Electrowetting and Droplet Transport in Digital Microfluidic Chips

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Introduction: One flexible technique used to manipulate fluids on a microscale platform is electrowetting-on-dielectric (EWOD). In EWOD, force appear on three phase line when a potential difference is applied between a conducting liquid surrounded by an insulating medium (like air) and an electrode covered with a dielectric film. .

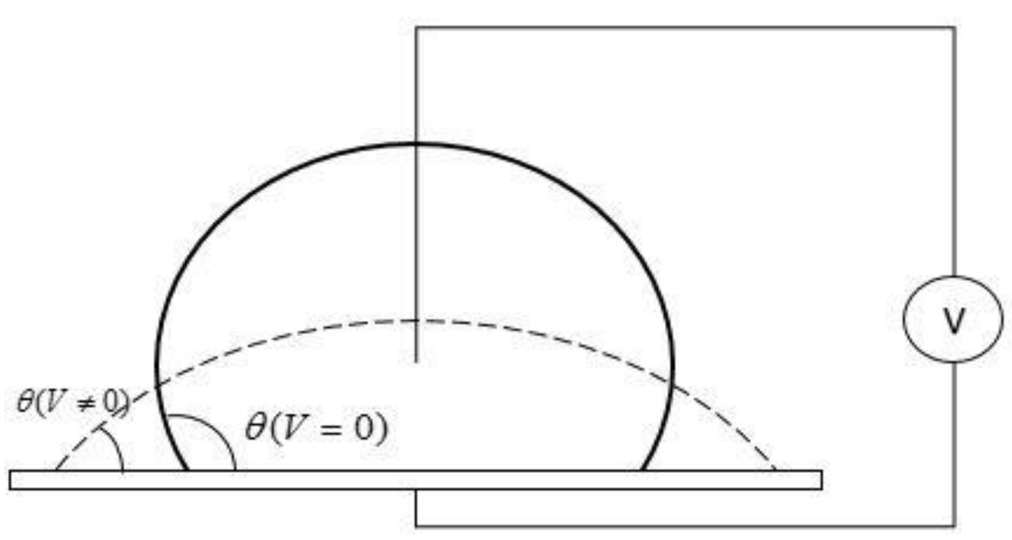

Figure 1. Schematic of Electrowetting

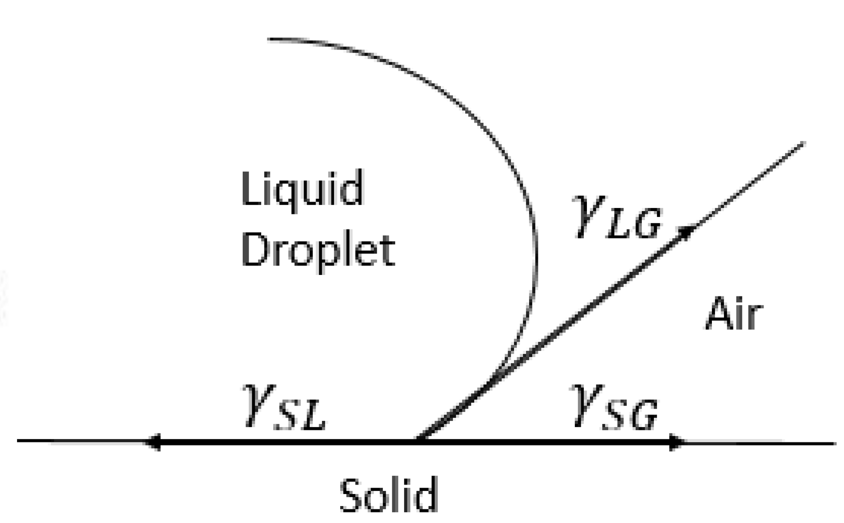

Figure 2. Three phase interphase line of solid, liquid and gass

Computational Methods: In particular we use Laminar Two-Phase Flow, Moving Mesh (tpfmm) for simulation of Lippmann-Young equation and, Level Set (tpf) with brochard's model for simulation of 2D droplet transport. And element size scale factor for meshing the simulation are 0.2 and 0.5 respectively.

$$\gamma_{SL}(V) = \gamma_{SL}(0) - \frac{1}{2}CV^2 \qquad \cos\theta(V) = \cos\theta(0) + \frac{1\varepsilon_o\varepsilon}{2\gamma_{LG}d}V^2$$

$$\cos\theta = \frac{\gamma_{SG} - \gamma_{SL}}{\gamma_{LG}} \qquad U = \frac{\varepsilon_o\varepsilon}{6\mu dl}V^2\frac{(1-\cos\theta(V))}{\sin\theta(V)}$$

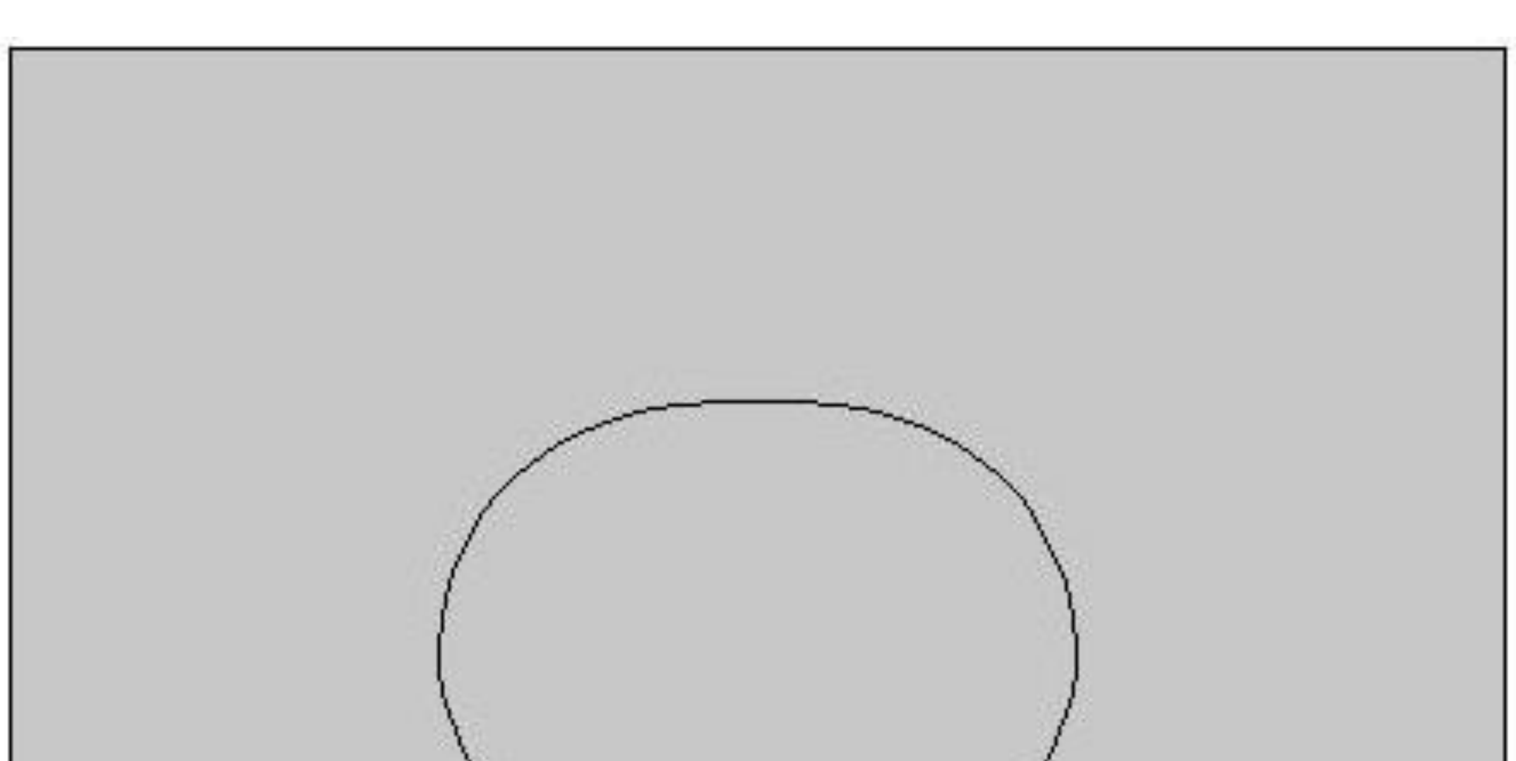

Figure 4. Model geometry for Change in contact angle

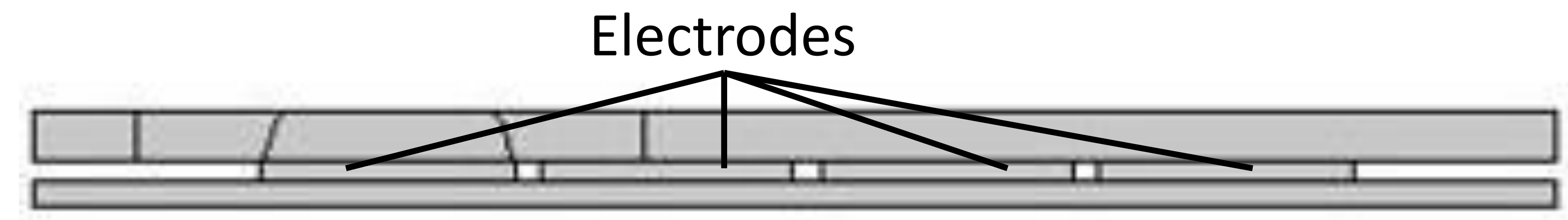

Figure 4. Model geometry for Droplet Transport

Results: A significant contact angle modulation efficiency (61.53%, 130° ° - 50°) has been achieved with voltage as low as 40V (Figure 5). An arrangement containing four electrodes in line is represented in Figure 4. The simulation results on single droplet transport and switching at different time in Figure 6.

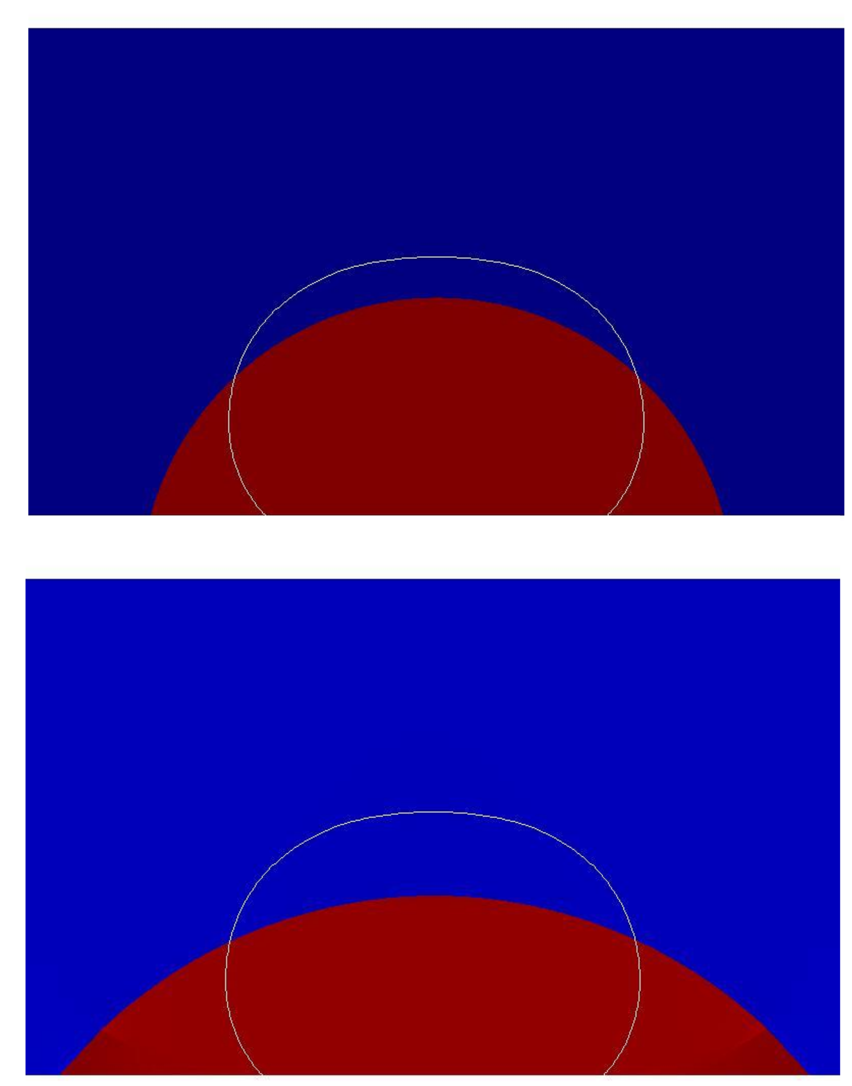

Figure 5. shape of the droplet at time (t) = 0.03 & 0.5 Sec at 40V

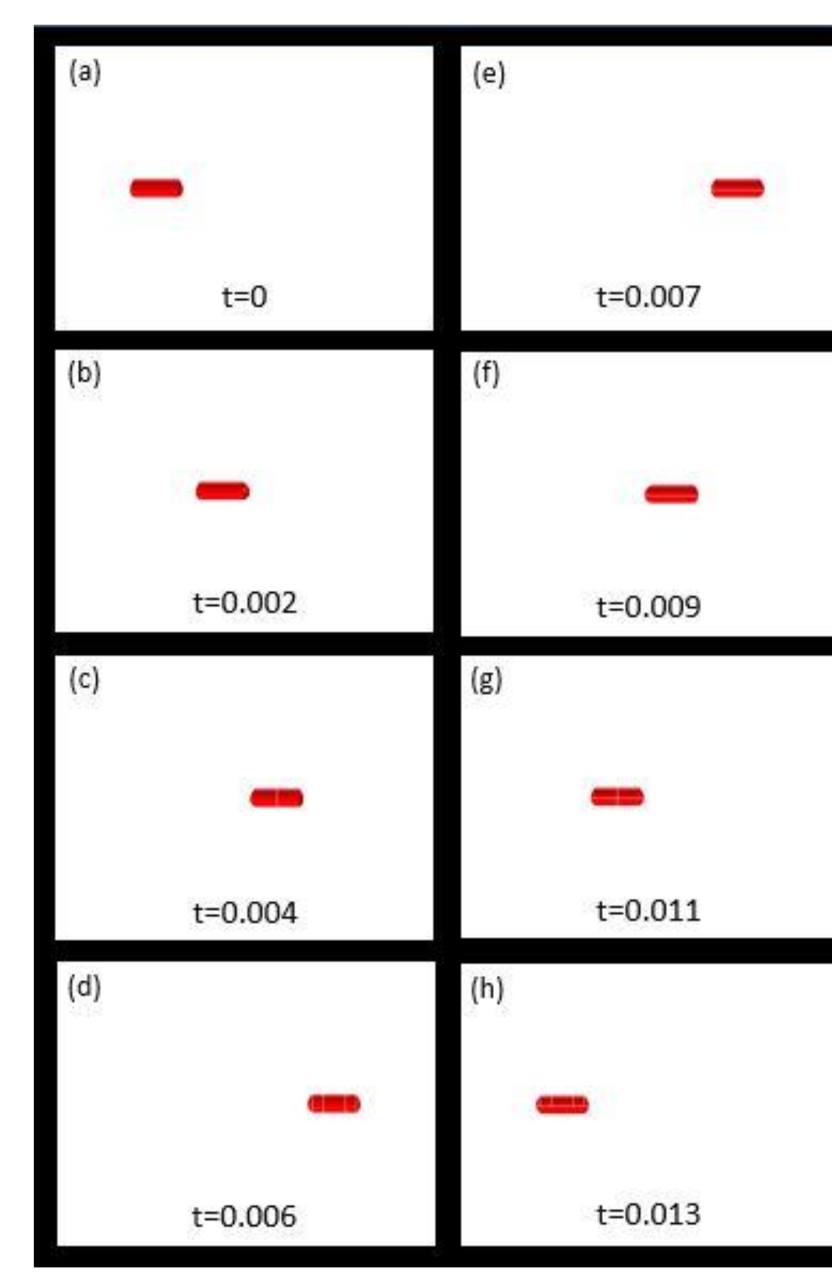

Figure 6. Droplet motion

Conclusions: Using the information gathered from the above simulation, complex systems involving 2D droplet transport can be modeled to represent a variety of functions such as transporting, forming, shaping and combining droplets, regulating and monitoring pressure.

References:

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