Digital Microfluidic Droplet Adapter for Interconnection of Biochips

R. Zhu[1], X. Xiong[2], P. Patra[1], C. Jin[1], J. Hu[3]

[1]Department of Biomedical Engineering, University of Bridgeport, Bridgeport, CT, USA
[2]Department of Electrical & Computer Engineering, University of Bridgeport, Bridgeport, CT, USA
[3]Department of Mechanical Engineering, University of Bridgeport, Bridgeport, CT, USA

Abstract

Introduction:
In this research, we use the COMSOL Multiphysics® software to design and simulate a digital microfluidic droplet adapter for board-level biochip integration. Digital Microfluidic Biochip (DMFB) has gained tremendous research interest in recent years due to its importance in Lab-on-a-Chip and other bio-MEMS (bio-Microelectromechanical Systems) devices [1]. DMFB-based bio-MEMS devices used for disease diagnosis have the advantages of low cost, small sample size, quick response time and easy operation [2]. As DMFBs are used for more and more applications, large-scale integration of DMFB microarrays is desired. Similar to VLSI (Very Large Scale Integration) technology, the concept of VLSB (Very Large Scale Biochip) is being proposed. However, different DMFB microarray from different manufacturers may have different electrode sizes [3]. This electrode size incompatibility becomes a problem for the integration of mulitiple biochips in VLSB. In order to solve this problem, for integration of multiple DMFB boards, a universal droplet adapter to convert droplets into different sizes is needed. In this way, the droplets coming out from one DMFB can be input to another DMFB to continue the processing. In this research, a digital microfluidic droplet adapter design is proposed. Theoretical analysis is performed to predict the behavior of droplet moving in the adapter. The function of the proposed adapter is verified with simulation. The adapter can convert the droplets between different DMFBs. The proposed adapter can be used for the board-level integration of multiple DMFBs with different electrode sizes.

Use of COMSOL Multiphysics:
COMSOL Multiphysics is used to verify the function of the designed droplet adapter. Specifically, we uses the Multiphase Flow interface, Laminar Two-Phase Flow, Level Set (tpf) in COMSOL to simulate the droplet behavior in the microfluid adapter. Animation clearly shows how the size of droplets is changed after passing through the droplet adapter.

Results:
The COMSOL simulation shows how the designed adapter work. It helps us understand the working mechanism of the droplet adapter. The simulation result also help guide us in finding the

optimized design parameters of the droplet adapter.

Conclusion:
Digital microfluidic biochips from different manufacturers may use different electrode sizes for specific applications. This leads to problem if we need to integrate multiple DFMB microchips into a single board. In this research, the design and simulation of a microfluidic droplet adapter used to connect multiple DMFB boards with different electrode sizes is reported. The proposed droplet adapter can convert droplet into different sizes, so that the digital droplets can be passed between multiple DMFB boards with different electrode size. This facilitates the board level integration of DMFBs with different electrode sizes from different manufacturers, so that DMFBs can be integrated into larger scale, just like PCB board level integration of VLSI chips. The working principle of the adapter is discussed. COMSOL simulation is used to simulate its behavior.

Reference

[1]. Chen, L. and E. Bonaccurso, "Electrowetting - From statics to dynamics", Advances in Colloid and Interface Science, Oct. 10, 2013.

[2]. Quilliet, C. and B. Berge, "Electrowetting: a recent outbreak", Current Opinion in Colloid & Interface Science, 2001. 6(1): pp. 34-39.

[3]. Chae, J.B., et al. "Three-dimensional digital microfluidics using an alternative current electrowetting-on-dielectric (AC-EWOD)", Solid-State Sensors, Actuators and Microsystems (TRANSDUCERS & EUROSENSORS XXVII), 2013 Transducers & Eurosensors XXVII: The 17th International Conference on. 2013.

Figures used in the abstract

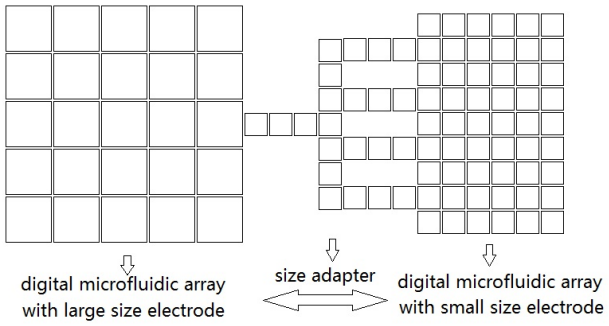

Figure 1: Design of microdroplet adapter for interconnect of biochips.