Pool Boiling Heat Transfer of Mixed Hydrophobic-Superhydrophilic Surface

バンバン, ジョコ, スロト

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論　文　要　旨

区　分	甲	氏　名	バンバン　ジョコ　スロト

論文題名

Pool Boiling Heat Transfer of Mixed Hydrophobic-Superhydrophilic Surface

（撥水・超親水混合伝熱面におけるプール沸騰熱伝達）

論 文 内 容 の 要 旨

The continuous trend in miniaturization and compact design, particularly in the cooling technology, has an impact on increasing of the power density. At present, the electronic device such as processor Pentium has a power density equal to the nuclear power density. In a heavy cooling duty, two issues are becoming so urgent, i.e. reduction in size of the coolant and coolant pumping power (parasitic reduce power). Boiling heat transfer is one of promising cooling schemes because of its high efficiency where energy transfer is dominated by the latent heat of evaporation. As widely known, heat transfer characteristic in nucleate pool boiling depends on the number of active nucleation sites and wall superheating. Recently, many techniques have been used to enhance the efficiency of boiling heat transfer. To increase active nucleation sites, two methods of surface modification are commonly used as the enhancement technique; one is to control wettability and the other is roughness.

The main goal of the study focuses on the effect of the wettability on the enhancement of nucleate pool boiling heat transfer. In order to successfully achieve the goal of the study, some sample surfaces have been developed and examined its heat transfer performance experimentally. In the present study sample surfaces developed are surfaces of uniform wettability, single PTFE hydrophobic-spot, mixed-wettabilty pattern on polished-copper and superhydrophilic (TiO_2).

The present dissertation consists of four chapters. Chapter 1 introduces the boiling regime, internal boiling characteristic and current status of enhancement of boiling heat transfer which is closely related with wettability. Based on the previous studies in regard to the bubble nucleation from mixed-wettablity pattern, the goal of the study has been presented. The novelty of the present study focuses on the effects of the edge (micro structures and length) of the PTFE hydrophobic-spot and degree of subcooling on boiling characteristics.

In chapter 2, the state-of-art of the experimental apparatus, method and fabrication of sample surfaces are described. The pool boiling experiment is conducted by immersing the sample surface into liquid with varying the degree of subcooling in the pool boiling vessel. The fabrications of sample surfaces are explained and also the new approach is proposed for design of mixed-wettability pattern surface. Observations of physical properties include a topography, roughness and wettability confirmed by using SEM, laser scanning microscope and goniometer, respectively. The experiments are conducted in steady state condition while one dimensional heat conduction is used to determine the surface temperature and heat flux.

In chapter 3, the discussion started with material characterization for all sample surfaces including surface roughness and wettability. Furthermore, by making use of a high speed camera the effect of wettability on internal boiling characteristic is observed in regard to two parameters that are the bubble departure diameter and frequency, respectively. At the same time, the effect of contact angle and topography of the hydrophobic-spot surface on bubble behavior is presented. Since the mixed-wettability pattern is a combination of the two materials, the boiling heat transfer characteristic is different from uniform wettability, i.e. hydrophilic, superhydrophilic and hydrophobic surfaces, respectively. Two conditions are applied that are saturated and subcooled conditions, and it is used as a reference. The previous analysis showed that the bubble dome on the hydrophobic-spot surface is merged from the smaller bubbles. The study of the boiling regime on single hydrophobic-spot surface shows the dependency of local film boiling on the hydrophobic-spot size and degree of subcooling.

The result of the mixed-wettability pattern on the polished - copper surface shows that the decrease in hydrophobic-spot size enhances boiling heat transfer performance at saturated and subcooled conditions. The reason behind the design is still obscure for mixed-wettability pattern on polished copper. Based on the material characterization of the edge and bubble behavior, the effect of topography of hydrophobic-spot and the novelty design of the mixed-wettability pattern are obtained. The length of hydrophobic-spot periphery is the most influential factor on the enhancement of boiling heat transfer. The longest hydrophobic-spot periphery shows the highest enhancement of boiling heat transfer at saturated and subcooled conditions.

In chapter 4, the conclusion of the present study and suggestion for future work are presented.