DROPLETS DRIVING AND SENSING PIXEL CIRCUITS FOR THIN FILM TRANSISTOR-BASED DIGITAL MICROFLUIDICS

Hanbin Ma, CAS Key Laboratory of Bio-Medical Diagnostics, Suzhou Institute of Biomedical Engineering and Technology; Chinese Academy of Sciences; Guangdong ACXEL Micro & Nano Tech Co., Ltd.
mahb@sibet.ac.cn
Dongping Wang, CAS Key Laboratory of Bio-Medical Diagnostics, Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Sciences
Chunyu Chang, CAS Key Laboratory of Bio-Medical Diagnostics, Suzhou Institute of Biomedical Engineering and Technology, Chinese Academy of Sciences
Yingbo Wei, School of Information Science and Engineering, Shandong University
Jun Yu, School of Information Science and Engineering, Shandong University
Arokia Nathan, School of Information Science and Engineering, Shandong University

Key Words: active-matrix, electrowetting-on-dielectric, digital microfluidics,.thin film transistor, droplets sensing

Thin film transistor-based active-matrix digital microfluidics (AM-DMF) is an emerging and promising technology for large-scale parallel biological sample handling. With electrowetting-on-dielectric (EWOD) method, DMF chip can realize accurately controlling discrete droplets, thus it has great application prospects in biology, chemistry, and drug discovery. With the rapid development of micro-analysis and detection requirements, the precise control of droplets in DMF chips is increasingly required, so it is necessary to conduct the real-time sensing of droplet position.

Figure 1 shows the designed droplet position detection unit circuit. The circuit consists of six thin film transistors, T1-T6. The input signals mainly include the enable signal Ven, the reverse enable signal Venb, the discharge signal Vdischarge, the detection signal Vdetect, and the ground signal Vgnd. The signal Vdrive is the driving voltage applied for driving electrode. Cpixel is the equivalent capacitance between the two plates of a pixel electrode in a microfluidic chip. Vout is the output voltage signal.

The simulation waveform diagram of the circuit is shown in Figure 2. Combined with the waveform diagram, the working principle of the circuit is explained as follows. In the initial state, Vdrive is a constant driving voltage applied to the driving electrode, and Vgnd is the ground signal. Ven, Vdischarge, and Vdetect are all low level and Venb is high level. When Ven changes from low level to high level and Venb changes from high level to low level, the droplet position detection circuit starts to enter the working state. T1 changes from on to off and the driving voltage Vdrive is isolated. T2 changes from off to on. T4 changes from on to off and the gate T5 is no longer forced to connect to the ground. Then the discharge signal Vdischarge changes to a high level and lasts for a fixed time, so that both T3 and T6 change from off to on. Therefore, the capacitor Cpixel is discharged through T3 for a fixed time and the output signal Vout is reset through T6. After Vdischarge recovers the low level, T3 and T6 change from on to off, and then the detection signal Vdetect changes from low level to high level. Therefore, by detecting the voltage magnitude of the output signal Vout during the high level of Vdetect, the voltage magnitude after Cpixel discharged can be obtained, and then the relative value of Cpixel can be judged, and finally whether there is a droplet above the pixel electrode.

The droplets sensing output voltage is about 6 V with the presence of a droplet above the electrode (equivalent capacitance is about 0.5 pF) and 0 V with the absence of a droplet (equivalent capacitance is about 0.1 pF), which has been verified by the droplet position detection unit circuit and array circuit simulation. This circuit can be integrated with the digital microfluidic chip pixel circuit with low cost and little space occupation, and it will provide a novel method to realize the droplet position detection in AM-DMF chips.