Boiling heat transfer enhancement by controlling microlayer behavior

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We explored the influence of the surface wettability on the behavior of the thin liquid film (microlayer) formed around the elongated boiling bubble and heat transfer characteristics in flow boiling in a minichannel. Initially the dynamic behavior of the water microlayer was observed through the air bubble injection experiment under adiabatic condition using a mini-channel. Dewetting of the microlayer was observed on a silicon substrate with the contact angle of 72^{o}. In boiling in a minichannel, microlayer evaporation is an important heat transfer mechanism, and the dewetting is considered to lead to heat transfer deterioration. On the other hand, the dewetting of the microlayer was able to be prevented by using superhydrophilic copper oxide nanostructured surface.

The minichannel boiling experiment using the bare silicon and the superhydrophilic surface was conducted to investigate the effect of the dewetting prevention on the critical heat flux and heat transfer coefficient. For the silicon surface, the dewetting was clearly observed during the boiling as in the air injection experiment, and the critical heat flux happened at ~ 1 MW/m^2. For the superhydrophilic surface, the stable microlyaer was formed under the elongated boiling bubble and the efficient heat transfer due to microlayer evaporation continued to 3.3 MW/m^2 corresponding to the maximum power of the used DC power supply. The super-hydrophilization of the surface was found to be effective to prevent dewetting of the microlayer and critical heat flux enhancement in flow boiling in the minichannel.