EWOD-Based Droplet Actuation by Active-Matrix Electrode Array

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The majority of current lab-on-a-chip devices use micro- and nanoscale fluidic channels to manipulate the fluid of interest based on the principles of continuous fluid flow. However, it is often difficult and complicated to integrate a large number of micropumps, microvalves and microchannels that are necessary for practical applications in a small chip. An alternative to microchannel is to use droplets as fluidic handlers [1]. In recent years, droplet-based microfluidics gained significant attention due to its easy fluid manipulation by the electrowetting on dielectric (EWOD) phenomenon [2]. The droplet can be easily actuated by an underneath electrode, thus greatly reducing the clutter of the channel-based fluidic systems by separating the fluidic components from the actuation components.

Current implementation of droplet-based digital biochips are based on the custom design of electrode pattern for each specific application [3]. In this work, we present a generic digital biochip in which the droplets are individually actuated by a 2D active-matrix electrode array. The device schematic is shown in Figure 1 and the actuation scheme is shown in Figure2. For each electrode in the 2D array, there is a switching transistor in the active-matrix circuitry. The switching transistor can be individually turned on or off without interference with neighboring electrodes, thus providing the ability of individually actuating a droplet through the row and column contacts. This feature enables ultimate flexibility in droplet actuation. Unlike traditional EWOD-based digital biochip development, this platform can perform all types of tasks through selectively actuating a sub-set of the 2D electrode array, thus eliminating the need for the custom design of the digital biochip. Moreover, the freedom in droplet actuation through active-matrix circuitry allows for the manipulation of multiple droplets simultaneously. Since the active-matrix electrode array can be easily scaled up to have hundreds to thousands of rows and columns, this platform is capable of handling massively parallel droplet reactions at one time. Such feature will potentially provide unprecedented power to address large and complex bioanalytical and biosynthetic tasks using micro-array technologies.

We will present the design, the fabrication and the initial testing of a prototype 2D active-matrix electrode array for EWOD-based droplet actuation. The simple implementation and the diverse capability of the 2D active-matrix electrode array allow the droplet-based microfluidics to be used in various bioengineering and biomedical engineering applications.

References

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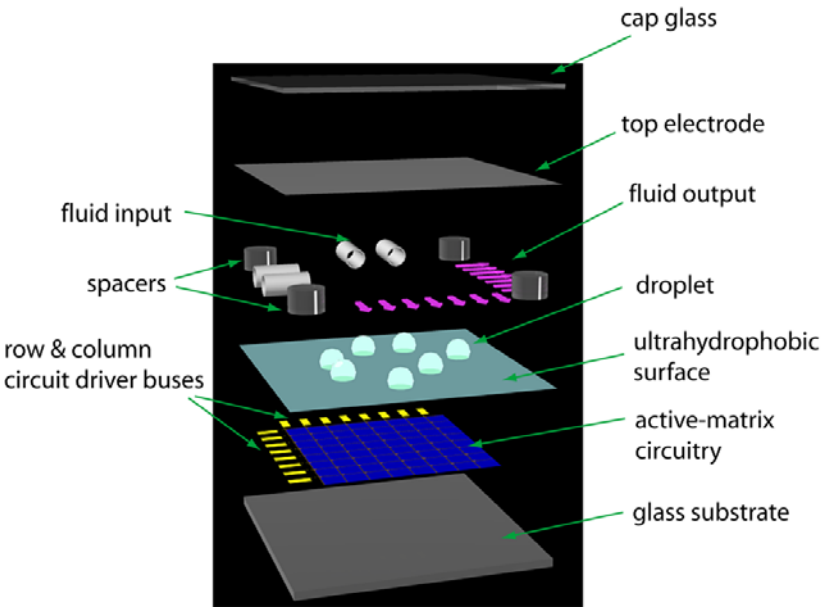

Figure 1. An exploded view of the active-matrix array electrode for droplet acutation based on the EWOD effect.

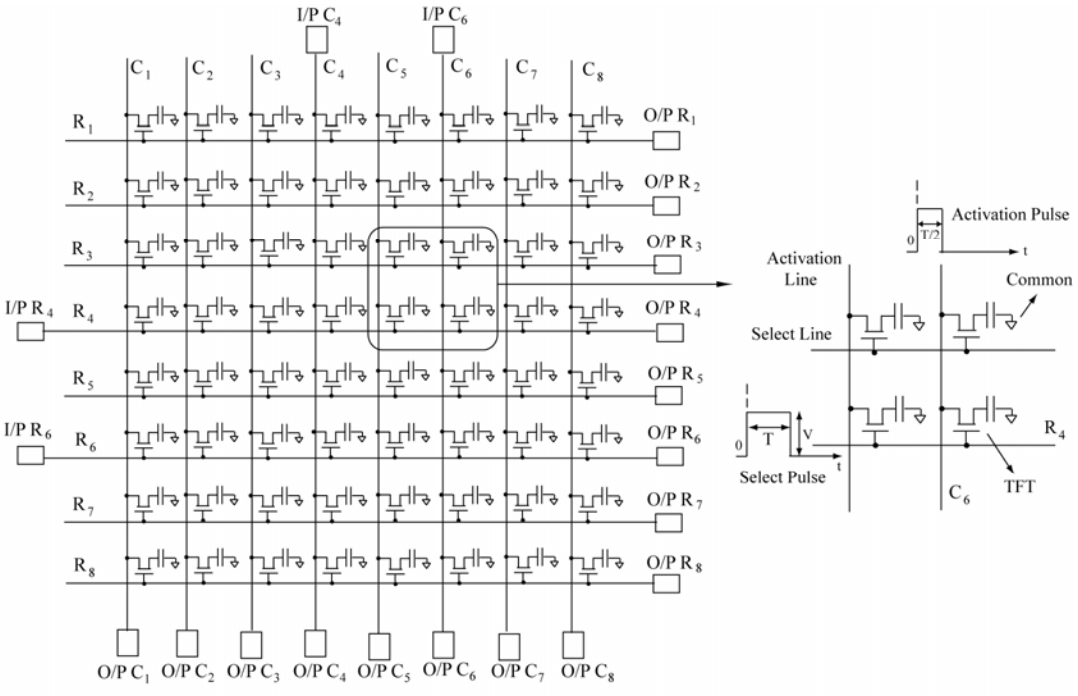

Figure 2. An exemplar 8 × 8 matrix circuitry for driving the digital microfluidic platform.