Dynamic Thin Film Morphology near the Contact Line of a Condensing Droplet: Nanoscale Resolution

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Abstract : The thin film region is so important in heat transfer process due to its low thermal resistance. On the other hand, the dynamic contact angle is crucial boundary condition in numerical simulations. While different modeling contains different assumption of the microscopic contact angle, none of them has experimental evidence for their assumption, and the contact line movement mechanism still remains vague. The experimental investigation in complete wetting is more popular than partial wetting, especially in nanoscale resolution when there is sharp variation in thin film profile in partial wetting. In the present study, an experimental investigation of water film morphology near the triple phase contact line during the condensation is performed. The state-of-the-art tapping-mode atomic force microscopy (TM-AFM) was used to get the high-resolution film profile goes down to 2 nm from the contact line. The droplet was put in saturated chamber. The pristine silicon wafer was used as a smooth substrate. The substrate was heated by PI film heater. So the chamber would be over saturated by droplet evaporation. By turning off the heater, water vapor gradually started condensing on the droplet and the droplet advanced. The advancing speed was less than 20 nm/s. The dominant results indicate that in contrast to nonvolatile liquid, the film profile goes down straightly to the surface till 2 nm from the substrate. However, small bending has been observed below 20 nm, occasionally. So, it can be claimed that for the low condensation rate the microscopic contact angle equals to the optically detectable macroscopic contact angle. This result can be used to simplify the heat transfer modeling in partial wetting. The experimental result of the equality of microscopic and macroscopic contact angle can be used as a solid evidence for using this boundary condition in numerical simulation.

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