

Self-patterning induced by a solutal Marangoni effect in a receding drying meniscus

F. Doumenc¹ and B. Guerrier¹

¹Univ Paris-Sud, Univ Paris 06, CNRS, Lab FAST, Bât 502, Orsay, F-91405, France,
doumenc@fast.u-psud.fr

This study explores through numerical simulations the impact of a solutal Marangoni effect on the deposit obtained by drying a polymer solution. A hydrodynamic model with lubrication approximation is used to describe the liquid phase in a dip-coating-like configuration. The studied case considers evaporation in stagnant air (diffusion-limited evaporation), which results in a coupling between liquid and gas phases. Viscosity, surface tension, and saturated vapor pressure depend on solute concentration. When surface tension increases with polymer concentration the Marangoni effect may induce a periodic regime. This results in a self-organized periodic patterning of the dried film in certain control parameter ranges (see Fig. 1). A morphological phase diagram as well as meniscus and dry-deposit shapes are provided as a function of the substrate velocity and bulk solute concentration.

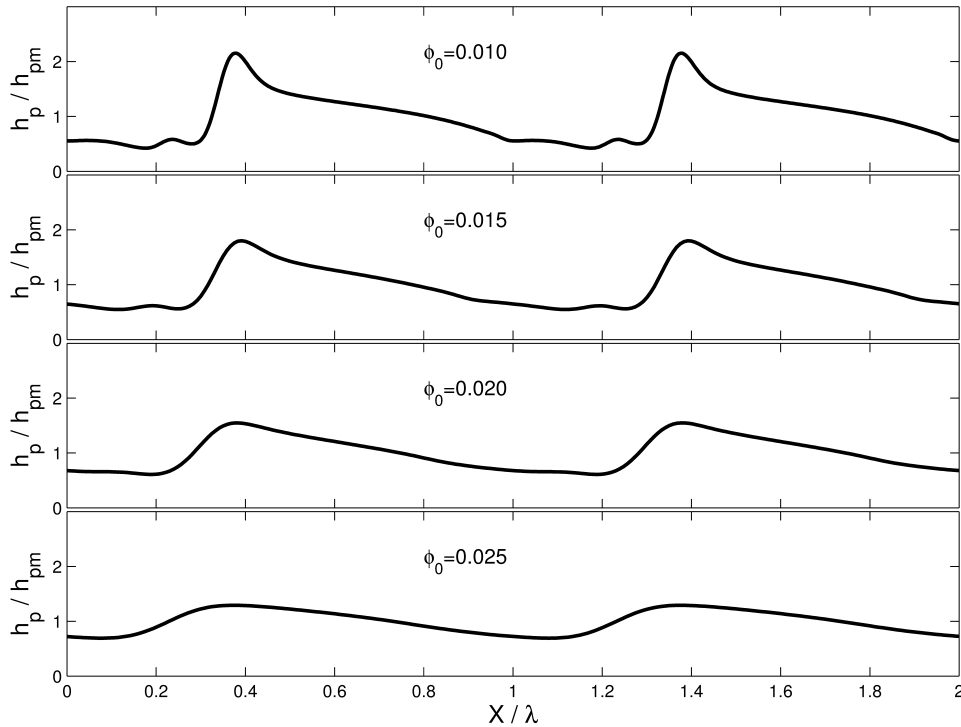


FIG. 1. Deposit shape for a substrate velocity $V_{sub} = 25\mu\text{m}/\text{s}$ and different initial polymer volume fractions Φ_0 . The distance X and the local deposit height h_p are normalized by the wavelength λ and deposit mean thickness h_{pm} , respectively. From top to down:

$\Phi_0 = 0.010$, $\lambda = 314\mu\text{m}$, $h_{pm} = 0.158\mu\text{m}$ — $\Phi_0 = 0.015$, $\lambda = 300\mu\text{m}$, $h_{pm} = 0.243\mu\text{m}$
 $\Phi_0 = 0.020$, $\lambda = 293\mu\text{m}$, $h_{pm} = 0.327\mu\text{m}$ — $\Phi_0 = 0.025$, $\lambda = 288\mu\text{m}$, $h_{pm} = 0.414\mu\text{m}$