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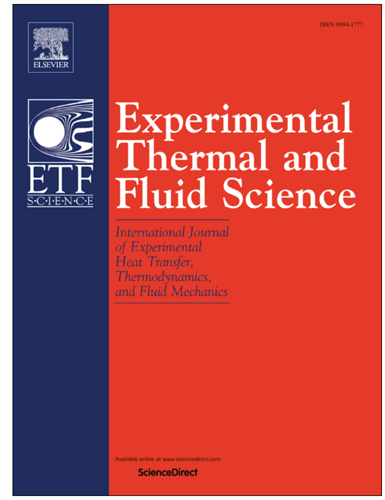

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Visualization of R134a flow boiling in micro-channels to establish a novel bubbly-slug flow transition criterion

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Highlights

- Flow patterns and heat transfer performance of R134a flow boiling in micro-channels were studied.
- Mechanisms of flow patterns transition were analyzed based on the visualization observation.
- New bubbly-slug flow transition criterion was proposed.

Abstract

In this study, the fundamental flow pattern characteristics of R134a flow boiling in a micro-channel heat sink were investigated based on high-speed flow visualization. Visual experiments were operated with R134a as the working fluid. The test section was composed with 20 parallel rectangular channels 500 μm wide, 500 μm deep, and 60 mm long. Mass flux and heat flux were variable from 164-573 kg/m^{2}s and 1 kW/m^2 to 200 kW/m^2, respectively, at the inlet temperature of 22℃. Flow images were recorded with speed up to 1,0000 frames/s. Bubbly flow, slug flow, churn flow, liquid lump flow, and annular flow were observed experimentally and the results plotted onto an *x*-*G* flow pattern map. For "M"-shaped heat transfer coefficient curve, five observed flow patterns were combined into one curve to reflect the heat transfer characteristics of flow boiling in micro-channels. Mechanisms of transition regions (bubbly-slug, slug-churn, churn-liquid lump, and liquid lump-annular) were established accordingly. The Active Nucleation Site Density N_a was found to be the most significant parameter in regards to the bubbly-slug and slug-churn transition mechanisms. To verify the effect of the Active Nucleation Site Density (N_a) on the bubbly-slug transition, the relations of N_a and Boiling number at bubbly and slug flow regions were compared; the resulting slope features made the relations of N_a and Boiling number easily distinguishable. Classification between the bubbly flow and slug flow of R134a was proposed based on these distinctions. The proposed criterion classified the transition region between the bubbly and slug flow. The proposed transition criterion was proven effective and feasible by comparison against previous transition criteria and datasets.

Keywords: Micro-channel; flow boiling; flow pattern; flow pattern transition