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Numerical Simulation of Flow Boiling of HFE-7100 in Horizontal Rectangular Single Microchannel

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ABSTRACT

Flow boiling in microchannel heat sinks is considered as a promising cooling solution for electronic components. Higher heat flux can be effectively dissipated by the utilization of the latent heat of vaporization. However, most of the current studies on flow boiling in microchannels are mainly experimental investigations and two-dimensional numerical studies. In this paper, the Volume of Fluid (VOF) model combined with the Lee evaporation-condensation phase change model is used to simulate the flow boiling of HFE7100 in horizontal microchannels by three-dimensional conjugate numerical simulation. The numerical simulation results are compared with the experimental results [1], showing an excellent agreement. The flow pattern of HFE7100 in the microchannels are obtained. The typical flow pattern includes bubble flow, slug flow, annular flow, et al. In addition, the effect of heat flux on the local wall superheat (ΔT_{loc}) and heat transfer coefficient (h_{loc}) along the flow direction is discussed in detail at a constant mass flux. At the entrance of the channel, the temperature boundary layer is thinner, showing a higher local heat transfer coefficient. At a low heat flux, the local heat transfer coefficient is higher due to the lower wall superheat at the entrance of the microchannel. Furthermore, it is observed that the local heat transfer coefficient decreases along the flow direction and tend to reach a constant value at a certain location. Overall, the local heat transfer coefficient increases with increasing heat flux. This is because more nucleation sites are activated at the high heat flux and thus enhance nucleate boiling. When the heat flux is 70 kW/m^2, the maximum local average heat transfer coefficient is 10862 W/m^{2}K. The numerical simulation methods used in this study can provide guidance for the design of microchannel heat sinks.

KEYWORDS

Microchannel; flow boiling; numerical simulation; conjugate heat transfer

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