75th ECTC 2025

Students‘ Competition

Approaches to Reduce Thermal Resistance and Improve Reliability of High-Temperature Power Electronics Modules

Students‘ Competition Team

Approaches to Reduce Thermal Resistance and Improve Reliability of High-Temperature Power Electronics Modules

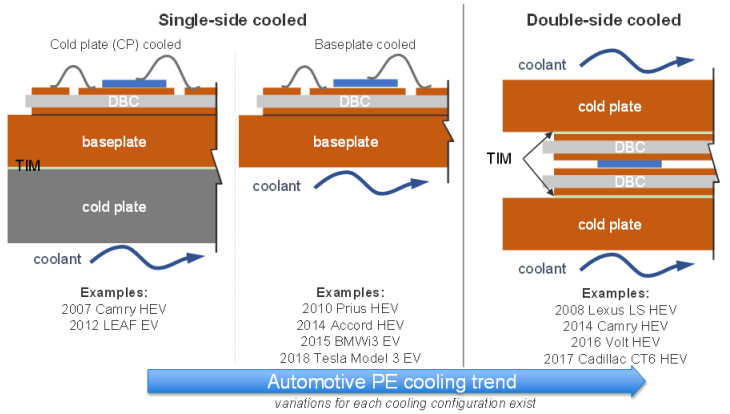
Context:

The challenge is to find innovative methods to reduce thermal resistance and enhance the reliability of high-temperature power electronics modules. These modules operate in harsh environments, encounter thermal stresses, and can degrade over time. Teams must explore advanced materials, designs, and cooling techniques to ensure better thermal management and longer module lifespans.

Challenge:

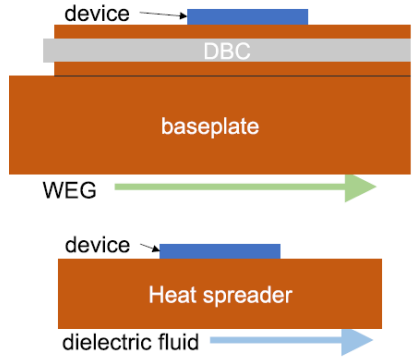
- Survey the current state of the art to determine the thermal resistance of power electronics modules (see Figs. 1 and 2 for some examples).
- Propose advanced configurations (including solid layers, fluid types, and thermal management techniques) to reduce the junction-to-fluid thermal resistance compared to the state of the art.
- Justify that the proposed configurations will also perform well in terms of thermomechanical reliability and electrical performance.
- Ensure that the proposed solutions use low-cost, abundantly available materials.

Figure 1. Schematics of typical power module configurations



Source: Moreno, G., Narumanchi, S., Feng, X., Anschel, P., Myers, S., and Keller, P., 2021, "Electric-Drive Vehicle Power Electronics Thermal Management: Current Status, Challenges, and Future Directions", ASME Journal of Electronic Packaging, Vol. 144(1): 011004, https://doi.org/10.1115/1.4049815

Figure 2. Schematics of a conventional power module (top) and low-thermal-resistance package suitable for a dielectric fluid cooling strategy (bottom).



Source: Moreno, G., Narumanchi, S., Tomerlin, J., Major, J., 2022, "Single-Phase Dielectric Fluid Thermal Management for Power-Dense Automotive Power Electronics", IEEE Transactions on Power Electronics, Vol. 37, No. 10, pp. 12474-12485, https://doi.org/10.1109/TPEL.2022.3171744.

PE: Power Electronics
TIM: Thermal Interface Material
DBC: Direct-Bond-Copper (Copper-Ceramic-Copper)
HEV: Hybrid Electric Vehicle
EV: Electric Vehicle
WEG: Water-Ethylene Glycol

If you select this challenge, use in the emails title code: **Ch3**