Dynamics of Wrinkle Growth and Coarsening in Stressed Thin Films

Rui Huang and Se Hyuk Im

Dept. Aerospace Engineering & Engineering Mechanics, University of Texas, Austin, TX 78712

Complex wrinkle patterns have been observed in various thin film systems, typically with integrated hard and soft materials. The underlying mechanism of wrinkling has been generally understood as a stress-driven instability. Much of the existing theoretical work on wrinkling is based on a linear perturbation analysis, which determines the onset of the mechanical instability. Some recent studies have investigated the nonlinear aspects due to large deflection in the film, and predicted different wrinkle patterns based on energy minimization. However, the energy approach cannot address the question as to how these patterns emerges and evolves from one type to another. Recently, a spectrum of evolving wrinkle patterns has been observed in metal/polymer bilayers, exhibiting a peculiar dynamics of evolution process, which has not been well understood. Based on a viscoelastic model, we identify three stages of wrinkle evolution: initial growth, coarsening, and equilibration. Asympotic solutions are obtained for each stage with simple scaling laws for the dynamic processes. Numerical simulations are conducted for both uniaxial and biaxial stress states using a spectral method. The numerical results compare closely with the asymptotic solutions; both qualitatively agree with the experiments of metal/polymer bilayers. Finally, the transition between various wrinkle patterns is discussed.