MODELING OF THIN FILM EVAPORATION HEAT TRANSFER AND EXPERIMENTAL INVESTIGATION OF MINIATURE HEAT PIPES

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ABSTRACT

The heat pipe, as one of the most efficient heat transport devices, is a peerless choice in the electronic cooling field. In order to better understand the heat transfer mechanisms of the heat pipe, a heat transfer model, which considers the effects of the surface condition, disjoining pressure, gravity force, and contact angle on the thin film profile, heat flux distribution, has been developed. The theoretical analyses showed that the heat transfer in the evaporator could be divided into three templates: CASE I, II, and III with increasing the heat load input. In order to verify the theoretical analysis, experimental investigations of a grooved heat pipe with micro trapezoid wicks, a miniature loop heat pipe with a copper sintered-layer flat evaporator, and a flat heat pipe with the wire core wicks were conducted, respectively. Comparison of the experimental data with theoretical results showed that the model can be used to predict the temperature response in evaporator at low heat load but is invalid at high heat load. The thin film evaporation heat transfer model is successful to address the heat transfer in a cell during the freezing process. In order to obtain ultra-high cooling rate and uniform temperature profiles at cryogenic temperature, one cryogenic oscillating heat pipe with the liquid nitrogen as its working fluid has been developed and experimentally studied. Experimental results showed that its heat transport capability reached 380W with $\Delta T_{Ave,e-c} = 49^0$C at charged ratio of 48 percent. At steady state, the amplitude of temperature response in evaporator was smaller than that of condenser while the temperature response kept the same frequency in both evaporator and condenser. The ΔT amplitude between evaporator and condenser decreased with increasing the heat load.