

Automated Electrowetting-Based Digital Microfluidic Chips for Next-Generation Sequencing and Sample Preparation

Faruk Azam, Shubha Jain, Dr. H. N. Unni
Department of Biomedical, IIT Hyderabad

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Introduction

Next-generation sequencing (NGS) technology is a prominent tool for Identifying and characterizing unknown pathogens, but its utility in high throughput biodefense and public health applications is currently limited by the lack of fast, efficient, and reliable automated DNA sample preparation methods like automated multiplexing techniques which are used for switching the voltage of electrodes, deciding the threshold voltage, for clinical diagnostic to protect the cell from damage and avoiding the cross talk between electrodes because of electrostatic effect to maintain droplet on proper track. We would like to address those limitations to enhance the system performance for digital microfluidic (DMF) platform to function as a fluid distribution hub.

Computational Methods

The Comsol Multiphysics platform has been used to achieve effective transport of droplets on DMF platform using the Electrowetting on dielectric (EWOD) principle. In particular we use Laminar Two-Phase Flow, Moving Mesh (tpfmm) for simulation of Lippmann-Young equation i.e change in contact angle and Laminar Two Phase Flow, Level Set (tpf) for simulation of 2D droplet transport.

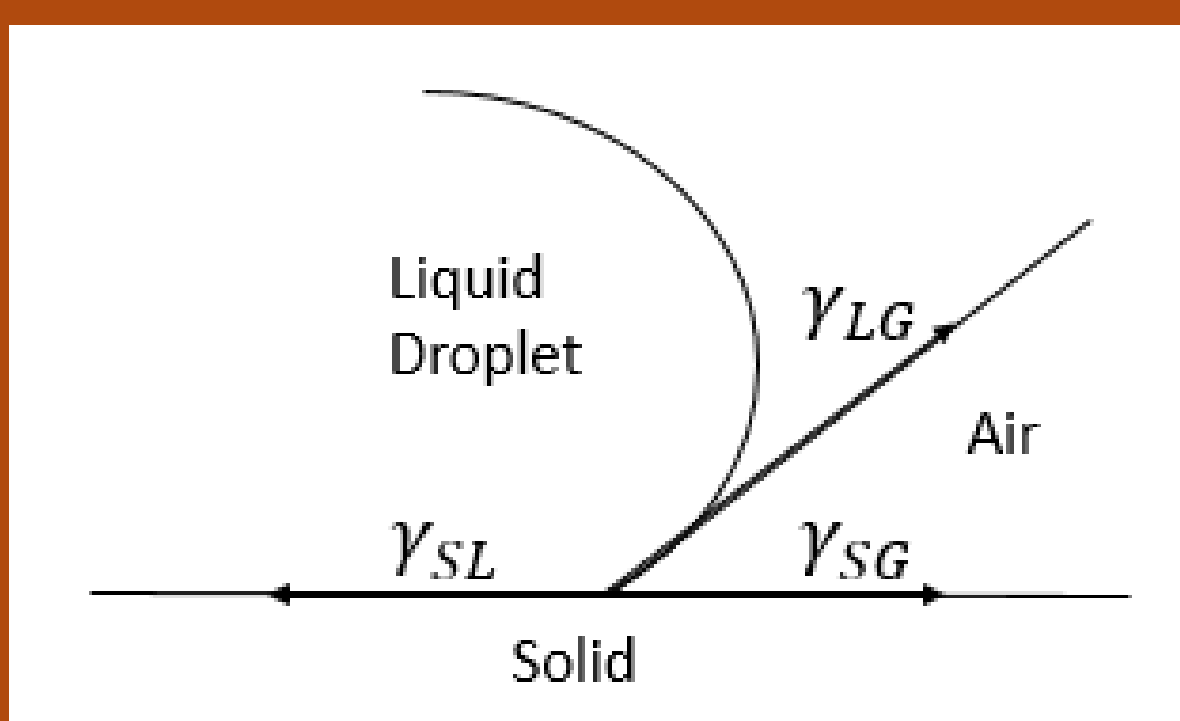
Lippmann-Young equation

$$\cos\theta(V) = \cos\theta(0) + \frac{\epsilon_0 \epsilon}{2\gamma_{LG}d} V^2$$

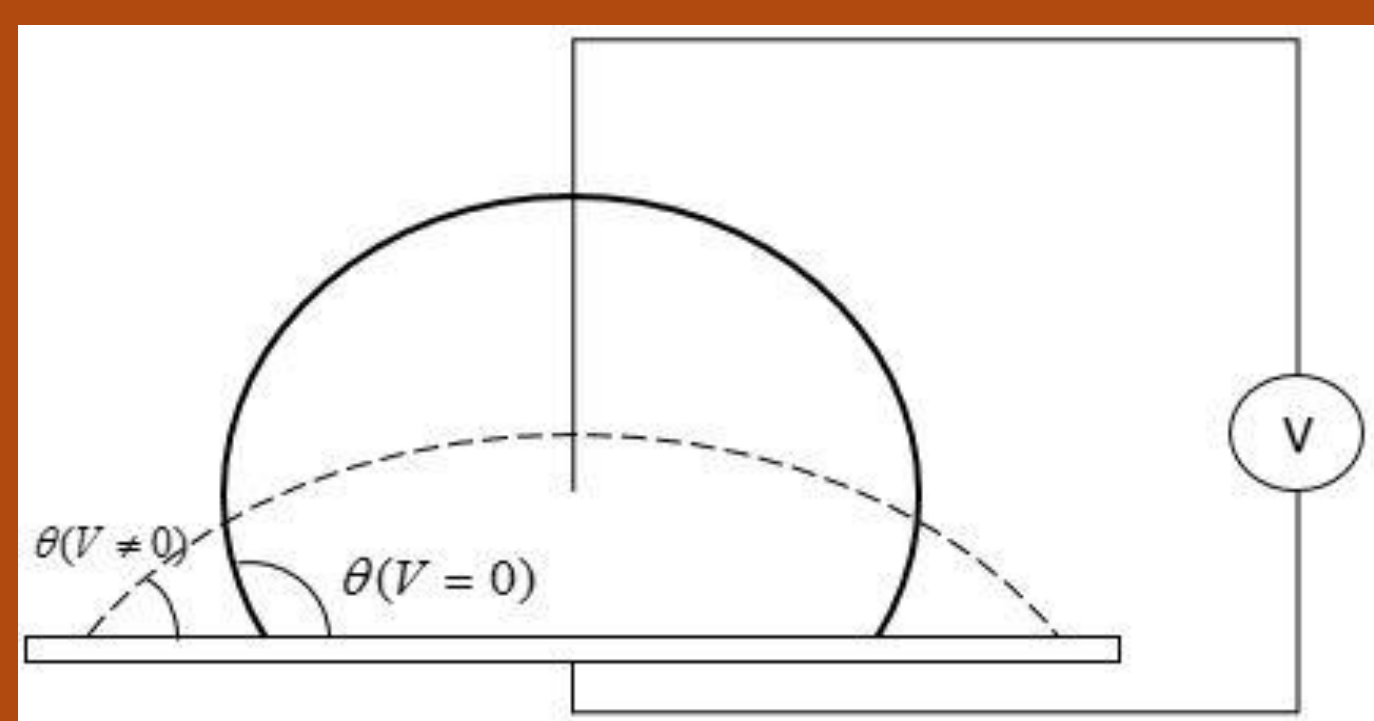
Brochard's model Eq

$$U = \frac{\epsilon_0 \epsilon (1 - \cos\theta(V))}{6\mu d \sin\theta(V)} V^2$$

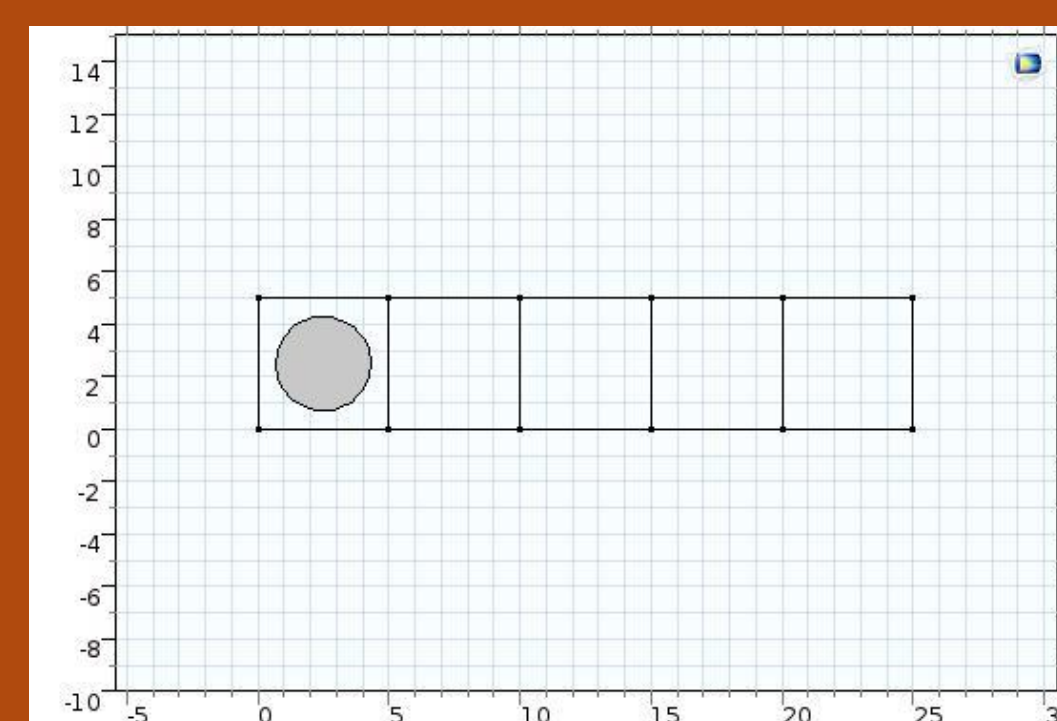
Geometry and Principle



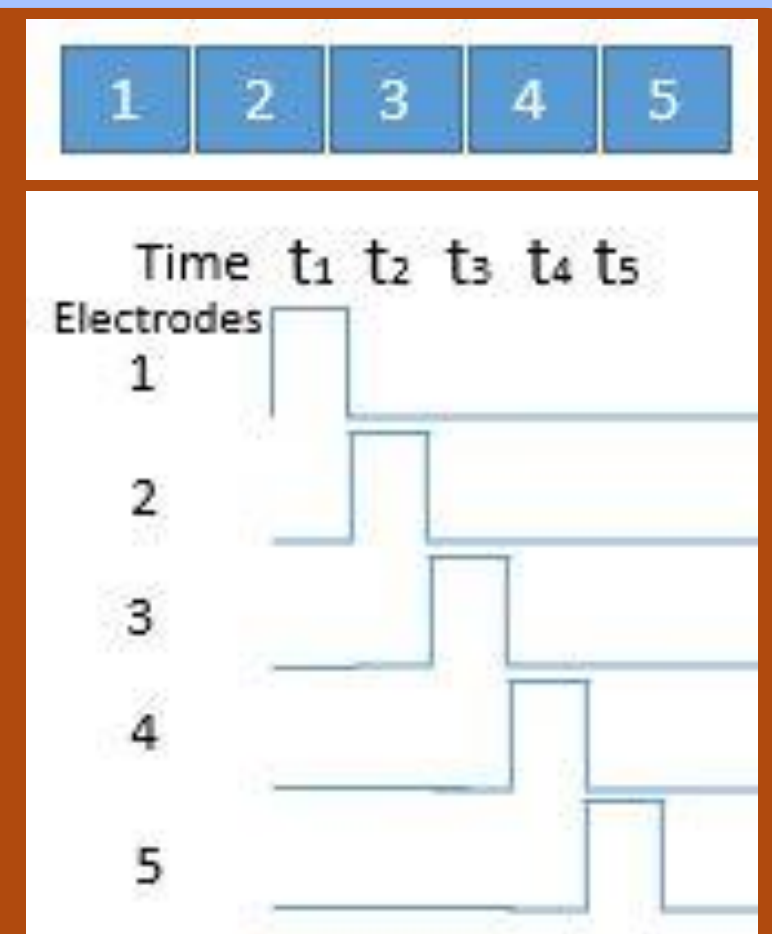
Three phase interphase line of solid, liquid and gas.



Electrowetting Principle



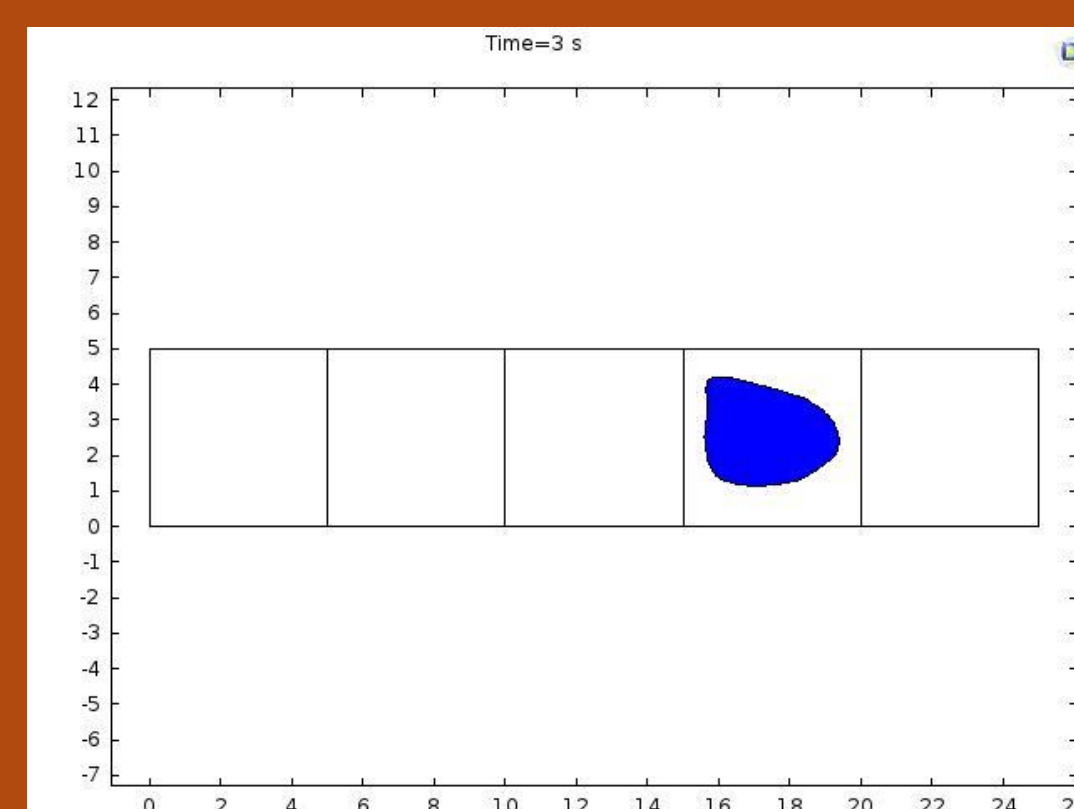
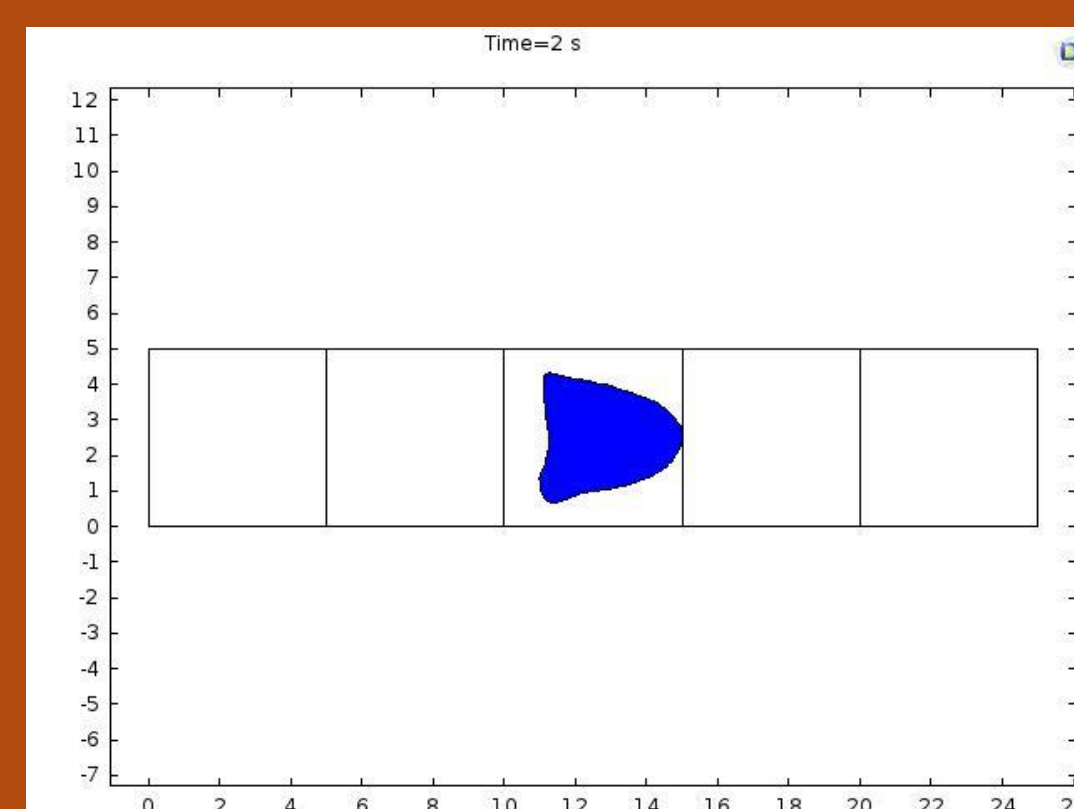
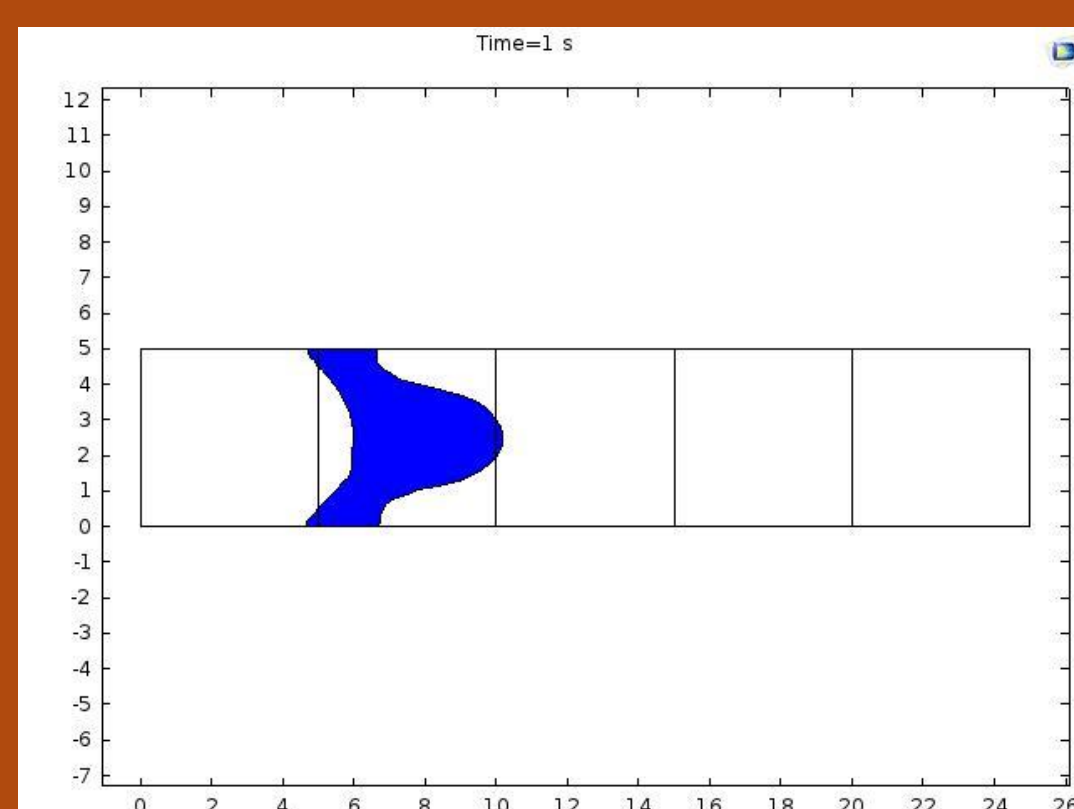
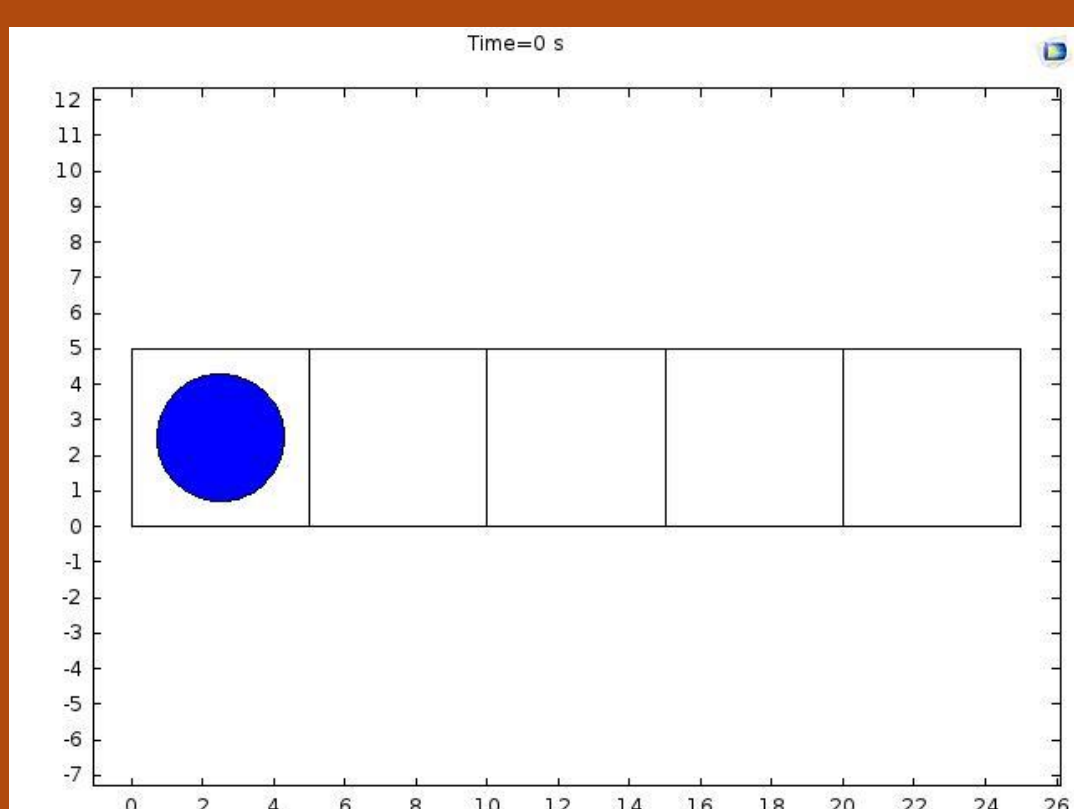
Model geometry designed in COMSOL



Diagrammatic view of electrodes switching

Result

We demonstrated droplet transport with angle modification on four electrodes single row platform only by 15V DC.



Conclusion

Using the information gathered from the above simulation, by integrating the concept of microfluidic mixer with magnetic beads, make feasible to study the next-generation sequencing applications like genomic DNA sequencing of microbial species from single cell and protein RNA interaction.

References

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Advances in Next Generation Sequencing