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Experimental Investigation of 3D-Printed Polymer Lattice Composite Thermal Interface Materials for Semiconductor Packages

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Polymerization enables precise control of polymer lattice architectures for thermal interface materials (P-TIMs), creating new opportunities to tailor heat transfer and mechanical compliance. This study experimentally investigates SLA-printed lattice P-TIMs as a function of unit-cell topology and composite formulation. A baseline lattice was modified by introducing vertical struts in uniform, alternating, and graded arrangements, and both open- and closed-cell configurations were designed within the Gibson–Ashby cellular solids framework.

A high-temperature photocurable resin was loaded with boron nitride (BN) microparticles and glass microfibers at varying weight fractions and printed using high-resolution stereolithography (SLA). Printed lattices were post-cured and subsequently infiltrated with thermally conductive polymer composites to enhance through-plane conduction. Through-plane thermal conductivity and thermal contact resistance were measured under controlled compressive loading, and mechanical compliance was evaluated to assess stability under representative interface pressures.

Results show that lattice configuration and filler composition jointly govern through-plane heat transfer and overall thermal resistance. Architectures that promote continuous vertical conduction pathways, combined with appropriate open/closed-cell topology, achieve improved thermal performance while maintaining compliance and mechanical stability. These findings establish additively manufactured, geometry- and composition-engineered P-TIMs as a clean, reusable, high-performance option for chip-to-heat-sink thermal management in advanced electronics cooling applications.

Academic or Professional Status

Postdoctoral Researcher / Research Scientist

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