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An Energy Approach to Capillary-Driven Thin Film Folding
HUAN LI, K. JIMMY HSIA, SASCHA HILGENFELDT, University of Illinois at Urbana-Champaign — Capillary-driven self-assembly methods provide a promising tool to fabricate three-dimensional, micro- or millimeter scale structures. Recently, we explored the self-assembly of 3D photovoltaic devices from Si thin films through equilibrium considerations of fluid-solid interactions (Guo, et al. 2009, Li, et al. 2010). In the present study, an alternative approach, the minimization of the total free energy is employed to investigate the interactions between fluid droplet and a flexible thin film. Variation of a 2D energy functional, comprising the surface energy of the fluid and the bending energy of the thin film, yields governing equations and boundary conditions. Through direct simulations with Surface Evolver (Brakke 2008), the shape of the droplet and the thin film at the equilibrium state is obtained. A critical thin film length necessary for complete enclosure of the fluid droplet, and thus successful device self-assembly, is determined and compared with the experimental study of Guo et al. (2009). Augmenting the formalism, we obtain an upper bound of the thin film length, beyond which gravity is dominant. The current 2D study can be extended into 3D. Critical parameters obtained from these analyses can be used to guide device fabrication and manufacturing.

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