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Shear-induced suppression of rupture in two-layer thin liquid films SREERAM K. KALPATHY, LORRAINE F. FRANCIS, SATISH KUMAR, University of Minnesota — The effect of shear on the rupture of two stratified thin liquid films confined between parallel plates and subject to van der Waals forces is examined in this work. Lubrication theory is applied to derive a one-dimensional nonlinear evolution equation for the height of the liquid-liquid interface. Linear stability analysis reveals that the real part of the growth rate and the wavelength of the fastest growing interfacial disturbance are unaffected by shear. However, the growth rate has an imaginary part which is non-zero in the presence of shear, indicating the existence of traveling waves. Nonlinear simulations of the interface behavior on homogeneous surfaces show that shear delays interfacial rupture, and suppression of rupture occurs beyond a critical shear rate. Propagation of traveling waves along the interface, and subsequent weakening of van-der-Waals-driven dewetting, is found to be the cause of the rupture delay. Analysis of flow on chemically heterogeneous surfaces also suggests a delay in interfacial rupture in the presence of shear. The problem studied here can serve as an idealized model for the lithographic printing process, and the results suggest that in the regime of shear rates relevant to printing, mechanisms of emulsification of one liquid into the other can be understood without incorporating shear. However, shear could be relevant in other physical systems such as microfluidic flows.

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