope image of a microporous coating developed by 3M. NREL researchers are using the coating to improve heat transfer in automotive power electronics devices. Photo by Bobby To, NREL/PIX 19223.

Key Research Results

Achievement

NREL's application of enhanced surfaces could potentially increase inverter performance in electric-drive vehicles.

Key Result

The surface enhancements delivered an improvement in heat transfer which resulted in 50% reduction in package/module thermal resistance.

Potential Impact

The reduction of thermal resistance may significantly improve power density, while making electric-drive vehicles more affordable.

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