Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

Shear Viscous Response of Molecularly Thin Liquid Films[1]

CHARLES TSCHIRHART, SANDRA TROIAN, Calfornia Institute of Technology, MC 128-95, Pasadena, CA 91125 — Fluids that exhibit Newtonian response at the macroscale can display interesting deviations at the nanoscale caused by internal fluid microstructure or conformational entropy reduction near an adjacent solid boundary. Such deviations signal the breakdown of the continuum and isotropic fluid approximations at molecular length scales. These effects are particularly pronounced near the interface separating a liquid film from a supporting solid substrate where molecular layering in the fluid can result in inhomogeneity in the shear viscosity. Here we describe ellipsometric measurements of the surface deformation of non-volatile liquid nanofilms subject to a constant interfacial shear stress. For simple Newtonian response, the slope of the deformation can be used to extract the value of the shear viscosity in ultrathin films, which in our experiments range from 2 - 200 nm in thickness. For complex films, we observe deviations from linear deformation which require augmentation of the analytic model normally used to describe the viscous response. These findings may be helpful for improved parametrization of the shear response of supported free surface films as well as course grained models for nanofluidic applications.

[1]Support from the Fred and Jean Felberg and Winifred and Robert Gardner Summer Undergraduate Research Fellowships is gratefully acknowledged.

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Date submitted: 01 Aug 2014 Electronic form version 1.4