ABSTRACT

In the present thesis, we address some of the limitations of the existing understandings of electrically controlled wetting and dynamics of liquid drops on dielectric films.

We first study the droplet spreading on dielectric elastomer films of different elasticities, under an applied electrical voltage. We show that the established electrospreading models fail to describe the macroscopic droplet electrospreading behaviour on soft, deformable dielectric films. We explain the droplet electrospreading characteristics on the soft dielectric films by considering the consequences of the soft substrate deformation, due to interfacial elastocapillary interaction. Thereafter, we focus on the wetting behaviour of sessile drops on dielectric elastomer films of varying elasticities, under an applied electrical voltage. Our results reveal that the classical Lippmann-Young model fails to describe the reduced extent of electrowetting on the soft dielectric film, as compared to that on the apparently rigid dielectric film. The macroscopic electrowetting behaviour on soft dielectric elastomer films is explained by a free energy minimization analysis, which considers all the consequences of the reduction of the dielectric elastomer elasticity from the 'apparently rigid' to the 'soft' domain. We also discuss here the previously unexplained electro-elastocapillarity induced displacement profiles for the soft film surface deformation, under the electrowetted droplet.

We also study here the electrically actuated transport characteristics of colloidal droplets, on a hydrophobic dielectric film covering an array of electrode pads. We show that the electrically actuated transport characteristics for the colloidal droplets are dependent on the size and the electrical properties of the suspended particles. We explain the unique transport characteristics for the colloidal droplets by independent fluorescence imaging experiments, and by a quasi-steady force balance model for the colloidal droplet transport dynamics. Finally, we present a study on electrowetting of suspension drops. We show that a thermodynamically consistent accounting of the additional attenuation of the effective dielectric-droplet interfacial tension, due to the presence of suspended particles, is imperative for an accurate estimation of the extent of electrowetting for a suspension droplet. We propose here a modification to the Lippmann-Young equation for better prediction of the macroscopic electrowetting behaviour of suspension drops.

Keywords: electrowetting-on-dielectric (EWOD), electrospreading, elasticity, Young's modulus, dielectric elastomer, elastocapillarity, electro-elastocapillarity, Lippmann-Young equation, colloidal droplet, droplet transport, micro/nanoparticles, electrocapillarity, digital microfluidics