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A Programmable Digital Bio-Chip for Biomedical Detection & Manipulation

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Introduction

This poster introduces a Field-Programmable Lab-On-a-Chip (FPLOC) system designed with the aim of manipulating antigens and antibodies. Based on EWOD tech, precision microfluidic operations like can be achieved. In addition, the chip is constructed by a MEDA, which improve the flexibility and programmability for different control mechanisms .

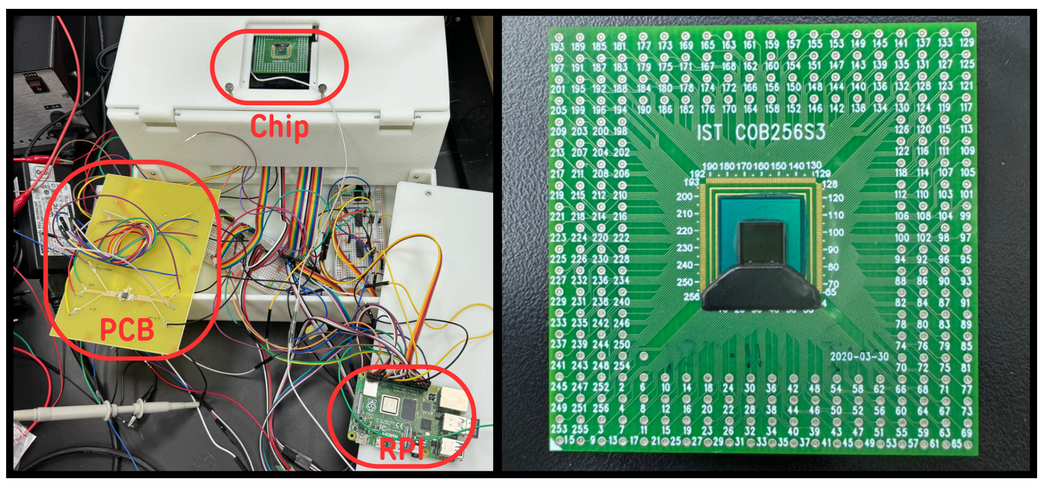


Fig. 1. The Device Panorama (Top View)

Principle & Architecture

- **EWOD (Electro-wetting-on-dielectric):**

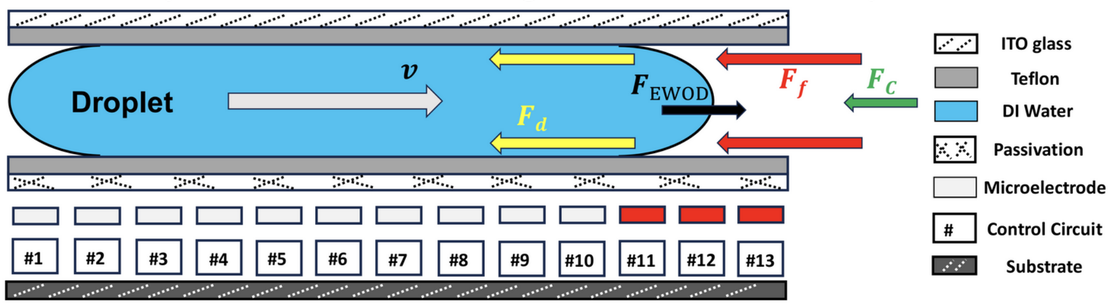


Fig. 2. Under higher voltage (electrical fields), the surface tension of droplet is weaker. With EWOD, dropping out, moving, mixing, and splitting droplets can be accomplished.

- **MEDA (Microelectrode Dot Array):**

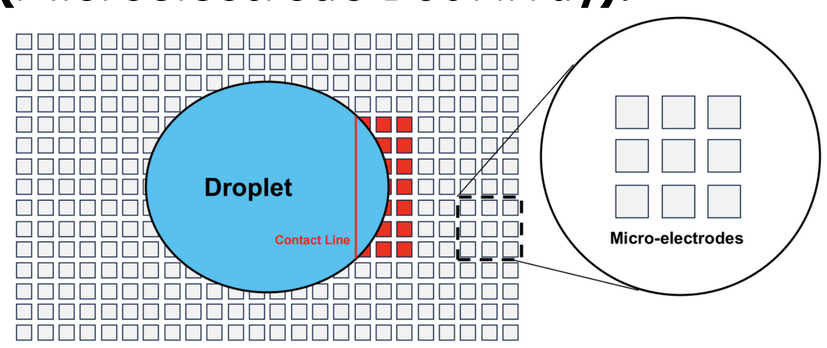


Fig. 3. This architecture achieves high resolution, programmability, and parallel processing for different pattern-control mechanisms.

Circuit Design

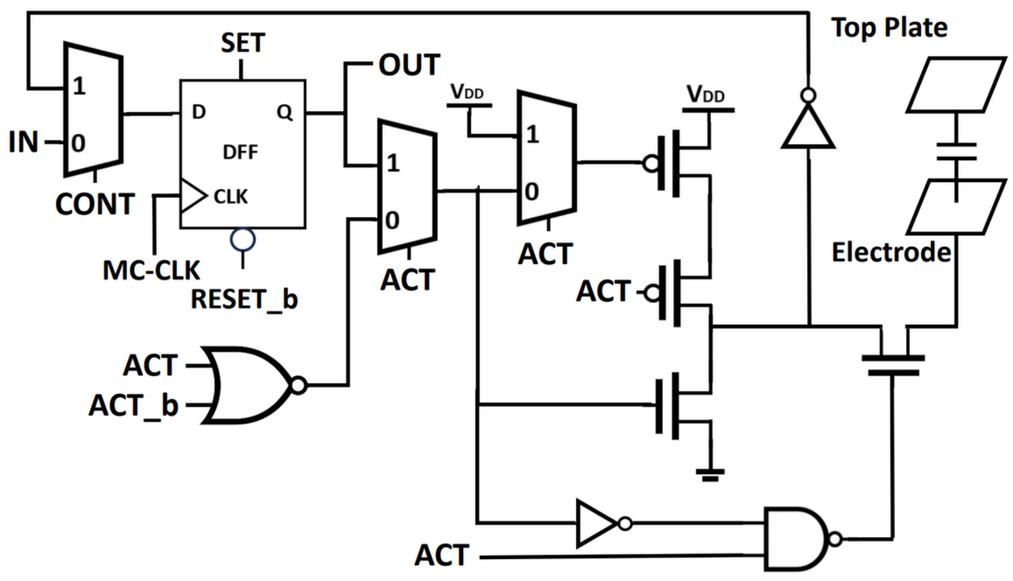


Fig. 4. Circuit of the system. This circuit is adapted from figure 3.6 in "System Integration of Field-Programmable Lab-on-a-Chip for Biomedical Detection" by M.-F. Shiu.

Manipulation	Top plate	Electrode	ACT	ACT_b	MC_CLK	CONT
Location sensing 1	GND	GND	GND	GND	GND	VDD
Location Sensing 2	GND	Charging[1]	GND	VDD	Rising	VDD
Actuation	Square wave	Floating or GND[2]	GND	VDD	GND[3]	GND

1: Charging rate is determined by the capacitance.
2: Being floating or GND is determined by data scanned in.
3: Before actuation, there will be 1800 cycles MC_CLK which enables data scanned into the circuit.

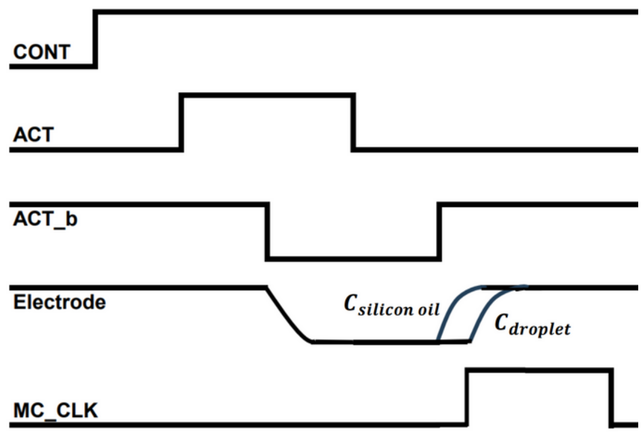
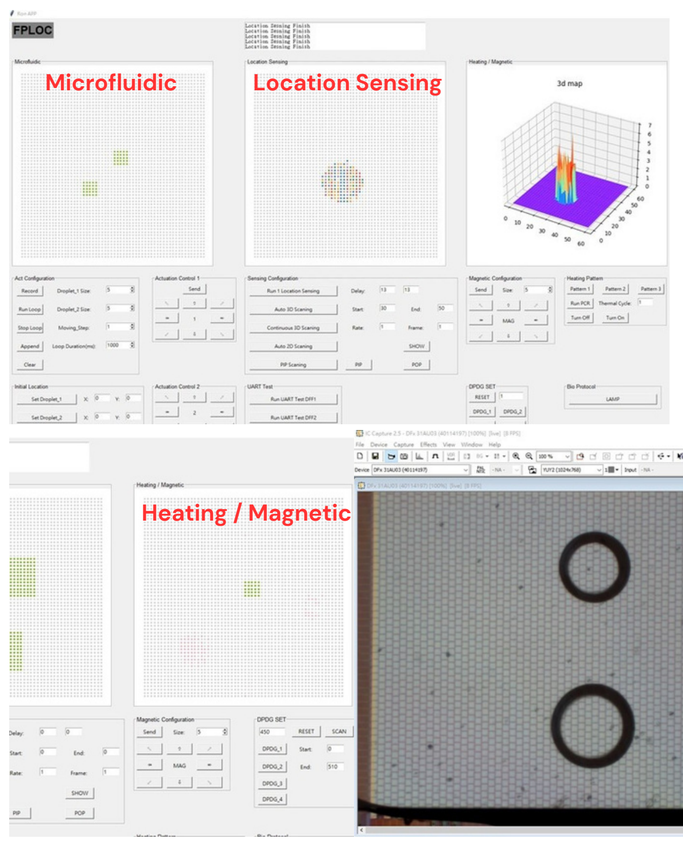


Fig. 5. Waveform of a part of signals. This circuit is adapted from figure 3.7 in "System Integration of Field-Programmable Lab-on-a-Chip for Biomedical Detection" by M.-F. Shiu.

Result & Conclusion



▲ **Fig. 6. Screenshot of the location sensing result. (Under GUI & microscope)**

◀ **Fig. 7. Screenshot of the droplet movement. (Under GUI & microscope)**

In figure 6 and 7, the left part is the GUI interface for users to control and detect the system, and the right part provides the real time state and position of the droplet. With the GUI interface, users can easily modify related parameters when detecting different kinds of droplets, which allows the system be popular.

Reference

1. M.-F. Shiu and C.-Y. Lee "System Integration of Field-Programmable Lab-on-a-Chip (FPLOC) for Biomedical Detection," Oct. 2015.
2. P.-H. Yu and C.-Y. Lee "Microfluidic Control and Biomedical Detection Based on Field-Programmable Lab-on-a-Chip system," Oct. 2016.
3. Y.- S. Chan and C.-Y. Lee "A Programmable Bio-Chip with Adaptive Pattern-Control Micro-Electrode-Dot-Array," Nov. 2022.