Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Optimization of Micropillar Arrays for Heat Pipe Applications[1]

RENEE HALE, CARLOS HIDROVO, The University of Texas at Austin — Demand is rising for improved thermal management solutions in areas such as electronics cooling. Heat pipes are an attractive technology, but their cooling capacity is limited by the maximum flow rate that their internal wicking structure can sustain. This capillary limit depends upon the interplay between the permeability of the internal wicking structure and the capillary forces produced by the wick pores. Micropillar arrays have recently received attention as potential wicking materials, and this project seeks to design, manufacture, test, and optimize micropillar arrays for heat pipe applications. The novelty of this work resides in the exploration of rectangular pillar arrangements where the pillar spacing is not identical in both directions. This work utilizes analytical and numerical models of fluid flow to determine array permeability. The capillary pressure is predicted by surface energy minimization techniques. Pillar dimensions are then optimized to obtain the maximum fluid flow rate through the wick. To test the wicks, a thermo-hydraulic characterization setup directly measures the mass flow rate of a working fluid through a wicking material as a function of applied heat load. The results give a clear indication of the heat capacity of each wick and provide a valuable connection between experimental results and model predictions for the fluid velocity. This work tests a range of micropillar array geometries and reports on their suitability as wicking structures for heat pipe applications.

[1]Support provided by NSF Grant 1134104

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Date submitted: 31 Jul 2013 Electronic form version 1.4