Effect of Electrode Geometric Parameters on Droplet Translocation in Digital Micro-fluidic Biosensor

M.P. Yogarajan, F. Ibrahim and N. Soin

INTRODUCTION

Digital microfluidic refers to the manipulation of digitized liquids as discrete particles in microfluidic platforms. It is realistically coined as the 2nd generation of microfluidic biochips technology attributing to a simple structural design with on chip re-programmability as opposed to continuous flow mechanical biochips. The full characterization of droplet movement in microsystems holds a significant value in the realization of novel point-of-care diagnostic tools. [1, 2]

Early theoretical and experimental studies in this area have focused on manipulation of surface tension which is the most dominant force in microfluidics. The tendency of a droplet to wet surface (hydrophilicty) is measured by droplet contact angle over a variation of chemically treated surface [3], surface roughness [4, 5], carbon nanotubes [6] and dielectic layers [7] The research communities' interest has been particularly over-whelming on electrowetting-ondielectric (EWOD) attributing to scalable microfluidic systems in that actuation is electrically controlled, rapid, reversible and requires low power. [8]

This paper demonstrates a parametric analysis using CoventorwareTM to identify the variations in geometric parameters of a EWOD on its droplet switching rate. The results attained will help us characterize mechanical parameters to identify optimum droplet translocation conditions in digital microfluidic biochips.

Background study

Previous Works

Electrowetting refers to an electrostatically induced reduction in contact angle of an electrically conductive liquid droplet on a surface [9] EWOD exploits the variation in contact angle of a droplet on a dielectric surface under specific electric potentials. Droplet translocation is thus possible if the electric field is continuously localized at on side of the droplet using array of electrodes [10]. Several experimental configurations of EWOD-based devices have been reported, including single-plate open air devices, parallelplate devices filled with silicone oil, parallel-plate open-air devices and organic/inorganic droplet actuations.

Washizu [11] reported actuation of 0.4mm/s with a minimum voltage of 300V. Pollack et al [8] introduced the use of silicone oil as filler and reported a comparative high switching rate of 30mm/s with as little as 40V. Cho [12] further reduced the actuation voltage to 15V using Barium Strontium Titanate (BST) as an insulator layer. Torkelli [9] introduced surface-texture alteration (super-hydrophobic) to reduce actuation voltage. A mathematical model by Chao [13] suggested that a single plane EWOD design will reduce actuation voltage of a similar double plane design. Chatterjee et al [14] reported variety of sample droplets ranging from organic solvents, aqueous surfactants, and ionic liquids to be movable via EWOD and identified a correlation between electric permittivity property of droplet and actuation.

Full text is available at :

http://link.springer.com/chapter/10.1007/978-3-540-69139-6_177