Probing Fluid Phase Change in Nanoconfinement with a Nanofluidic Device

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Phase change and fluid flow on the nanoscale play important roles in various natural processes and engineering practices (e.g., shale gas/oil reservoir estimation and production). In the dynamics, they are different from that on the macroscale. For the phase change, when the system size decreases to nanoscale, the saturation condition will change as a result of the rapid reduction of the liquid-vapor interface radius. For fluid flow, when the characteristic length of the system is close to the mean free path of the fluid molecule, the fluid flow behavior can fundamentally deviate from that on the macroscale.

Historically, most of the investigations on nanoscale phase change and fluid flow were carried out through gravimetric or volumetric measurement of adsorption, in fixed bed geometries, by interferometry or through surface force apparatus. Recent advances in nanotechnology allow for the investigation of phase change and fluid transport in deterministic structures such as nanochannels. In this presentation, we show our experimental work on cavitation, condensation, and evaporation at scales ranging from 8 nm to 1000 nm within nanofluidic systems. Direct observation enabled by the nanofluidic device allows us to accurately measure the initiation of phase change and also the dynamic process. The effects of thermodynamic conditions and geometry are discussed and compared to bulk theories.