TEM Study on Nanobubble Generation and Growth

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The bubble nucleation mechanism at the onset of nucleate boiling remains unclear, because of the difficulty of in-situ observations, which is due to the small size of the phenomena. Thus, a new experimental technique enabling the investigation of the dynamic behavior of bubbles near the solid–liquid interface is highly desired. So far, we prepared a nano liquid cell fabricated using MEMS technology and observed the generation and growth of bubbles in nanoscale and in real time using transmission electron microscopy (TEM). When the water was irradiated with the electron beam, nanobubbles with a radius of under-5-nm generated due to the radiolysis of water. Basically, TEM images gives no information on the vertical position of these bubbles. However, we developed the Fresnel fringe method, which provides the three-dimensional information on bubble position from two-dimensional TEM images by sifting the observation point slightly, and it was revealed that all nanobubbles were interfacial nanobubbles. When the electron beam irradiation was continued, nanobubbles grew and coalesced with the neighboring nanobubbles. On the other hand, when bubbles grew to such an extent that they covered the whole irradiation area, they did not coalesce, but overlapped with others. In the process, the 2-nm-thick water film between two bubbles is stable. These experimental results provide the insight into the mechanisms of heterogeneous bubble nucleation, which break through the current technological barrier of boiling heat transfer.