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Fluid flow and heat transfer in polygonal micro heat pipes SAI RAO, HARRIS WONG, Louisiana State University — Micro heat pipes have been used to cool microelectronic devices, but their heat transfer coefficients are low compared with those of conventional heat pipes. We model heat and mass transfer in triangular, square, hexagonal, and rectangular micro heat pipes under small imposed temperature differences. A micro heat pipe is a closed microchannel filled with a wetting liquid and a long vapor bubble. When a temperature difference is applied across a micro heat pipe, the equilibrium vapor pressure at the hot end is higher than that at the cold end, and the difference drives a vapor flow. As the vapor moves, the vapor pressure at the hot end drops below the saturation pressure. This pressure drop induces continuous evaporation from the interface. Two dimensionless numbers emerge from the momentum and energy equations: the heat-pipe number H, and the evaporation exponent S. When $H \gg 1$ and $S \gg 1$, vapor-flow heat transfer dominates and a thermal boundary layer appears at the hot end, the thickness of which scales as L/S, where L is the half-length of the pipe. A similar boundary layer exists at the cold end. Outside the boundary layers, the temperature is uniform. We also find a dimensionless optimal pipe length Sm=Sm(H) for maximum evaporative heat transfer. Thus, our model suggests that micro heat pipes should be designed with $H \gg 1$ and S=Sm. We calculate H and S for four published micro-heat-pipe experiments, and find encouraging support for our design criterion.

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