Enhanced Boiling of Ethanol under the Effects of Surface Texturing and Wettability Patterning

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Abstract

Effective thermal management of high-performance electronic systems relies on boiling heat transfer, which often employs low-boiling-point fluids such as ethanol. Conventional boiling surface design for ethanol entails complex shape modifications[1]. In this study, we explore the possibility of enhancing ethanol boiling using both porous texturing and wettability patterning.

Boiling on a microporous (sulfuric acid anodized) surface was found to be enhanced significantly (~500%) compared with the Rohsenow correlation (see Fig. 1(a)). However, it was noted that the onset of nucleate boiling (ONB) varied wildly between experimental runs. Specifically, dependent on the wetting state of the porous cavities in the surface, a significant delay in ONB (as large as 50 Kelvin) could occur (see Fig. 1(a)), which would lead to catastrophic outcomes in electronic cooling applications in particular. After the deposition of a biphilic pattern (consisting of amphiphobic coating of fluoropolymer modified halloysite nanotubes[2]), boiling on the phosphoric acid anodized surface (with increased porosity) led to an over-40-Kelvin shift in ONB while retaining the same gains in the heat transfer rates, as Fig. 1(b) shows. The resulting biphilic pattern was able to prevent the porous structure from being fully wetted by ethanol by retaining a thin layer of gas.

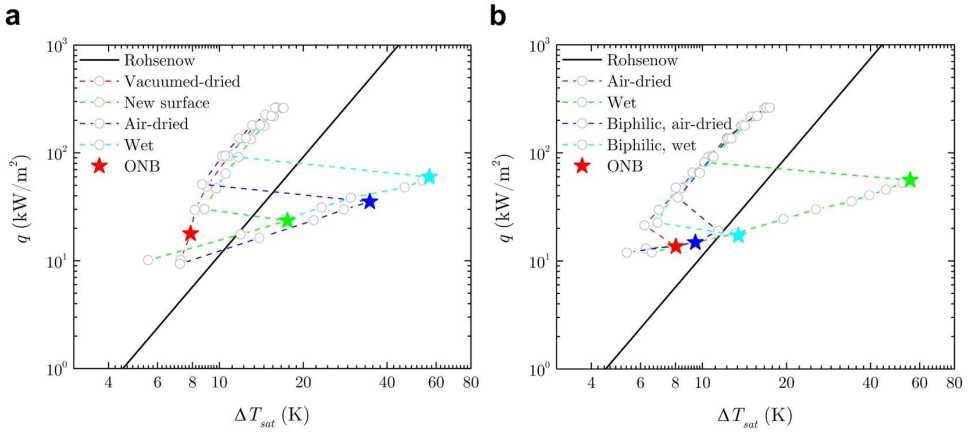

Fig. 1 Boiling curves for (a) the sulfuric acid anodized surface and (b) phosphoric acid anodized surface.

[1] Kalani, A. and Kandlikar, S. G., Journal of Heat Transfer, 135 (2013), 111002.
[2] Ma, W. et al., Advanced Material Interfaces, 4 (2017), 1700907.