Simulation of Timescale Matching between Organic and Metallic Phase-change Materials for Transient Thermal Reduction

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Most thermal reduction technology utilizing phase-change materials (PCMs) focuses on employing organic or metallic PCMs, but not both. This study reports a synergistic transient effect –timescale matching of organic and metallic PCMs – using the Army Research Laboratory's ParaPower. Four procedures were implemented. First, a convergence study of ARL ParaPower was conducted. Second, with ARL ParaPower's convergence ascertained, Monte Carlo simulations of a single-chip module with a flux of 350 W/cm2 for 2.5 seconds were employed to gain insight using Pareto optimization. Third, manufacturing constraints and the insight obtained were applied to reduce the search space to find synergistic effects of organic and metallic PCMs on a single-chip module. Fourth, the insights gained were applied to a multi-chip module, using a flux of 120 W/cm2 for 2.5 seconds, to further understand timescale matching of PCMs. The results show ARL ParaPower converges with first-order temporal and second-order spatial convergence. Of the three PCMs, Field's metal was eliminated for poor performance in timescale matching with other materials. Most importantly, superior timescale matching of metallic gallium and organic PureTemp29 has been confirmed in single- and multi-chip modules, which nearly quadruples the set of Pareto-optimal points with the greatest transient thermal reduction using PCMs.

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