Microlayer Evolution and Heat Transfer with a Steady State Vapor Bubble

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We create a steady-state vapor bubble that can remain stable for hours in a pool of sub-cooled water using a laser source. The stability of the bubble allows us to measure the contact angle and perform *in-situ* imaging of the contact-line region and the microlayer (Fig. 1), on hydrophilic and hydrophobic surfaces and in both degassed and regular (with dissolved air) water. Using experimental data and numerical simulations, we obtain permissible range of maximum heat transfer coefficient possible in nucleate boiling and the width of the evaporating layer in the contact-line region. Microlayer evolution is studied during the early growth stage of the bubble where we surprisingly see a completely wetted bubble base (i.e. no contact line), and the bubble does not depart from the surface due to the reduced liquid pressure in the liquid film (Fig. 2a). As the bubble grows in size, the completely wetting liquid film decreases in thickness and eventually evaporates at the center to create the three-phase contact line (Fig. 2b). This technique of creating and measuring fundamental characteristics of a stable vapor bubble can facilitate our understanding on the origin of the microlayer and the forces which govern its behavior.

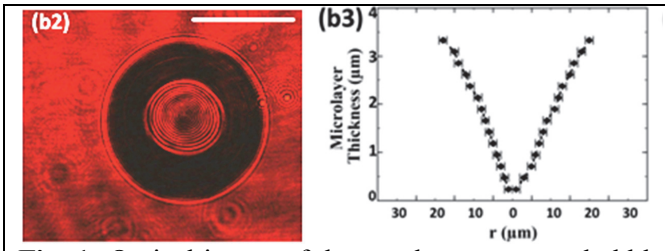

Fig. 1: Optical image of the steady-state vapor bubble with 50× magnification under HeNe laser illumination, and the corresponding microlayer curvature.

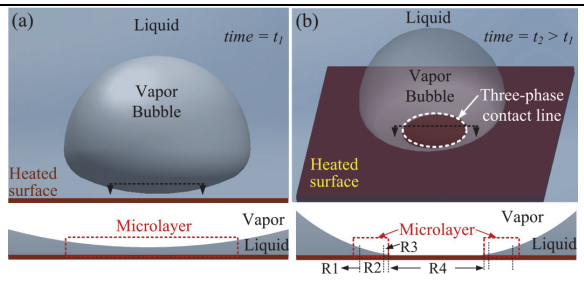

Fig. 2: Microlayer and three-phase contact line evolution during early stages of vapor bubble growth process.