Stress-induced acceleration and ordering in solid-state dewetting

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Abstract

Solid films are often metastable or unstable in the as-deposited state. They may dewet to form solid "droplets", or islands, when nanometrically thin films are heated to sufficiently high temperatures. Solid-state dewetting shares similarities with liquid-state dewetting. For example, both processes involve surface and interface energy minimization. However, there are differences. First, mass transport in solid films is usually mediated by surface diffusion. This leads to specific dewetting dynamics, and in particular to the pinching of the film away from the triple-line, which gives rise to a periodic mass shedding process [4]. A second difference between liquids and solids is the ability for solids to sustain elastic strain. The relaxation of the elastic energy in solid films under stress leads to the Asaro-Tiller-Grinfeld (ATG) instability [3].

Using a lubrication-like thin-film model, we have studied the the nonlinear dynamics of solid-state dewetting in the presence of elastic stress. Elasticity makes the thin film model nonlocal. We found an interplay between pinching and the ATG instability. Stress gives rise to an acceleration of the pinching process and to the tuning of the mass shedding time and wavelength [1]. The decrease of the mass shedding wavelength is consistent with experimental observations [2]. Finally, we also find stress-induced ordering of islands due nonlocal elastic interactions.

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Keywords: solid state dewetting, dewetting, thin films, elasticity, modelling