Drying of Multicomponent Thin Liquid Films on Substrates with Topography

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Abstract

Drying of multicomponent thin liquid films is an important step in coating and printing processes. In many cases, the substrate on which the film rests may possess topography, either intended or unintended. We present a lubrication-theory-based model describing the fundamentals of drying on such substrates. The film consists of volatile solvent and additional non-volatile components such as colloidal particles, surfactants, and non-volatile solvents. A system of one-dimensional partial differential equations accounting for the film height, depth-averaged concentration of bulk non-volatile components, and interfacial concentration of insoluble surfactant is derived. Evaporation is included using the well-known one-sided description, and the governing equations are solved with finite-difference methods to study various limiting cases. The results highlight the influence of evaporation rate, and thermal, surfactant, and solutal Marangoni flows on the final film thickness and colloidal particle distribution. We find that in a realistic region of parameter space, the addition of a non-volatile solvent yields a dried film that is conformal to the substrate topography.

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