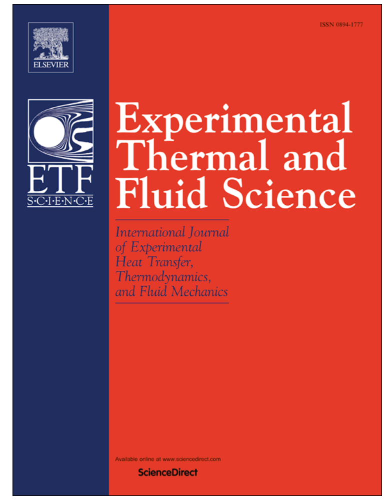

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Boiling Heat Transfer on Surfaces with 3D-printing Microstructures

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Abstract: We fabricate plane surface and surfaces with different microstructures, such as coral-rock, star-like, and inner-fin structures, for boiling heat transfer, through 3D microprinting. The thickness of the surfaces is 1.3mm, while the maximum depth of the microstructures reaches 0.9mm. With these surfaces, subcooled boiling and saturated nucleate boiling of de-ionized water are carried out, respectively, by applying different heating voltages from 50V to 105V. The experimental results show that the boiling heat transfer could be weakened by the entrapped vapor in the microstructures. The heat flux on the microstructures decreases with the increase of real surface area in subcooled boiling because of the increase of the entrapped vapor thickness in the microstructures. However, during the saturated nucleate boiling, the surface with inner-fin structure has higher heat flux than that with star-like structure, due to the generation of more nucleation sites in inner-fin structures.

Keywords: boiling heat transfer; microstructure; entrapped vapor; weakening effect; nucleation site

1 Introduction

Heat transfer has a close relationship with human life from heat preservation of drinking water to the heating and cooling of the buildings and electric power generation. As boiling heat transfer has excellent heat transfer performance compared with other heat transport modes, it has been widely applied in engineering equipment such as air conditioner and heat pipe in electronic devices [1-3]. With the increase of the excess temperature on the heating surface, boiling heat transfer is divided into four regions including natural convection, nucleate boiling, transition boiling, and film boiling. Generally, nucleate boiling is accompanied with high heat transfer coefficient, while during transition boiling and film boiling, vapor film will be anchored on most part of the boiling surface, and thus weaken the heat transfer process. To obtain appropriate thermal behavior of the boiling surfaces, fabrication of microstructures on them is a promising approach and thus widely applied in many engineering problems[4, 5].

Microstructures affect the boiling process from three aspects: (1) existence of random micro size crevices and surface irregularities for nucleation initiation, (2) a somewhat porous surface structure that allows fluid inflow to keep nucleation sites active, and (3) surface protrusions that create more active boiling area[6]. In most cases, microstructures could enhance boiling heat transfer significantly, on which many studies are focused [7, 8]. Kim et al. [9-11] studied the liquid behavior on the surfaces with microstructures, which showed that microstructures play an important role in the water inflow and thus increase the critical heat flux of boiling heat transfer. Furthermore, Yao et al., Dong et al. and Jo et al. also showed that the microstructures could enhance the heat flux at given excess temperature compared with smooth surfaces[12-14]. On the other hand, numerical simulations [15-17] also indicated that microstructures on heating surfaces could enhance boiling heat transfer. However, it is interesting to note that each microstructure

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