172a A Model for Rupture of Thin Equilibrium Films Due to Random Mechanical Perturbations

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A generalized formalism for the rupture of a non-draining thin film due to imposed random mechanical perturbations, modeled as a Gaussian white noise, is presented. The evolution of amplitude of perturbation is described by a stochastic differential equation. The average film rupture time is the average time for the amplitude of perturbation to equal one half the film thickness and is calculated by employing a first passage time analysis for different amplitudes of imposed perturbations, wavenumbers, film thickness, van der Waals and electrostatic interactions and surface tensions. The results indicate the existence of an optimum wavenumber at which the rupture time is minimum. A critical film thickness is identified based on the sign of the disjoining pressure gradient, below which the film is unstable in that the rupture time is very small. The calculated values of rupture time as well as the optimum wavenumber in the present analysis agree well with the results of linear stability analysis. For stable films, the rupture time is found to increase dramatically with film thickness near the critical film thickness. As expected, the average rupture time was found to be higher for smaller amplitudes of imposed perturbations, larger surface potentials, larger surface tensions and smaller Hamaker constants.