Surface deformation of a thin liquid film in the vicinity of a vertical fiber

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The deposition of homogeneous thin liquid films is a ubiquitous goal in the industry, for example, to confer mechanical or optical properties on a solid surface. A standard technique involves depositing a liquid film, which will dry and lead to the formation of the desired layer. Many heterogeneities can appear during the deposition of the liquid film or its drying [1], due to thickness instabilities [2] or particle accumulation, for example. Dust deposition can be an issue during such coating processes as it leads to thickness heterogeneities [3].

To study the impact of the shape and size of the solid defect, we deposit a cylindrical fiber vertically on a film of silicone oil that is spin-coated on a solid surface. We measure the thickness of the film in the region of the surface deformation by interferometry, using a hyperspectral camera.

We obtain thickness profiles at different times (see fig. 1a), which exhibit a space-minimum thickness h_g for each time. Plotting this space-minimum thickness over time (see fig. 1b) reveals that this minimum thickness is non-monotonic, allowing us to extract the time-minimum $h_\mathrm{g}^\mathrm{min}$, which is significant because if it reaches zero, the film will dewet.

We propose that the time-minimum thickness $h_\mathrm{g}^\mathrm{min}$ is reached when the meniscus formed at the bottom of the fiber reaches its equilibrium. This leads to a time-minimum thickness scaling with h_0^3/r_f^2, where h_0 is the initial thickness and r_f is the fiber radius, in good agreement with experimental data (see fig. 1c).

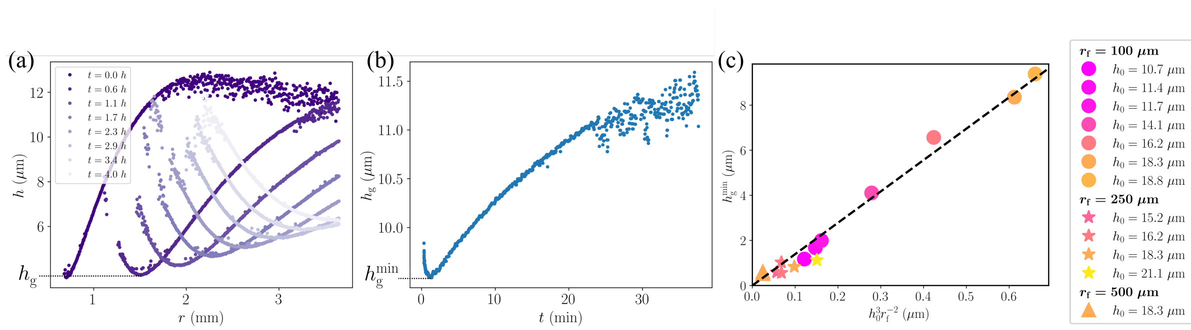

Figure 1. (a) Thickness profiles along the radial direction ($x = 0$ is the center of the fiber) at different times. First, the thickness decreases along the meniscus, then it reaches a minimum, and finally the thickness relaxes towards the initial thickness of the initial film. (b) The space-minimum thickness h_g as a function of time is non-monotonous and reaches a minimum. (c) Space-time-minimum thickness $h_\mathrm{g}^\mathrm{min}$ as a function of the theoretical value coming from the scaling law, for different initial thicknesses h_0 and fiber radii r_f.

Références

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