DROPLET EVAPORATION DYNAMICS ON HETEROGENEOUS SURFACES: NUMERICAL MODELING OF THE STICK SLIP MOTION

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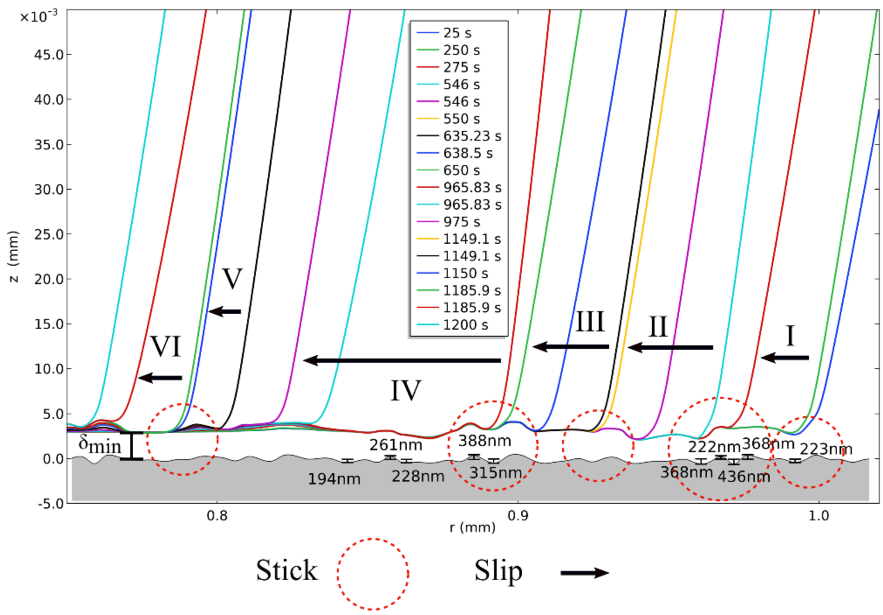
ABSTRACT

Evaporation of sessile droplets on solid substrates is a fundamental phenomenon present in everyday life and numerous industrial and engineering processes [1]. The complicated physical mechanisms that govern droplet evaporation involve a strong interplay of wetting and capillary effects, fluid flow, heat, and mass transfer in a three-phase system: solid, liquid and gas. A usual observation during evaporation of a sessile droplet on chemically heterogeneous or rough substrates is the so-called stick-slip motion of the three-phase contact line (TPL) [2-4]. During a stick-slip type of evaporation, the TPL remains pinned while the contact angle decreases. Then, crossing a threshold a "jump" occurs, and the TPL immediately retracts, increasing the height of the droplet apex and the contact angle. This sequence can be repeated until the droplet completely evaporates. Several attempts have been made to develop consistent mathematical models to obtain a better picture of the interplay between the different physical phenomena during evaporation [5-6]. The prediction of mixed evaporation modes, i.e., stick slip motion on heterogeneous substrates, is not a trivial task since the change in the droplet topology demands reconfiguration of both the number and position of the TPLs.

In this work, we present a novel continuum level, sharp-interface, ALE (Arbitrary Lagrangian-Eulerian) numerical model, developed by our research group to efficiently deal with the problem of the moving three-phase contact line (TPL) during sessile droplet evaporation. This is made feasible by include the solid-liquid interactions in a Derjaguin pressure term (also known as disjoining pressure). A rough hydrophobic substrate with modest pinning effects is used to provide interesting insights into the processes of stick-slip motion. The results are compared to experiments [7], which demonstrate excellent consistency.



KEYWORDS: Sessile droplet evaporation, Stick-slip motion, Roughness, ALE, Numerical modelling

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