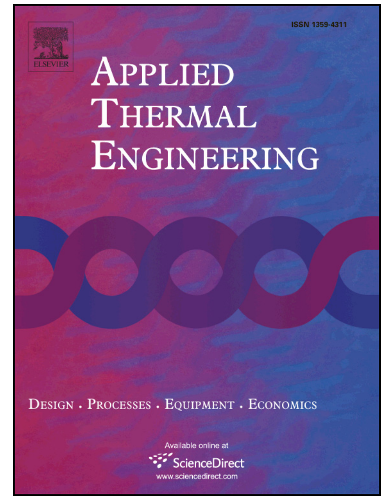

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Two-phase flow patterns for condensation of ethanol-water mixtures in triangular microchannels

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ABSTRACT

An array of isosceles triangular microchannels with sidewalls inclined at 54.7 degrees were fabricated by the wet etching method. The condensation of water and ethanol binary mixtures was visualized with additional measurements to investigate the condensation flow patterns in the silicon microchannels with hydraulic diameters of approximately 155 μm. The visualization study indicated that the flow patterns were influenced by the inlet ethanol concentration and the mass flux. Annular, injection, droplet-injection and bubble flow patterns were observed along the channels. The condensation instability effects were stronger with increased equivalent surface free energy differences. The increasing equivalent surface free energy differences caused droplets to form in the microchannel that moved from the condensing surface to the top corner due to the Marangoni effect, which led to fluctuating flow patterns. The frequency of the injection flow increased with increasing Re_v and input ethanol concentration. The mass flux and the steam quality during condensation were measured at various locations in the experiments. Two phase flow pattern maps were developed for various inlet ethanol concentrations.

Keywords: microchannels; flow patterns; condensation; Marangoni effect; water-ethanol mixtures

1. Introduction

There have been many studies of the two-phase flow and heat transfer characteristics in microchannel flows due to the development of very small, high power devices in various engineering applications, including high heat-flux compact heat exchangers, biomedical devices, and cooling systems. Microchannel condensation has the advantages of high condensation heat transfer coefficients, large area-to-volume ratios and the potential of reducing the required working fluid charge. The high heat transfer rates for condensation in microchannels has been investigated in recent years with the focus on the two-phase flow patterns[1-3], the pressure drop[4] and the influence of the microchannel cross section[5, 6]. Studies have shown that the condensation flow patterns in microchannels differ significantly from those in large channels[7] and millimeter size channels. Cheng and Wu[8] classified the flows in microchannels by introducing the dimensionless parameter Bo defined as:

$$\mathrm{Bo} = \frac{(\rho_L - \rho_V)\cdot g \cdot D^2}{\sigma} \quad (1)$$

Where g is the gravitational constant, ρ_l is the liquid density, ρ_v is the vapor density, D is the hydraulic diameter, and σ is the surface tension. If Bo<0.05, then the gravitational effect becomes