Mechanical Engineering Department Seminar

3:35pm February 1, 2017
1130 Mechanical Engineering
111 Church Street SE, Minneapolis, MN 55455

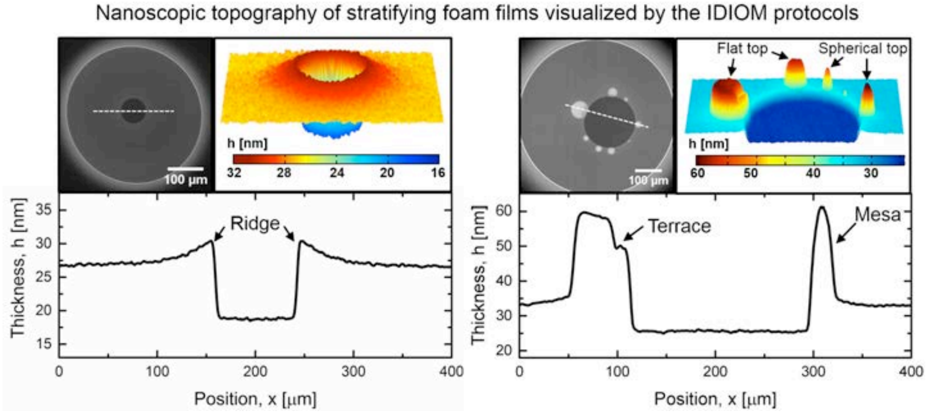
Dynamics of Stratification in Micellar Freestanding Films

Vivek Sharma

Assistant Professor; Chemical Engineering, University of Illinois - Chicago

Understanding and controlling the drainage kinetics of freestanding films is an important problem that underlies the stability, lifetime and rheology of foams and emulsions. Foam films typically consist of fluid sandwiched between two surfactant-laden surfaces that are ~ 5 nm - 10 microns apart, and the drainage in films occurs under the influence of viscous, interfacial and intermolecular forces, including disjoining pressure. Drainage in foam film formed by surfactant concentrations above the critical micelle concentration proceeds in a non-monotonic, step-wise fashion called stratification in contrast to the monotonic thinning exhibited by films containing no micelles. In reflected light microscopy, stratifying films display regions with distinct shades of grey implying that domains and nanostructures with varied thickness coexist in the thinning film. Understanding and analyzing such nanoscopic thickness transitions and variations have been long-standing experimental challenge due to the lack of technique with the requisite spatio- temporal resolution, and theoretical challenge due to the absence of models for describing hydrodynamics in stratified thin films. Using interferometry, digital imaging and optical microscopy (IDIOM) protocols we developed recently, we show that the nanoscopic thickness variations in stratifying films can be visualized and analyzed with an unprecedented spatial (thickness ~ 1 nm, lateral ~500 nm) and temporal resolution (< 1 ms). Stratification proceeds by formation of thinner domains that grow at the expense of surrounding films. Using the exquisite thickness maps created using IDIOM protocols, we provide the first visualization of nanoridges as well as mesas that form at the moving front around expanding domains. We measure the supramolecular oscillatory surface force contribution to disjoining pressure as a function of thickness. Most significantly, we develop a self-consistent theoretical framework, a nonlinear thin film equation model that explicitly accounts for the influence of supramolecular oscillatory surface forces, and physicochemical properties of surfactants. We demonstrate that the complex spatio-temporal evolution of nanoridges and domains can be modeled quantitatively, and we show that the nanoridges sculpted by the supramolecular oscillatory structural forces, modulate the domain expansion and stratification dynamics.

Nanoscopic topography of stratifying foam films visualized by the IDIOM protocols



Bio: Dr. Vivek Sharma is an Assistant Professor of Chemical Engineering at the University of Illinois Chicago. Before joining UIC in November 2012, he worked as a post-doctoral research associate in Mechanical Engineering at Massachusetts Institute of Technology. He received his Ph. D. (Polymers/MSE, 2008) and M. S. (Chemical Engineering, 2006) from Georgia Tech., an M. S. (Polymer Science, 2003) from the University of Akron, and a bachelor's degree from IIT Delhi. Dr. Sharma's research interests broadly lie in optics, dynamics, elasticity, and self-assembly (ODES) of complex fluids and soft materials. At UIC, Dr. Sharma's Soft Matter ODES-lab combines experiments and theory to pursue the understanding of, and control over interfacial and nonlinear flows, focused on the interplay of (a) viscoelasticity and capillarity for printing applications and extensional rheometry, and (b) interfacial thermodynamics and hydrodynamics in fizzics (the science of bubbles, drops, thin films, emulsions and foams).