High-heat-transfer boiling surface with micropattern replicated by nanoimprinting

S. Miyazaki[1*], K. Nagato[1,2], Y. Watanabe[1], K. Takahashi[1], N. Shikazono[3], M. Nakao[1]

[1] *Department of Mechanical Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan*

[2] *Research Fellow of Precursory Research for Embryonic Science and Technology (PRESTO), Japan Science and Technology Agency (JST)*

[3] *Institute of Industrial Science, The University of Tokyo*

[*] *E-mail: miyazaki@hnl.t.u-tokyo.ac.jp*

Boiling heat transfer is one of the heat transfer types. In the boiling surface, bubbles are generated and they enhance the heat flux from the high-temperature surface to liquid. In order to control the generation of the bubbles for the higher heat flux, micropattern on boiling surface is useful. However, the previous studies obtained the micropattern by impractical fabrication methods such as drilling and lithography.[1] In this study, we fabricated the pyramid-shaped cavities on the boiling surface by nanoimprinting. We investigated the effect of the controlled pitch and depth of the pyramids on the heat-transfer coefficient.

The mold used for the nanoimprinting was made by electroplated Ni. The master for the Ni mold was fabricated by anisotropic wet etching of Si. The pyramid pattern is replicated to aluminum sheets by a rolling system.[2] Fig. 1 shows the scanning electron microscope (SEM) images of the molds and aluminum samples. The pitches were 5, 20, 80, 200 µm. The heat flux of the samples with micropattern and that with a flat surface were investigated by the pool boiling experiment.

Fig. 2(a) shows the relationship between the overheating temperature of wall and the heat flux of each aluminum sample. It was found that the heat flux with 80-µm-pitch pattern was the highest among these pitches. Fig. 2(b) shows the maximum heat flux as a function of the pitch. On the pattern with smaller pitch, after the small bubble occurred at the cavities, the bubbles are aggregated each other. On the other hand, on the pattern with longer pitch, the number density or frequency of bubble generation was small. (Fig. 3)

Fabrication of the micropattern by nanoimprinting leads to high-heat-transfer boiling surface.

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[1] J. J. Wei, L. J. Guo, and H. Honda, *Heat Mass Transfer,* 41 (2005) 744

[2] Y. Watanabe, K. Nagato, N. Shikazono, K. Shimamoto, and M. Nakao, *American Society for Precision Engineering (ASPE) Annual Meeting,* 54 (2012) 46

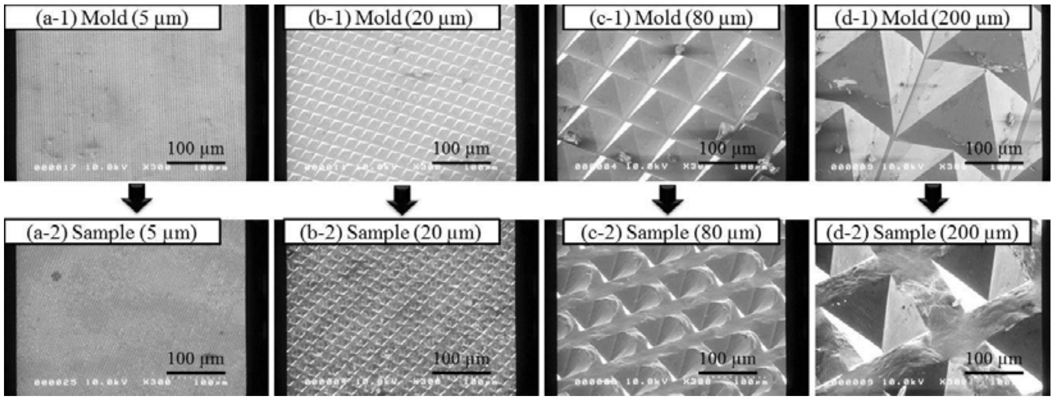

Figure 1: SEM image of molds with pitches of (a-1) 5, (a-2) 20, (a-3) 80, (a-4) 200μm, and replicated Al samples with pitches of (b-1) 5, (b-2) 20, (b-3) 80, (b-4) 200μm

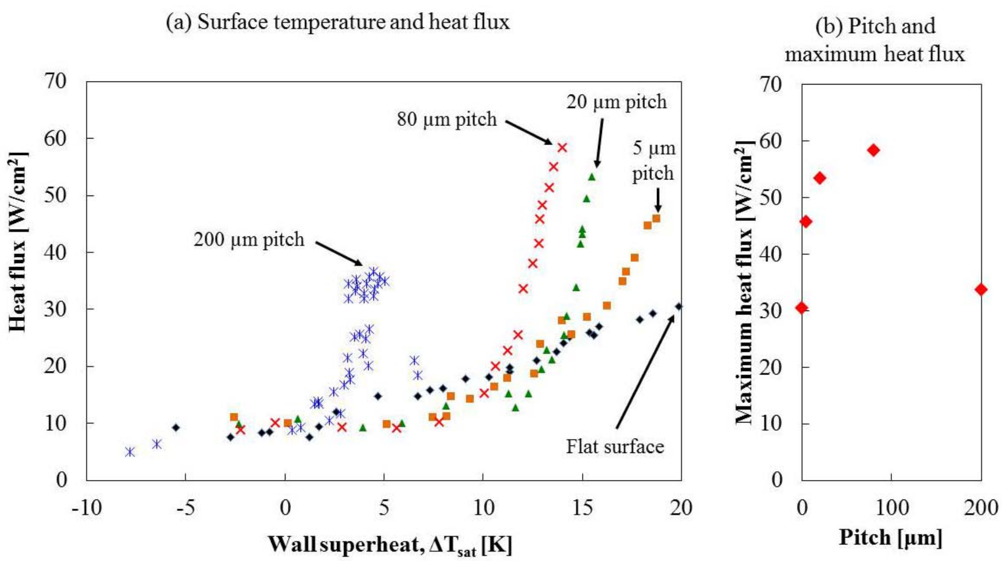

Figure 2: (a) Heat flux as a function of the superheating temperature of the wall, and (b) maximum heat flux as a function of pitch of pyramids.

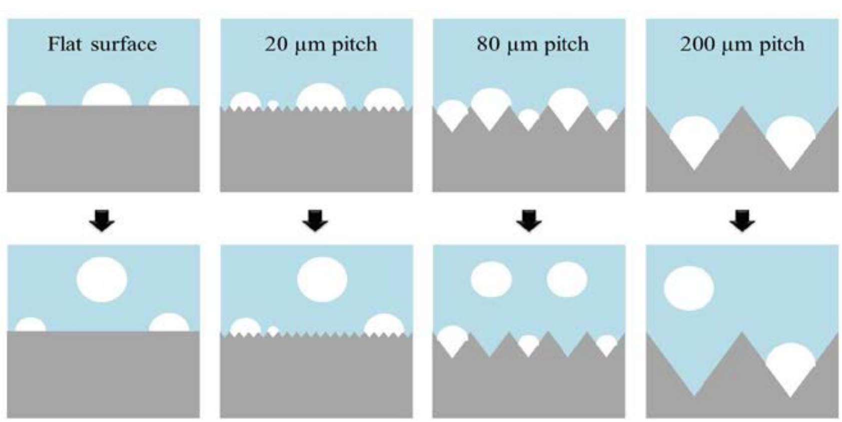

Figure 3: Schematic of generation and aggregation of bubbles on different pitch pattern surface