Design and Simulation of High-throughput Microfluidic Droplet Dispenser for Lab-on-a-Chip Applications

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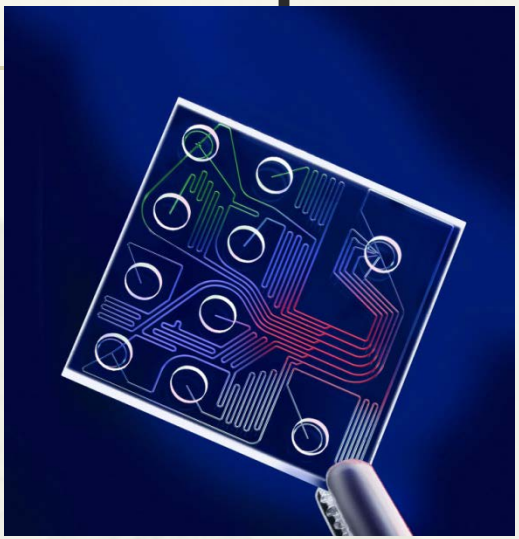
Outline

- Introduction
  - Mirofluidic biochips
  - Dispenser
- Device structure
- Simulation
- Result
- Conclusion

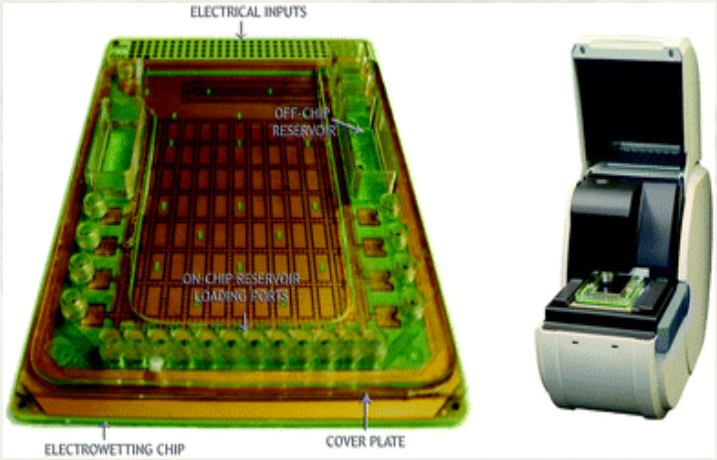
Introduction microfluidic biochips

* Analog microfluidic biochips (AMFBs) (e.g. micropumps, microvalves, microchannels)



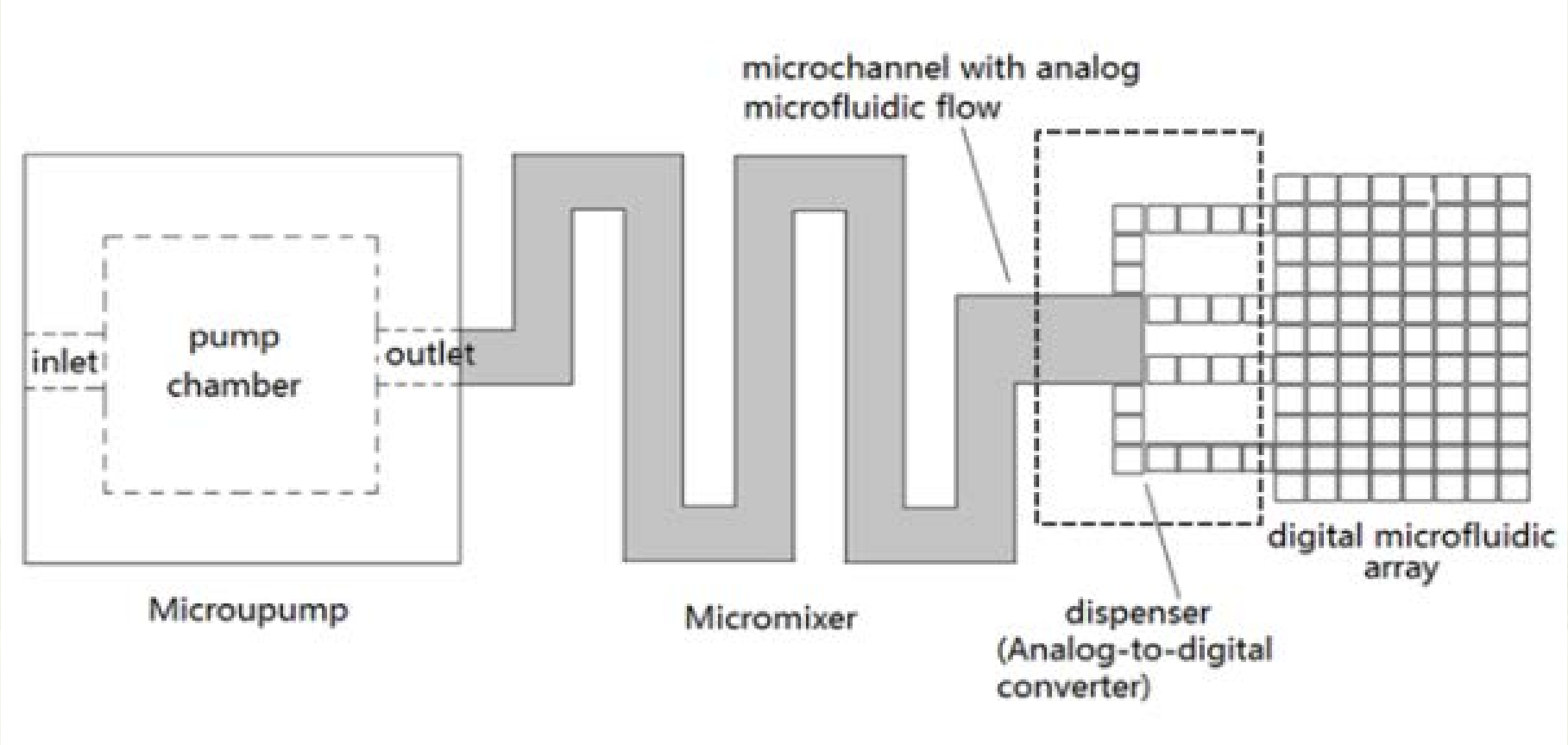
http://www.chromatographytechniques.com/articles/2011/12/microfluidics-evolution

* Digital microfluidic biochips (DMFBs) (e.g. EWOD)

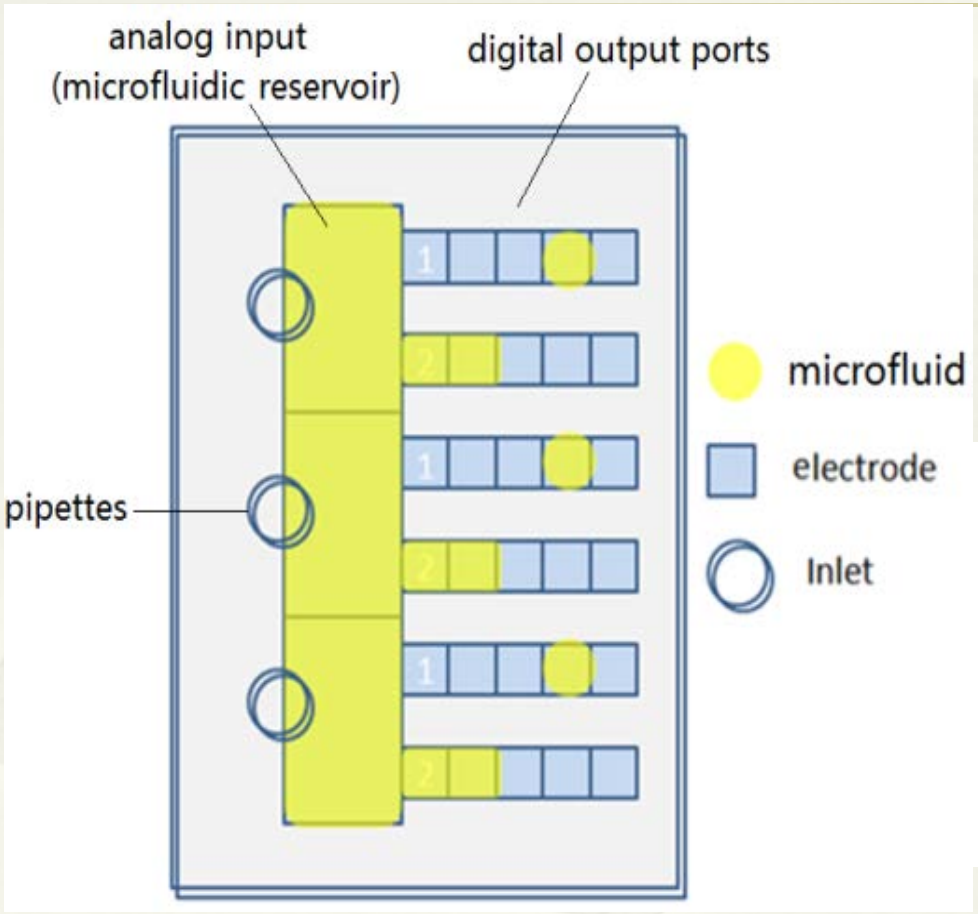


http://pubs.rsc.org/en/content/articlelanding/2008/lc/b814922d#!divAbstract

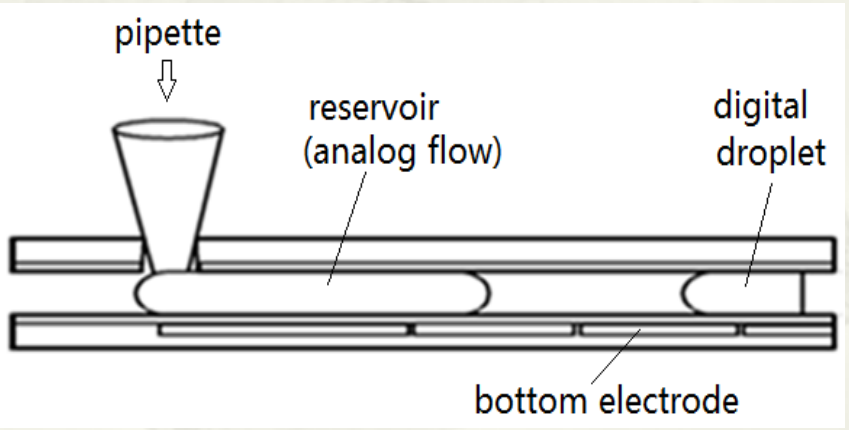
Introduction dispenser



Device structure



(a) top view



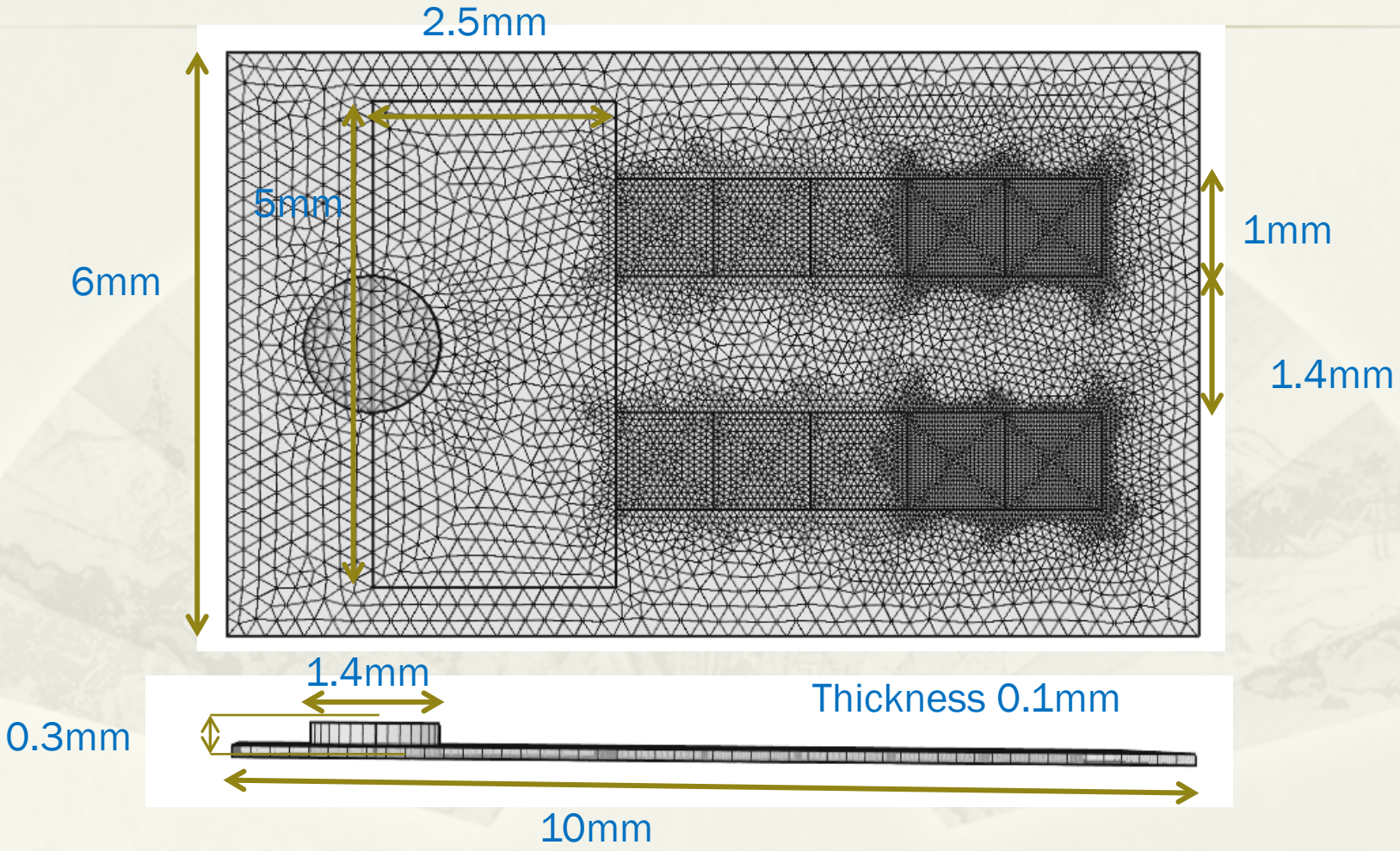
(b) Cross-sectional view

The structure design of the microfluidic droplet dispenser

Simulation setup

- COMSOL MultiPhysics 4.3.b
- 3D Laminar Two-Phase Flow, Level Set

Meshed model of droplet dispenser



Simulation setup parameters

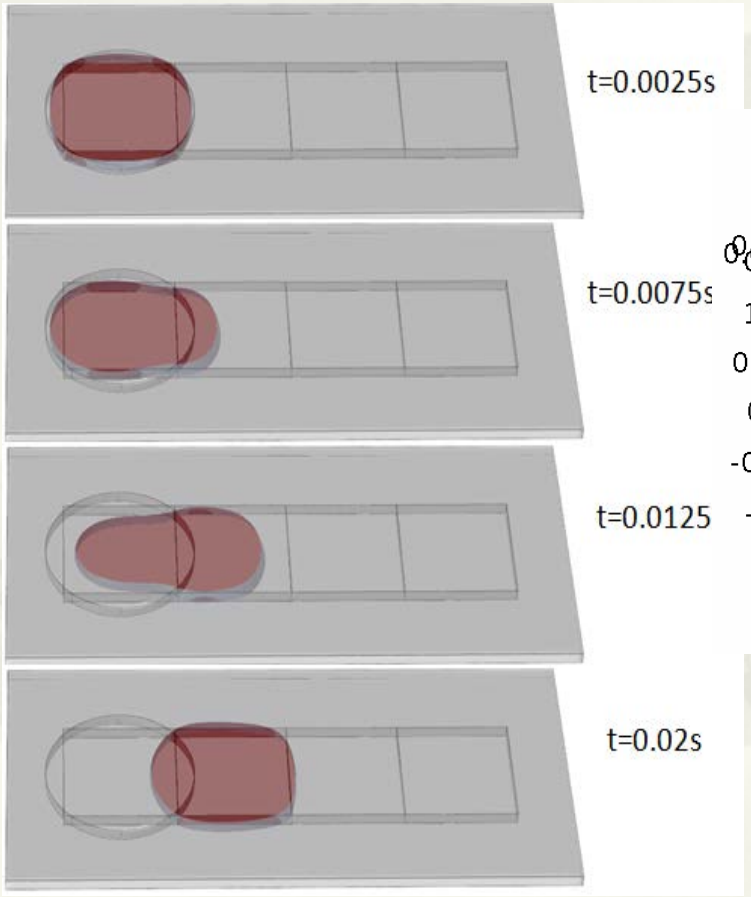
Table 1. Fluid properties used in COMSOL simulation

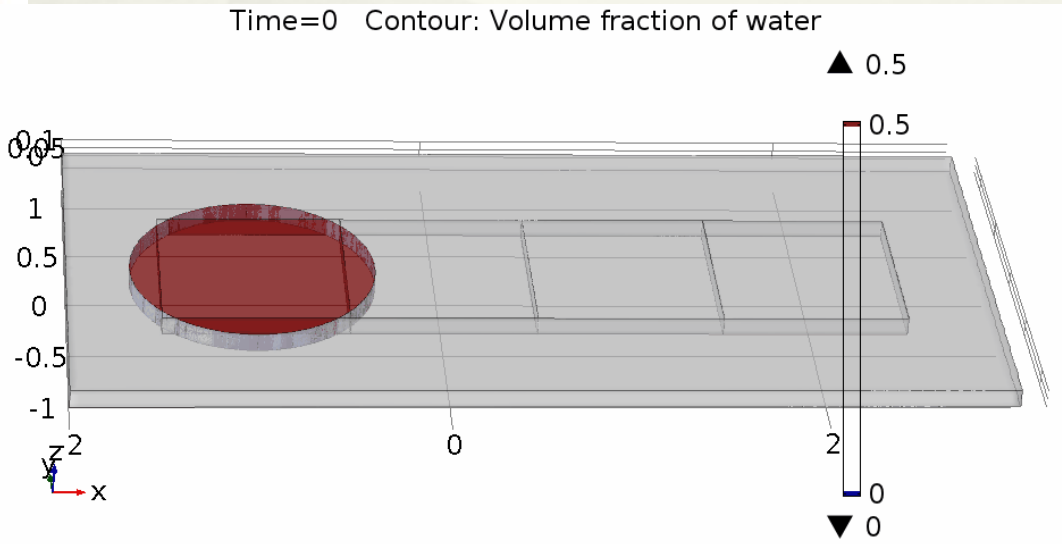
Material Property	Oil (DP)	Water (CP)
Density (Kg/m^3)	1000	1000
Dynamic viscosity (mPa)	8	1.5

Table 2. Design parameters of droplet dispenser

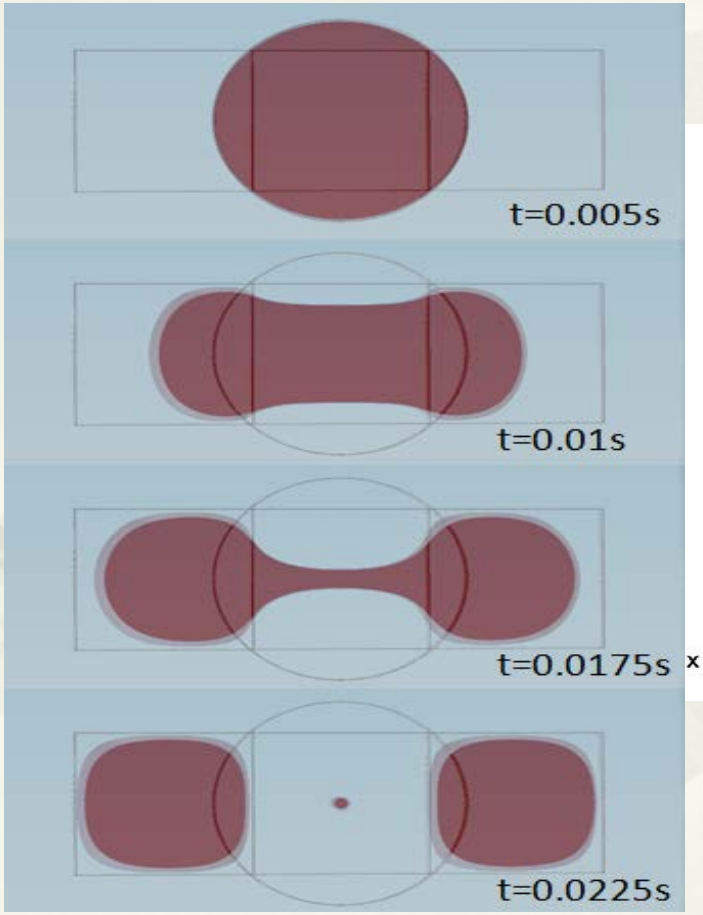
Design Parameter	Value
Electrode size	1mm×1mm
Channel gap d	0.1mm
Liquid-gas interfacial tension γ_{lg}	0.05N/m
Relative dielectric constant ε_r of the dielectric layer	3.27
Dielectric layer thickness *t*	140nm
Actuation voltage V_d	22V
Inlet flow rate	0m/s
Outlet pressure	1×10^5Pa
Contact angle without actuation voltage	120°
Contact angle after actuation voltage	60°

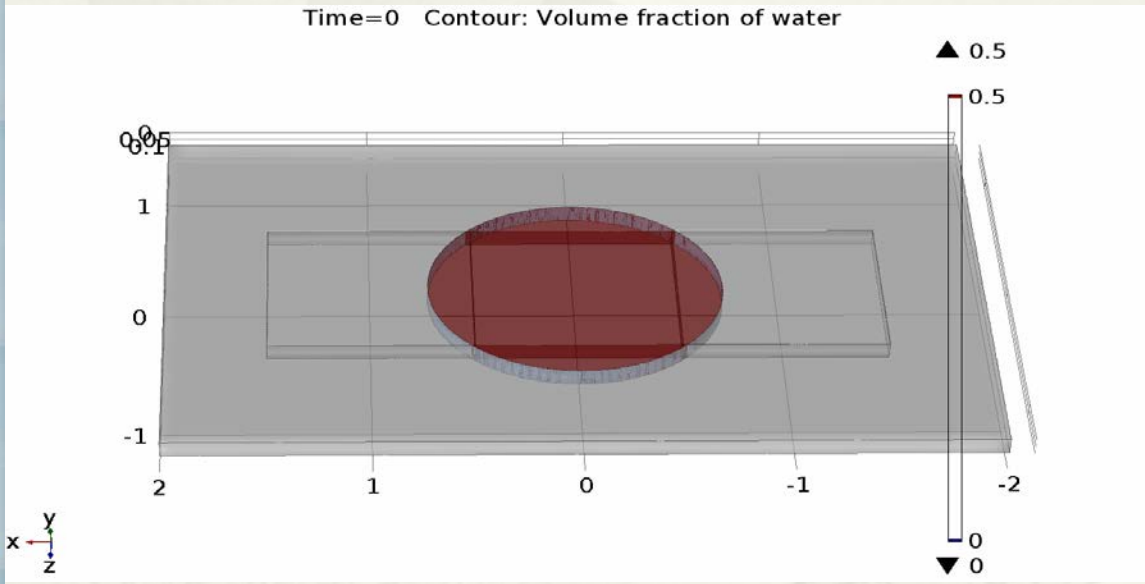
Result moving



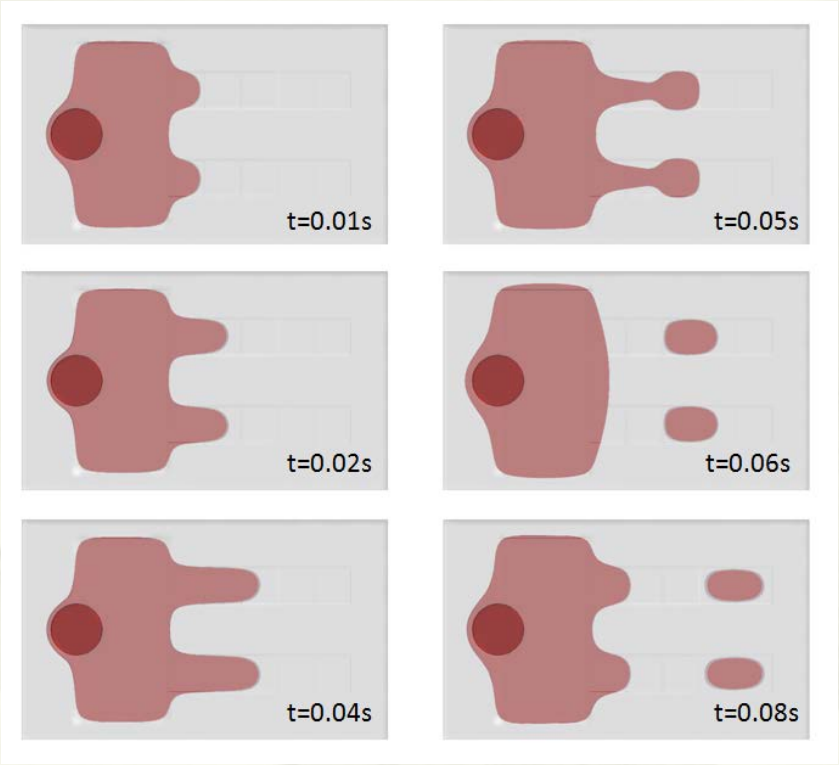


Result spliting

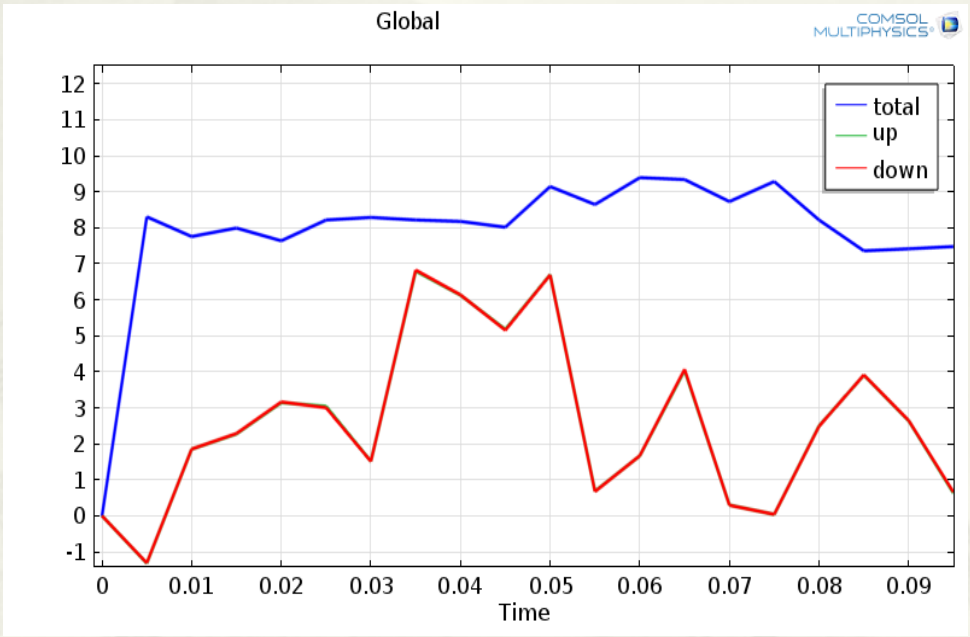




Result dispensing

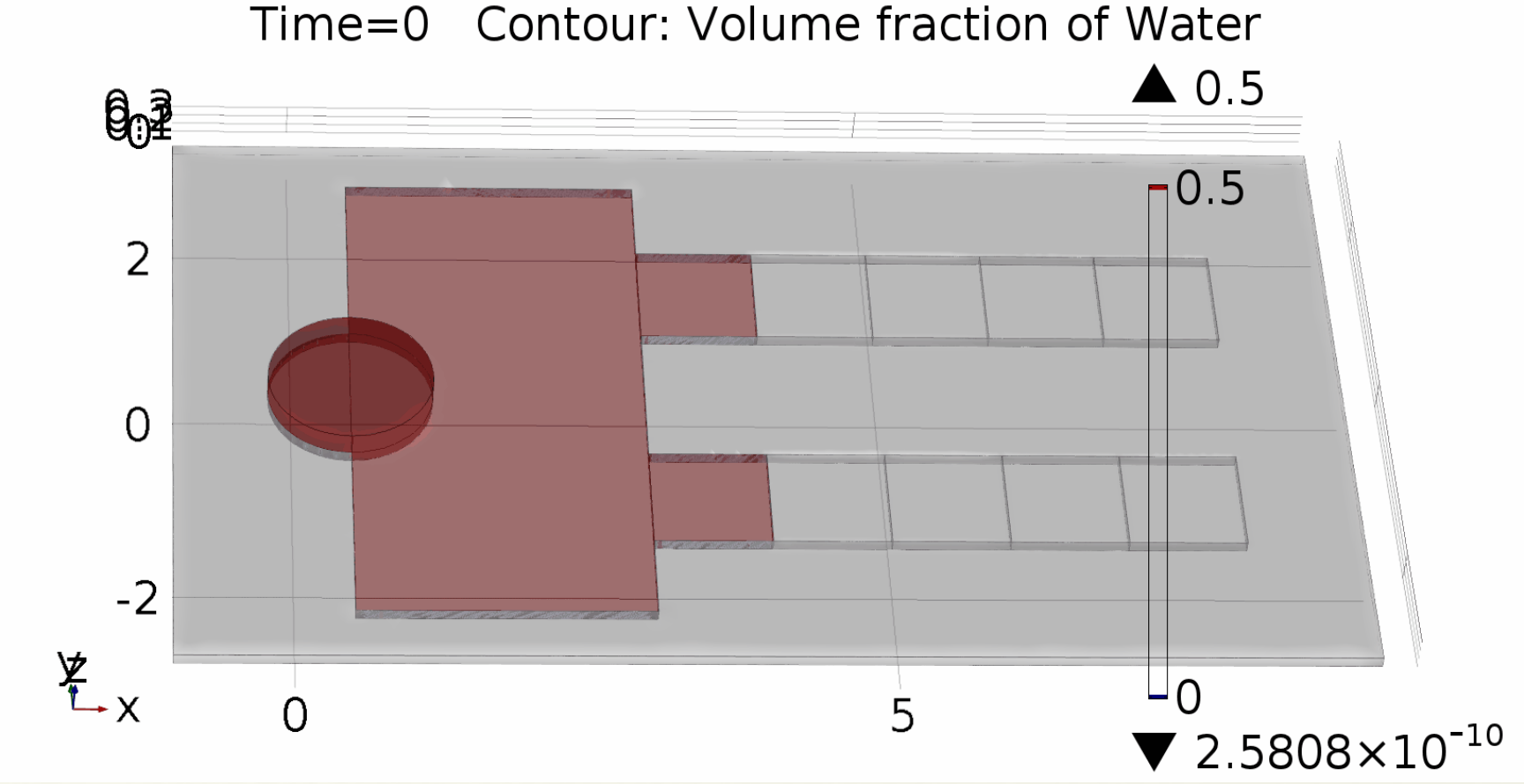


COMSOL simulation of droplet dispenser in parallel mode

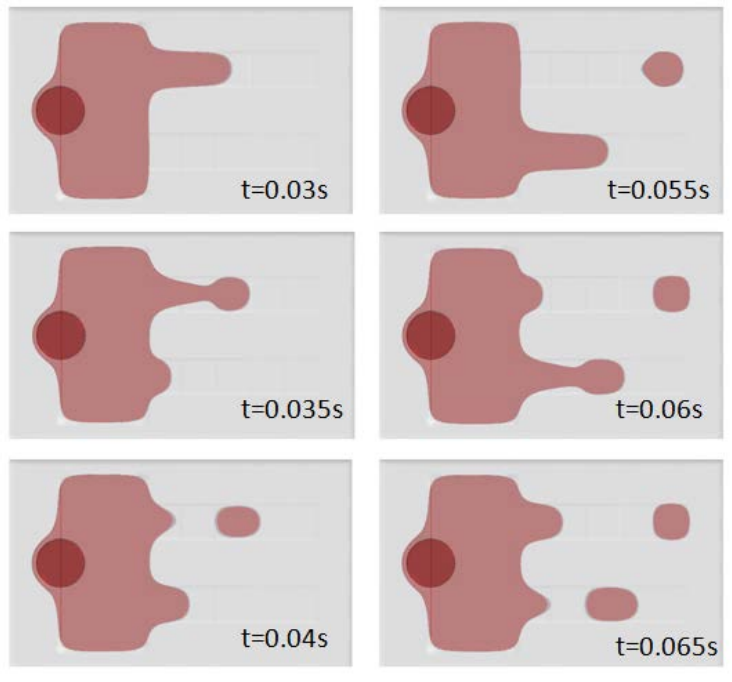


Flow rate of inlet ("total"), top port ("up") and bottom port ("down").

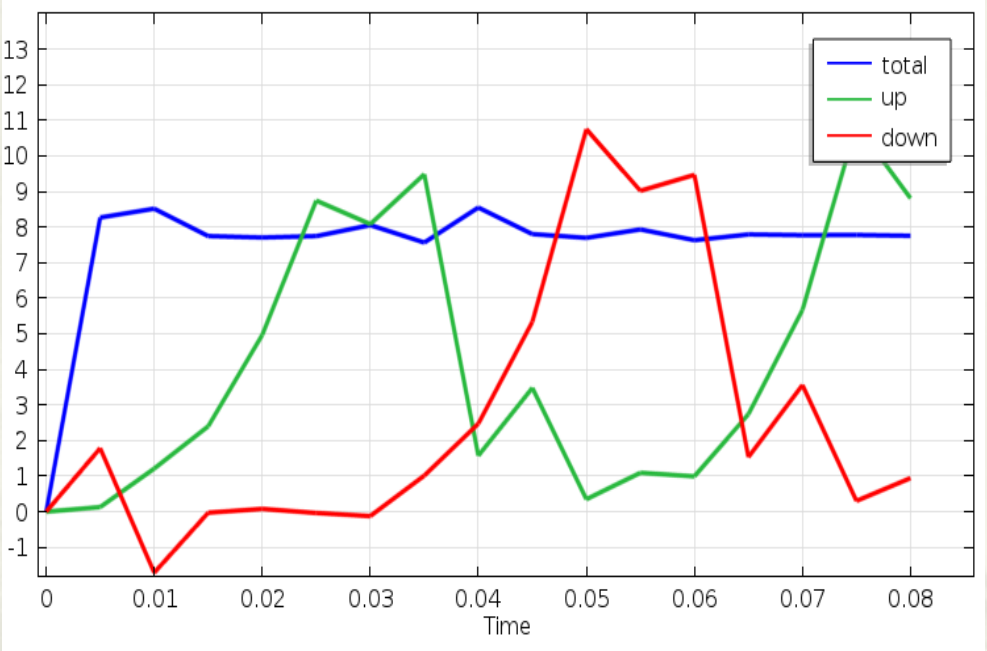
Dispensing parallel mode



Result dispensing

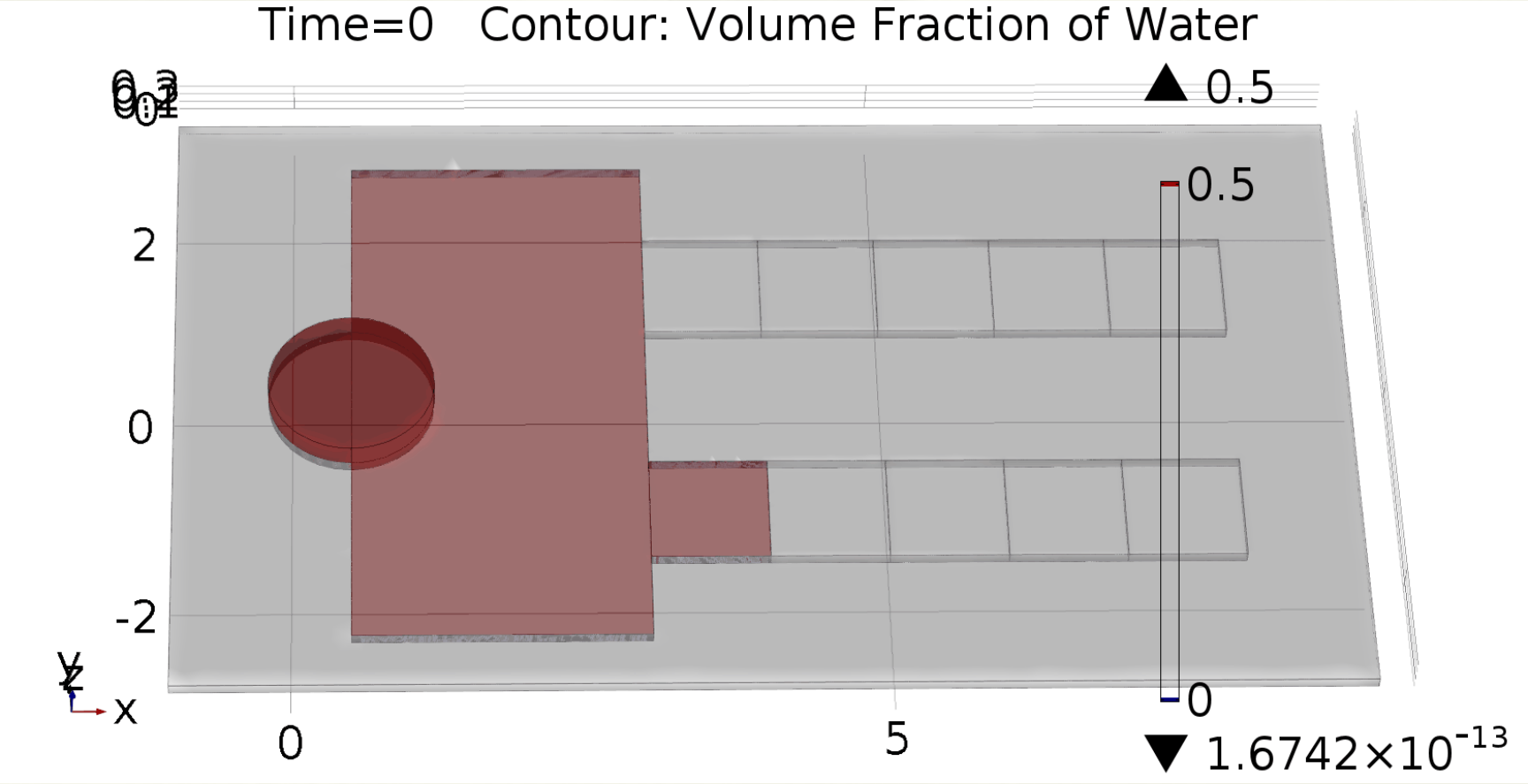


COMSOL simulation of droplet dispenser in alternate mode



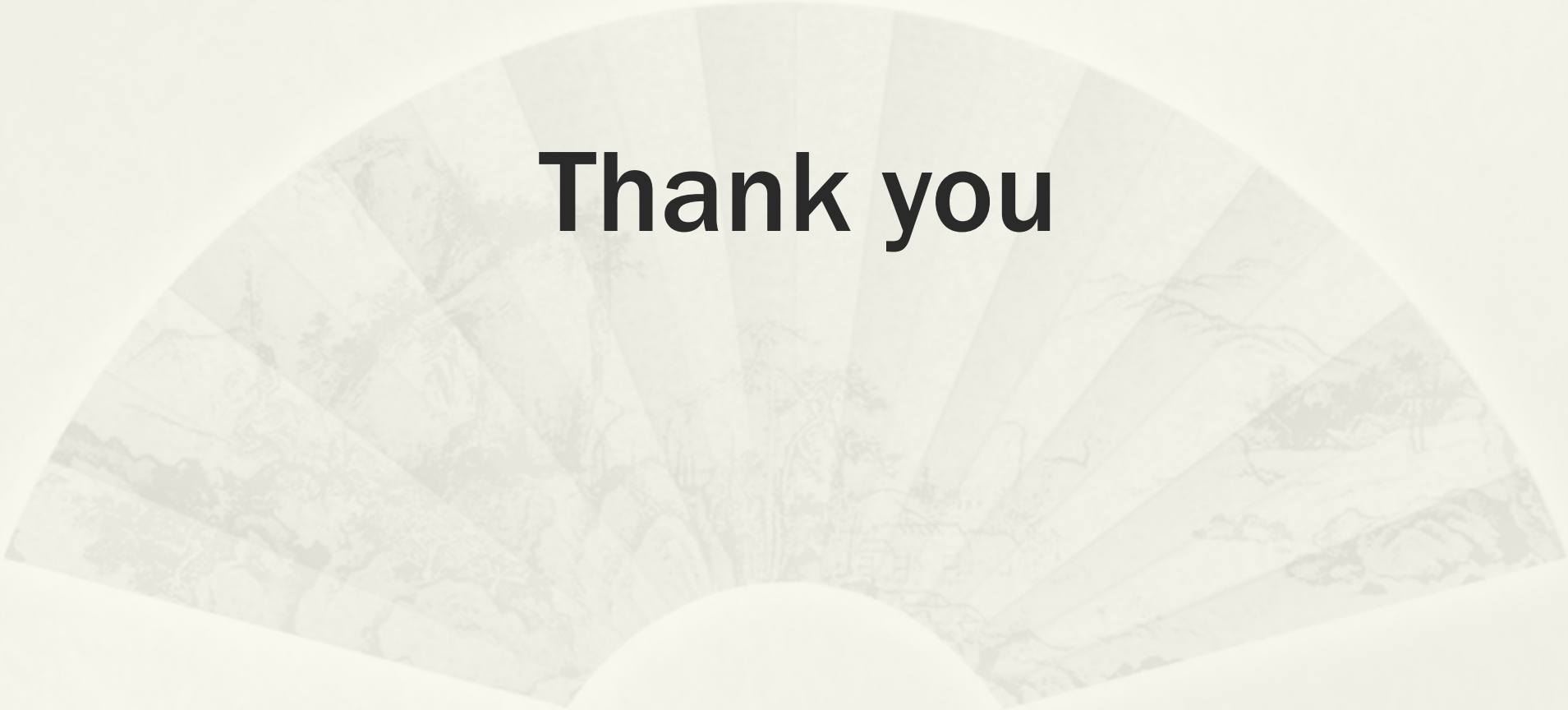
Flow rate of inlet ("total"), top port ("up") and bottom port ("down").

Dispensing alternate mode

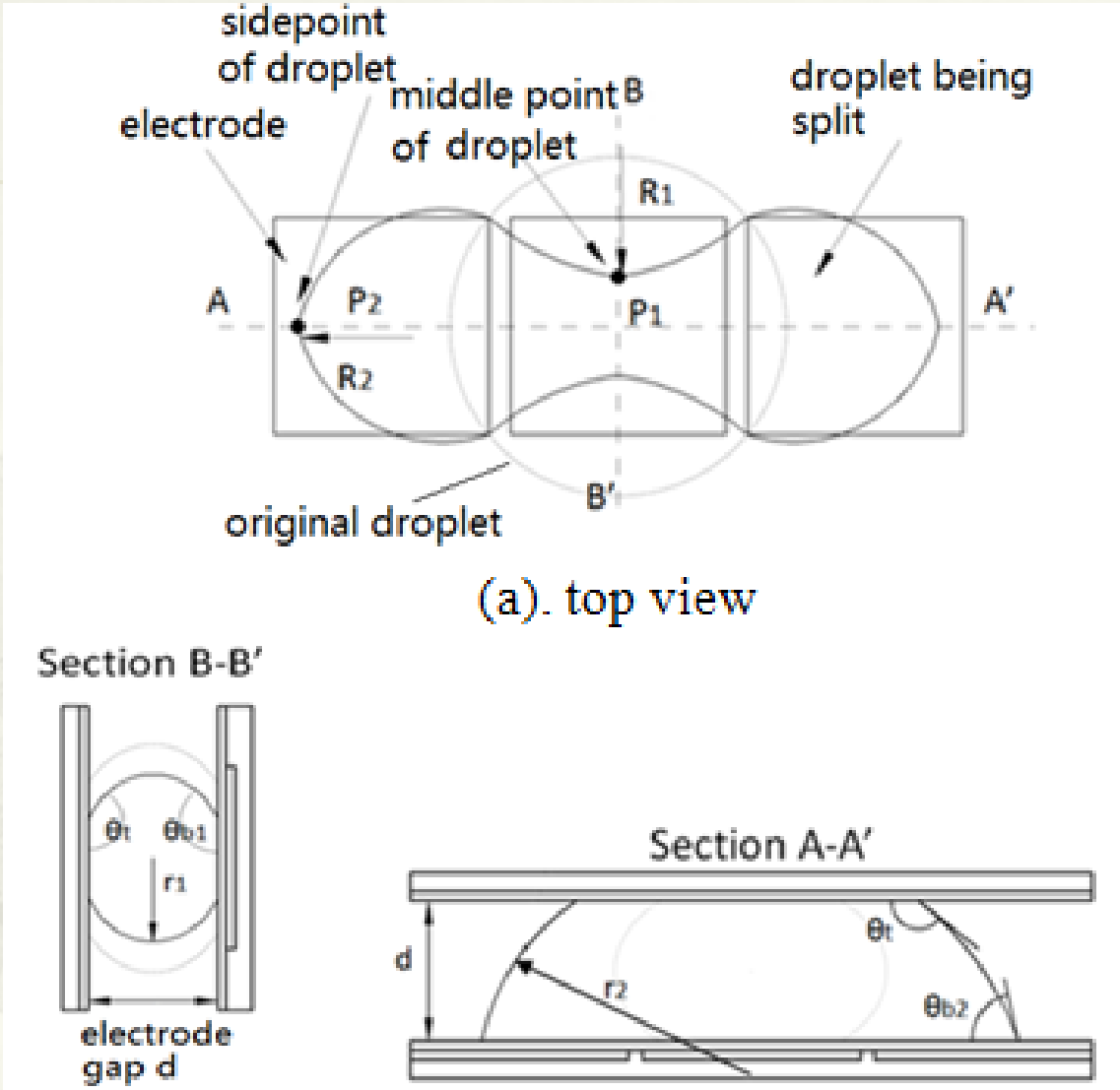


Conclusion

- The design and simulation of a microfluidic analog-to-digital droplet dispenser for Lab-on-a-Chip application is proposed.
- The proposed droplet dispenser has multiple digital output ports. This allows multiple droplets to be dispensed at the same time.
- COMSOL simulation is used to understand the mechanism of dispensing and verify the function of the device.



Thank you



(b). (B-B') section view (c). (A-A') cross-setion view

Figure 4. Mechanism of droplet splitting [10]