Investigating the effect of pin-fin configurations on the efficiency of a hybrid nanofluid cooled heat sink system

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ABSTRACT

High cooling capacity makes micropin-fin heat sinks highly feasible for the thermal management of the miniaturised microprocessor system. In addition to the enlarged effective surface area for heat exchange, the interruption of the thermal-viscous boundary layer primarily enhances the heat transfer rate of the micropin-fin heat sink. In the present study, the performances of a micropin-fin heat sink equipped with variable pin-fin configurations are analysed by considering the water and hybrid nanofluid as coolant.

The probed pin-fin shapes include sharp and streamlined pin-fin configurations arranged in a staggered assembly. The discrete phase numerical approach is implemented to simulate hybrid nanofluid with the nanoparticle volume fraction of 1% and diameter of 15nm. In the discrete phase model, the governing equations for the base fluid are solved in Eulerian approach while trajectories of the nanoparticles are traced in the lagrangian approximation. The interphase interactions are solved by introducing source terms in the momentum and energy equations of Eulerian phase. The results demonstrate that nanoparticle dispersions in the water improve the cooling efficiency of the heat sink.

The efficacy of both the water and nanofluid cooled micropin-fin heat sink is a strong function of pin-fin cross-section. The streamlined fin cross-sections demonstrated the highest cooling efficiency compared with the sharp-cornered pin-fins. At the small nanoparticle concentrations, the performance enhancement of the water-cooled streamline pin-fins may even exceed the efficiency of the hybrid nanofluid cooled sharp cornered fins.

KEYWORDS

Micropin-fin, fin configuration, heat sink, hybrid nanofluid, heat transfer coefficient

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