2026 HBCU CHIPS Network Conference

Contribution ID: **21**   Type: **POSTER**

Finite Element Analysis of 3D-Printed Polymer Lattice Thermal Interface Materials: Effects of Lattice Configuration and Open/Closed-Cell Topology

Finite element analysis (FEA) was used to investigate the thermal behavior of additively manufactured polymer lattice thermal interface materials (P-TIMs) across a range of architectural configurations. Starting from a baseline lattice, we generated multiple designs by selectively adding vertical struts in uniform, alternating, and graded arrangements to enhance through-plane heat conduction. Both open- and closed-cell configurations were considered within the Gibson–Ashby cellular solids framework to assess the influence of unit-cell topology on effective thermal performance. Three-dimensional lattice models were analyzed in Abaqus using steady-state and transient thermal simulations to quantify effective thermal resistance, heat-flux distributions, and temperature gradients under representative operating conditions. Thermal contact at the chip–TIM and TIM–heat-sink interfaces was modeled to capture the impact of interface pressure on heat transfer.

The simulations show that architectures promoting continuous vertical conduction pathways, combined with optimized open/closed-cell topologies, reduce effective thermal resistance and improve heat-transfer efficiency relative to the baseline lattice. Overall, the results highlight the critical role of unit-cell topology and strut arrangement in controlling through-plane conduction and demonstrate that FEA-guided geometry optimization is an effective design strategy for high-performance 3D-printed polymer lattice TIMs for advanced electronics cooling.

Academic or Professional Status

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Session Classification: Poster Session

Track Classification: Materials & Devices: Materials & Devices - (a)