Enhancement of Boiling Heat Transfer using Surface Wettability Engineering

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Boiling heat transfer, due to its superior efficiency in comparison with single-phase heat transfer schemes such as conduction and convection, is of great importance to a wide range of industrial applications from electronics cooling to high-power nuclear reactors [1]. In pool boiling [2], higher heat transfer rates result mainly from repeated bubble growth and departure from the surface induced by buoyancy force. Other contributing factors include the significant latent heat of vaporization and increased microconvection (namely, the agitation effect) surrounding growing bubbles. The key to boiling enhancement lies in controlled bubble generation and growth, which can be achieved by means of surface wettability engineering. Here we report a boiling surface design that takes advantage of the unique role played by wettability in manipulating bubble behavior. In short, hydrophobicity promotes bubble nucleation whereas hydrophilicity prevents bubble expansion on the surface. By artificially combining these two characteristics, the resulting *biphilic* surface (patterned with alternating hydrophobic and hydrophilic regions) [3] proves effective in encouraging well-regulated bubble nucleation as well as suppressing bubble coalescence. Figure 1 shows that the biphilic surface design led to significantly increased heat transport under various boiling scenarios. In subcooled boiling, unusually high concentrations of dissolved gas that were retained by surface hydrophobicity helped drastically lower the threshold for boiling nucleation; in subatmospheric boiling, the strong pinning of bubble contact line at the wettability interface was critical to delaying the deleterious transition to intermittent boiling. Additionally, our recent results demonstrated that surface *biphilicity* could be used for boiling enhancement of organic fluids, such as ethanol, as well.

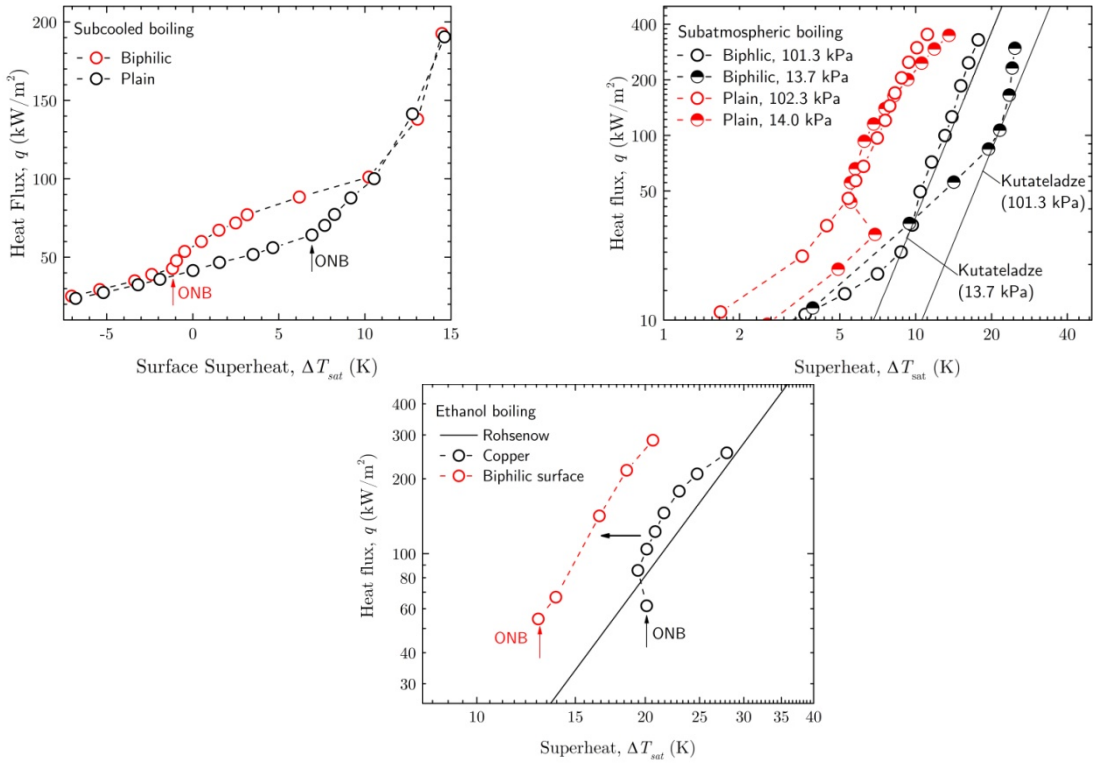

Figure 1. Boiling enhancement on biphilic surfaces

References

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