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Flow boiling of self-rewetting 1- butanol/water mixture in a square microchannel

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The progress over the past few decades in microelectronics has led to the requirement for more effective cooling techniques. Two-phase flow heat transfer with phase change is a promising way of cooling as it allows for high heat transfer coefficients and uniform temperatures. One of the factors that affect the heat transfer performance is the cooling fluid used and hence, its selection is of paramount importance to ensure heat transfer enhancement [1]. Refrigerants were the most commonly used fluids in the past, however their environmental impact has come to light and alternative fluids have been under investigation. The use of mixtures is one such alternative to refrigerants and thus, several studies have been conducted on them.

In this study, a 5% v/v butanol/water mixture and its pure components (deionised water, butanol) were used as working fluids and their heat transfer behavior was examined. The experiments were conducted with a 5mm inner hydraulic diameter square borosilicate glass channel at a vertical orientation. The channel was covered with a thin layer of tantalum (metal), which allowed it to conduct electricity while remaining transparent and hence, it could be used as a resistive heater. Three heat fluxes were examined in this experiment (2.8kW/m^2, 4.2kW/m^2 and 6.1kW/m^2) and the liquids were induced in the system subcooled at three mass fluxes: 0.33kg/m^{2}s, 0.66kg/m^{2}s and 1.00kg/m^{2}s, and were heated up to saturation and boiling. The experiments were run in an enclosed environment with a controlled temperature of 40°C in order for the heat losses to be minimized. For each experiment, high speed imaging was obtained in order to identify the flow boiling patterns. The channel wall temperature was measured along with the pressure drop across the channel and the local heat transfer coefficients (h_L) over time were calculated along the length of the channel (Figure 1).

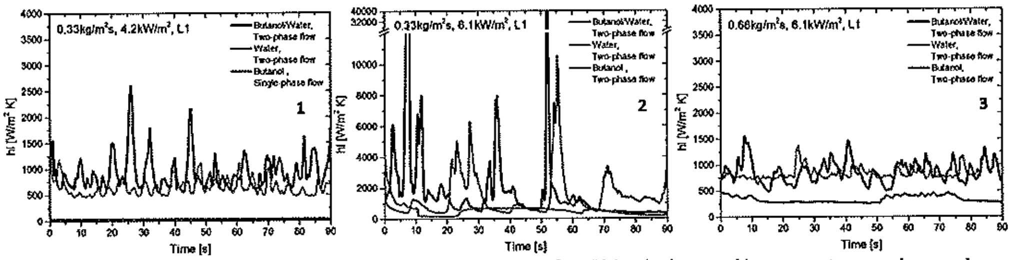

Figure 1. Local heat transfer coefficient ,h_L, over time for 5% v/v butanol/water mixture, butanol and water at the highest point of the channel (L1) at mass flux G=0.33kg/m^{2}s and heat flux (1) q=4.2kW/m^{2}s, (2) q=6.1kW/m^2 and at (3) G=0.66kg/m^{2}s and q=6.1kW/m^2

The boiling regimes observed using high seed visualization for all the fluids were: bubble, slug and elongated slug/annular flow. Furthermore, the channel wall temperature was found to fluctuate over time with two-phase flow, which was attributed solely to boiling within the channel. Recoiling and rewetting were observed for all the fluids but a periodic pattern was observed for the butanol/water mixture. Moreover, the channel wall temperature was found to be lower for the butanol/water mixture comparing to those of pure butanol and water. Concluding, the mixture showed an enhancement in heat transfer comparing to its pure components. Heat transfer coefficients were found to increase with increasing heat flux and the periodicity of the heat transfer coefficient fluctuations for the mixture suggested more consistent heat transfer over a longer period of time.

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References

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