Numerical Simulation of Electrostatic Charging Droplets in Microfluidic Devices

S. Yao[1], H. Zhou[1]

[1]HKUST, Hong Kong, China

Abstract

Precharged droplets can facilitate manipulation and control of low-volume liquids in droplet-based microfluidics. However, the working principle and charge quantification of the non-contact charging system remains elusive for precise control of droplets in practical systems. In this paper, for the first time, the mechanism of charging process (Fig. 1) was simulated and analyzed.

The simulation was conducted using a commercial finite element code, COMSOL Multiphysics® software, based on the laminar two-phase flow level-set interface coupling with the electrostatic interface. Namely, the interface between the immiscible water and oil phases is tracked using the level set method, while the electric field in the droplet, oil and dielectric layers is calculated by the Poisson equation.

A new design for more efficient charging was proposed based on the simulation results. This new design could increase the system capacitance (Fig. 2) and low the charging voltage to several tens volts. Finally, microfluidic devices of the proposed design were developed using standard microfabrication technology. The induced charge in a droplet was characterized by measuring the droplet trajectory in presnece of a transverse electric field.

Figures used in the abstract

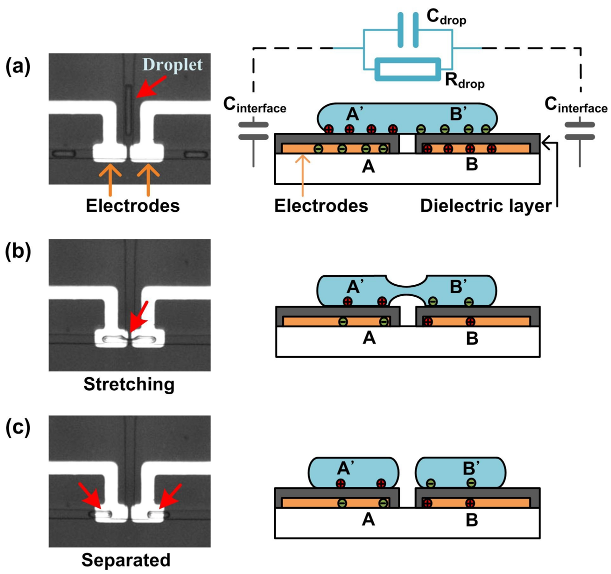

Figure 1: Fig.1 Principle of the charging process. The left column is the top view and the right column is the side view. (a) a neutral droplet travels to the induction electrodes and, charges are induced and distributed on the surface. (b) a droplet is stretched at the T- junction by hydrodynamic force. (c) a droplet is divided into two daughter droplets with opposite net charges.

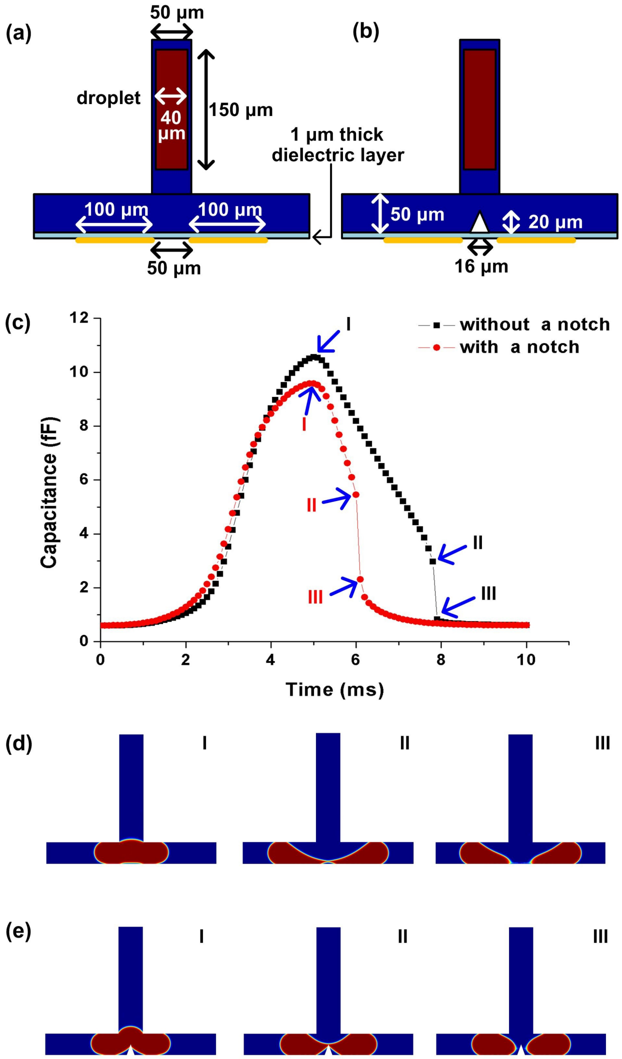

Figure 2: Fig. 2 Simulation of the charging process. (a) and (b) computational domain for the T-channels without and with a notch, respectively. (c) The system capacitance during the splitting process. (d) and (e) Snap images of the droplets at the critical instants.