Abstract

In the recent years, research in the field of evaporation and boiling heat transfer at microscale level has been constantly growing due to the rapid advancement of the high heat dissipating electronics in the fields of biomedical, fuel cells, spacecraft, refrigeration and air conditioning and automobiles etc. In spacecraft applications, there is a mandate for developing advanced cooling devices with phase change which can handle high heat flux dissipating elements. To meet this demand, we identified two significant areas i.e. thin film evaporation and boiling in microchannels which can cater to the future need in the applications of heat pipes and pumped fluid loops. The present dissertation focuses on the investigations on thin film evaporation and boiling in microchannel heat sinks of two different shapes.

The first problem of thesis work deals with detailed analytical modeling of the evaporating thin film region considering the effects of the surface tension, disjoining pressure, and thermo-capillarity on the thin film region assuming the constant wall heat flux boundary condition. Heat transfer rate was found to be different from previous studies. The second problem gives the conjugate effects on the thin film evaporation region taking into account the effects of solid substrate and bulk liquid meniscus region.

The third problem focuses on experimental investigations of flow boiling in microchannel heat sinks. Two different configurations of microchannel heat sinks were considered, namely, straight and wavy shaped. The straight microchannel heat sink consists of 22 microchannels of size 500 μm (width) $\times$ 500 μm (depth) $\times$ 50 mm (length). Three different working fluids were chosen namely, ethanol, acetone, and pentane. The results from the flow visualization identified three major flow regimes: bubbly, slug, and annular. Heat transfer coefficient found to decrease with exit vapour quality for all test conditions.

The fourth problem is to investigate flow boiling in wavy microchannel heat sink (13 No.s) of size 500 μm (width) $\times$ 500 μm (depth) embedded in same footprint as of the straight microchannels. Comparison studies were presented between thermal hydraulics of wavy and straight microchannels.

However, there are limitations in the experimental studies which we would like to indicate in advance. First, we are unable to measure the pressure drop across the microchannels due to the malfunction of pressure transducer and lack of alternate availability. Second, for one of the fluid i.e. pentane, high-speed videos were not able to capture because of the dysfunction of the camera and lack of time to restore. These limitations are mainly due to the limited available resources and lack of better quality instruments.