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Non-linear dynamics of the electro-hydrodynamic patterning of viscoelastic materials

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Abstract

Recent experimental and theoretical work has shown that interfacial electro-hydrodynamic instabilities can be used in the manufacturing process of micro/nano-structures. The scope of this work is to investigate the non-linear dynamics of the electro-hydrodynamic instability of a viscoelastic polymeric film under a patterned mask. The polymer film is in general considered to be separated from the mask by another viscous fluid. We develop a computational model and carry out 2D numerical simulations fully accounting for the flow and electric field in both phases. For the numerical solution of the governing equations we employ the mixed finite element method combined with a quasi-elliptic mesh generation scheme which is capable of following the large deformations of the liquid-liquid interface. We model the viscoelastic behavior using the Phan-Thien and Tanner (PTT) constitutive equation taking fully into account the non-linear elastic effects as well as a varying shear and extensional viscosity. We perform a thorough parametric study and investigate the influence of the various rheological parameters, the applied voltage and geometrical characteristics of the mask in order to define the fabrication limits of this process in the case of periodic structures.

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