Electrostatic Assist of Liquid Transfer between Flat Surfaces

Chung-Hsuan Huang and Satish Kumar

Department of Chemical Engineering and Materials Science, University of Minnesota, Minneapolis, MN 55455, USA

ISCST-20180918AM-A-CF2

Presented at the 19th International Coating Science and Technology Symposium,
September 16-19, 2018, Long Beach, CA, USA†.

Extended Abstract

Transfer of liquid from one surface to another plays a vital role in printing processes. During liquid transfer, a liquid bridge is formed and subjected to substantial extension, but incomplete liquid transfer can produce defects that are detrimental to the operation of printed electronic devices. One strategy for minimizing these defects is to apply an electric field, a technique known as electrostatic assist (ESA). However, the physical mechanisms underlying ESA remain a mystery. To better understand these mechanisms, slender-jet models are developed for both perfect dielectric and leaky dielectric axisymmetric Newtonian liquid bridges with moving contact lines. Nonlinear partial differential equations describing the evolution of the bridge radius and interfacial charge are derived, and then solved using finite-element methods. For perfect dielectrics, application of an electric field enhances liquid transfer to the more wettable surface over a wide range of capillary numbers. The electric field modifies the pressure differences inside the liquid bridge, and as a consequence, drives liquid toward the more wettable surface. For leaky dielectrics, charge can accumulate at the liquid-air interface. Application of an electric field can augment or oppose the influence of wettability differences, depending on the direction of the electric field and the sign of the surface charge. Flow visualization experiments reveal that when an electric field is applied, more liquid is transferred to the more wettable surface due to a modified bridge shape that causes depinning of the contact line. The measured values of the amount of liquid transferred are in good agreement with predictions of the perfect dielectric model.