Modeling a film of binary mixture with a free surface undergoing simultaneous demixing and dewetting

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Thin films, in particular polymeric ones, are being increasingly used in advanced technological applications. The usage of such films as coatings is often limited by their lack of stability due to wettability properties of the substrates. However, it has become usual to employ the instabilities to create complex microscopic functional structures such as arrays of droplets or polygonal networks of biomolecules.

In various technological applications the thin films of interest are binary mixtures such as polymer blends. Such systems pose interesting fundamental questions that are not yet entirely resolved even for bulk systems, not to speak about systems involving solid substrates and free interfaces. For instance, for a thin film of a polymeric blend the dynamics of the decomposition within the film and the dewetting of the film itself couple. This allows for new pathways of structuring like decomposition induced dewetting [1, 2].

Normally, the dynamics of a binary mixture is described by the so called model-H coupling momentum transport (Navier-Stokes) and nonlinear diffusion (Cahn-Hilliard) [3, 4]. We complete model-H by incorporating boundary conditions that allow to describe an evolving free surface. The model is used to analyse the spinodal decomposition of a film of a binary mixture. Linear results obtained with the full transport equations for (a) solely diffusive transport described by the Cahn-Hilliard equation and (b) diffusive and convective transport described by model-H between parallel plates are compared to the case of a free surface.

Detailed results are given for the dependence of the critical gap width (below which decomposition is suppressed [5]) on the physico-chemical properties of the bounding plates. A lubrication approach is also discussed.

References

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