Experimental Thermal and Fluid Science
Volume 115, 1 July 2020, 110088

Effect of pattern geometry on bubble dynamics and heat transfer on biphilic surfaces

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https://doi.org/10.1016/j.expthermflusci.2020.110088

Abstract

Recognizing the relevance of wettability in pool boiling heat transfer, few authors have reported significantly enhanced heat transfer coefficients using the so-called biphilic surfaces, i.e. hydrophilic surfaces with hydrophobic regions. However, the development of these patterns is still scarcely reported in the literature and many studies rely on a trial and error approach. In this context, the present work addresses a systematic analysis of the effect of the geometry of biphilic patterns on bubble dynamics and consequently on the heat transfer processes occurring in pool boiling. Geometric representative quantities such as the size of the superhydrophobic regions and their relative position are systematically varied and their effect is analyzed in detail in both bubble dynamics and heat transfer processes, using synchronized high-speed video and time-resolved thermography. The results show that the size of the superhydrophobic regions affects bubble dynamics and the rate of evaporated mass, thus influencing the heat flux term associated to the latent heat of evaporation. In this context, patterns with smaller superhydrophobic areas are the most effective at removing heat through evaporation. Regarding the distance between the superhydrophobic areas, the results support the use of the minimum distance between superhydrophobic areas, that is, in the limit to promote coalescence. For this distance there is still no significant interaction between the bubbles sites, but the controlled coalescence promotes the occurrence of a periodic induced flow between the superhydrophobic regions, which contributes to cool the surface. Also, heat flux calculations confirm that heat flux peaks coincide with bubble departure occurrences in the superhydrophobic areas, thus confirming the heat transfer enhancement promoted by this kind of surfaces.