Nanobubble dynamics studied using liquid-phase electron microscopy

Sarthak Nag

Department of Mechanical Engineering, Kyushu University, Japan
International Institute for Carbon-Neutral Energy Research (I2CNER), Kyushu University, Japan

More than 65% of the world's energy production depends on the phase-change of water. Thus, making this process efficient would help in the generation of electricity in a cleaner way. Surface nanobubbles are the nanoscopic gaseous domains that are present at the liquid-solid interface and play a major role in the nucleation of boiling by serving as seeds for bubble growth, thus, reducing the threshold required for bubble nucleation. It is important to understand the characteristics of the surface nanobubbles for strategizing efficient energy production. Much of the existing understanding of surface nanobubbles is based on experimental techniques lacking real-time temporal resolution capabilities. The ability to visualize nanobubbles at real-time scales has the potential to reveal the dynamics of nanobubbles and comprehend their oddities. Therefore, in this talk, I will be presenting my work on studying the dynamic behavior of surface nanobubbles using in-situ liquid-phase electron microscopy (Fig 1A). Our studies show that pinning is not an essential criterion for the stability of nanobubbles, and the balance between the gas influx and outflux from the nanobubble interface plays a major role in their stabilization. Additionally, our study reveals that a freely growing-shrinking nanobubble induces anisotropic depinning in the three-phase contact line of the neighboring nanobubble (Fig 1B). Lastly, we focussed on the quasistatic coalescence of surface nanobubbles and found the role of gas deposition on the solid surface on the merging of surface nanobubbles (Fig 1C). We believe that our studies will potentially pave the way for a better understanding of gas transport and behavior at the nanoscale.

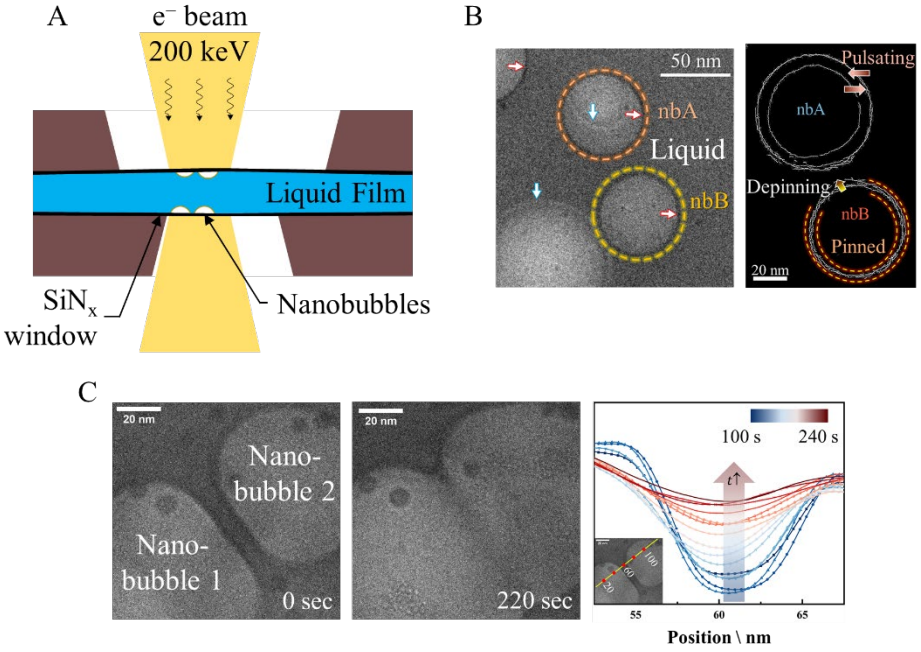

Figure 1 (A) Schematic image of the in-situ liquid phase electron microscopy. (B) TEM image of the surface nanobubbles and their contact line traced for studying their dynamics. (C) TEM image of the nanobubbles before and after coalescence, and the qualitative estimation of the growth of thin gas film between the bubbles.