Analog to Digital Microfluidic Converter

Renaud Dufour, Chang Wu, Farida Bendriaa, Vincent Thomy and Vincent Senez
BioMEMS Group, IEMN (UMR 8520 – University of Lille Nord de France)

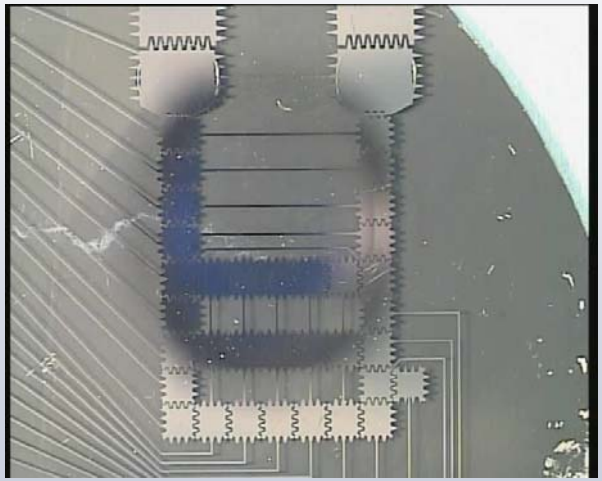
Introduction

Nowadays, 2 kinds of microfluidic technologies:

- Continuous/Analog systems (micro-channels).

- Digital systems(droplets displacement)

  → EWOD



Introduction

European Nanobe project :

- Objective: Real time control of bioprocesses.
- BioMEMS Group: Samples preparation-module using a Digital microfluidic technique.
- **Need to develop Analog ↔ Digital interfaces.**

Table of contents

Modeling and calibration

Dynamic capillary filling using two-phase flow, phase field method

Theoretical models

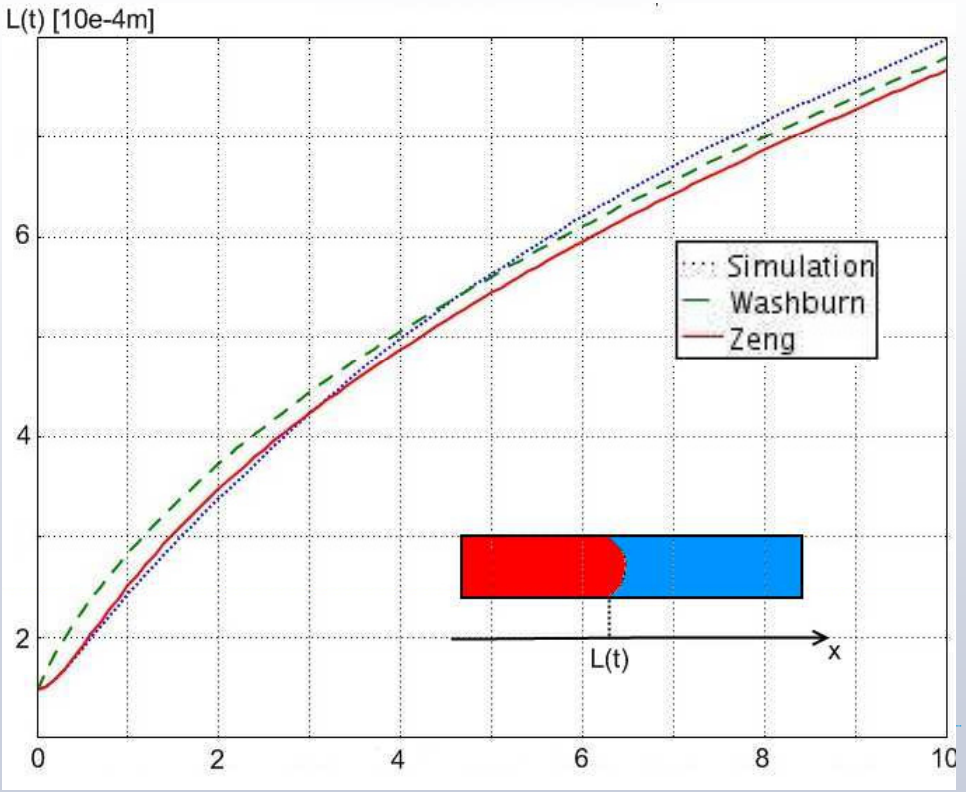
Washburn

$$L^2(t) = (A+B)t +$$

Zeng

$$L^2(t) = C(e^{-\alpha t} - 1) + (A+B)t + L_0^2$$

Results :



Modeling and calibration

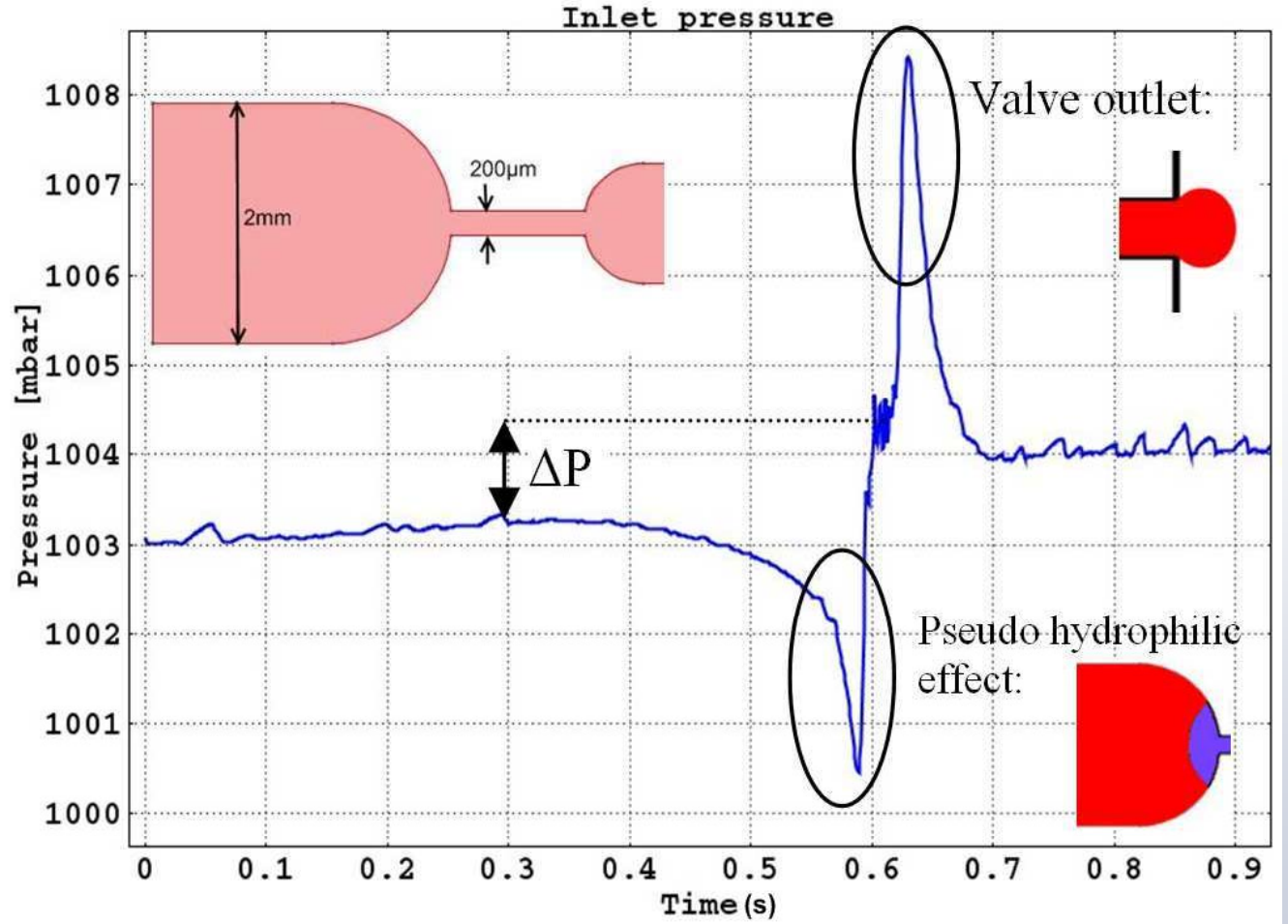
Passive valves

3D simulation with phase field method

Constant inlet flow rate (100µL/min)

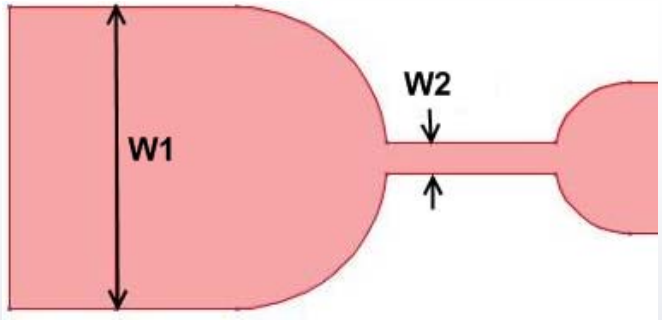
Hydrophobic channels (theta = 110°)

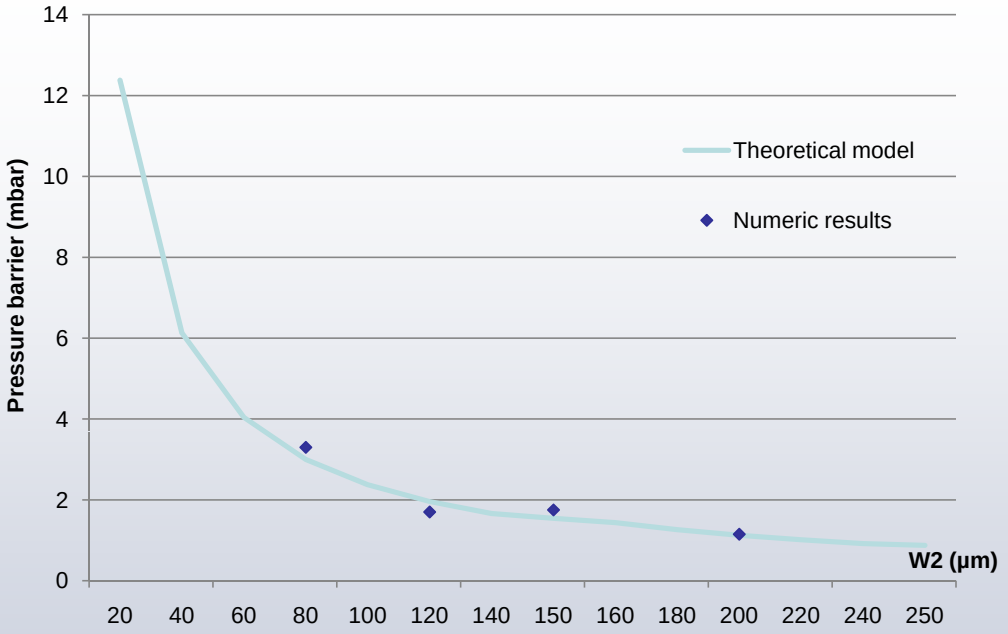
200µm thickness



Modeling and calibration

Pressure barrier according to valve width W2 (for constant channel width W1)

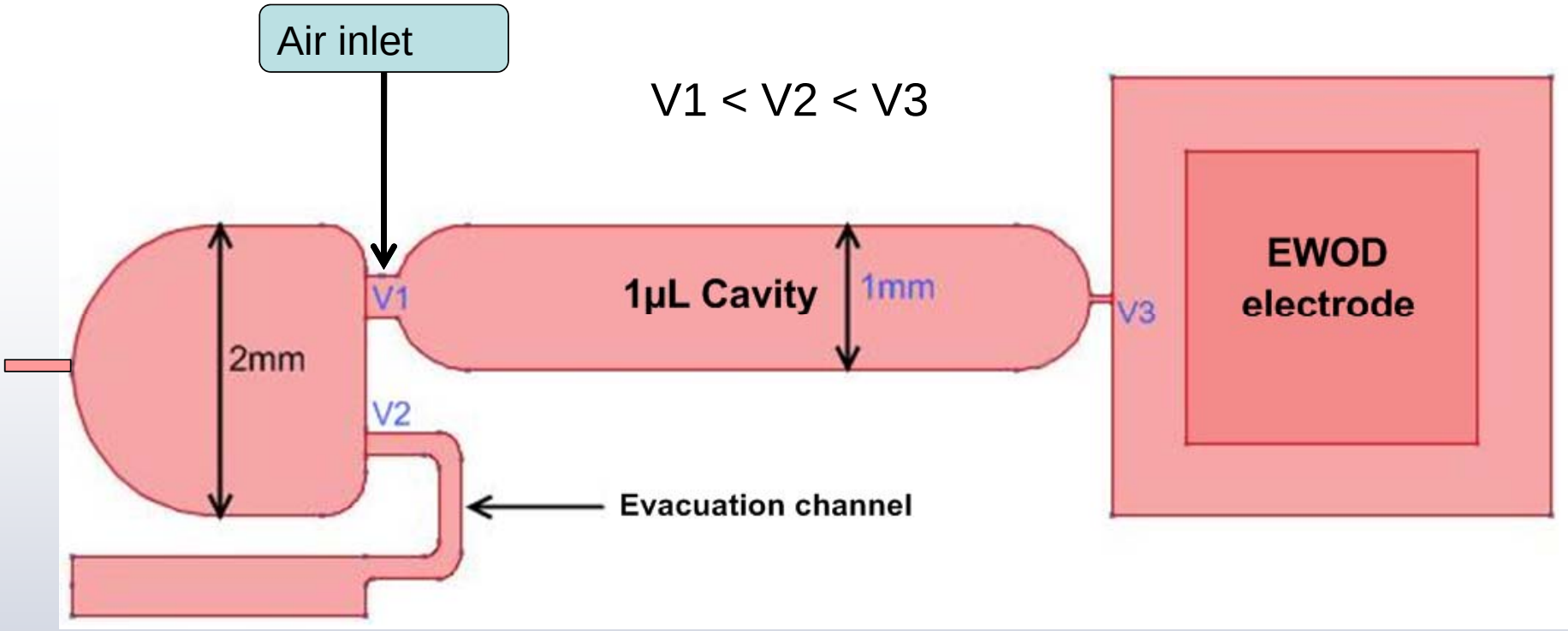




Analytical solution :

$$\Delta P = -2\sigma cos(\theta)\left(\frac{1}{W_2} - \frac{1}{W_1}\right)$$

ADMC : Design



Top view (Thickness = 200µm)

ADMC : modeling parameters

3D Model

Two phase flow, phase-field application mode

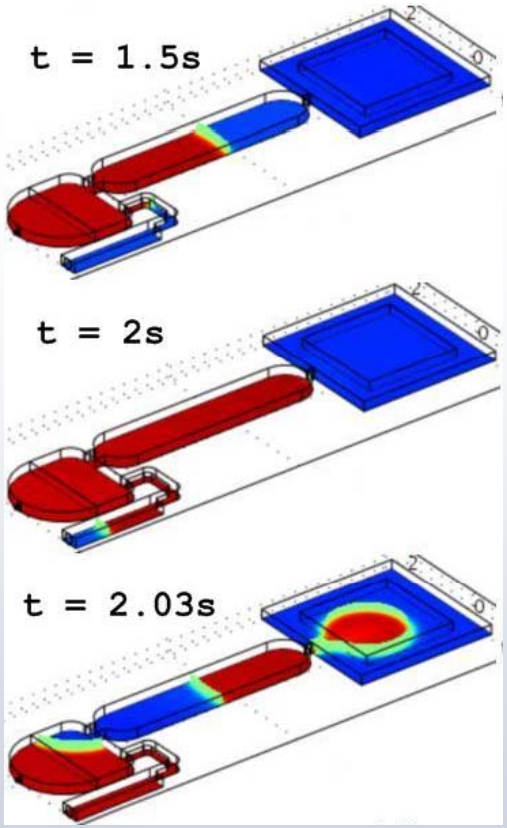
Boundaries

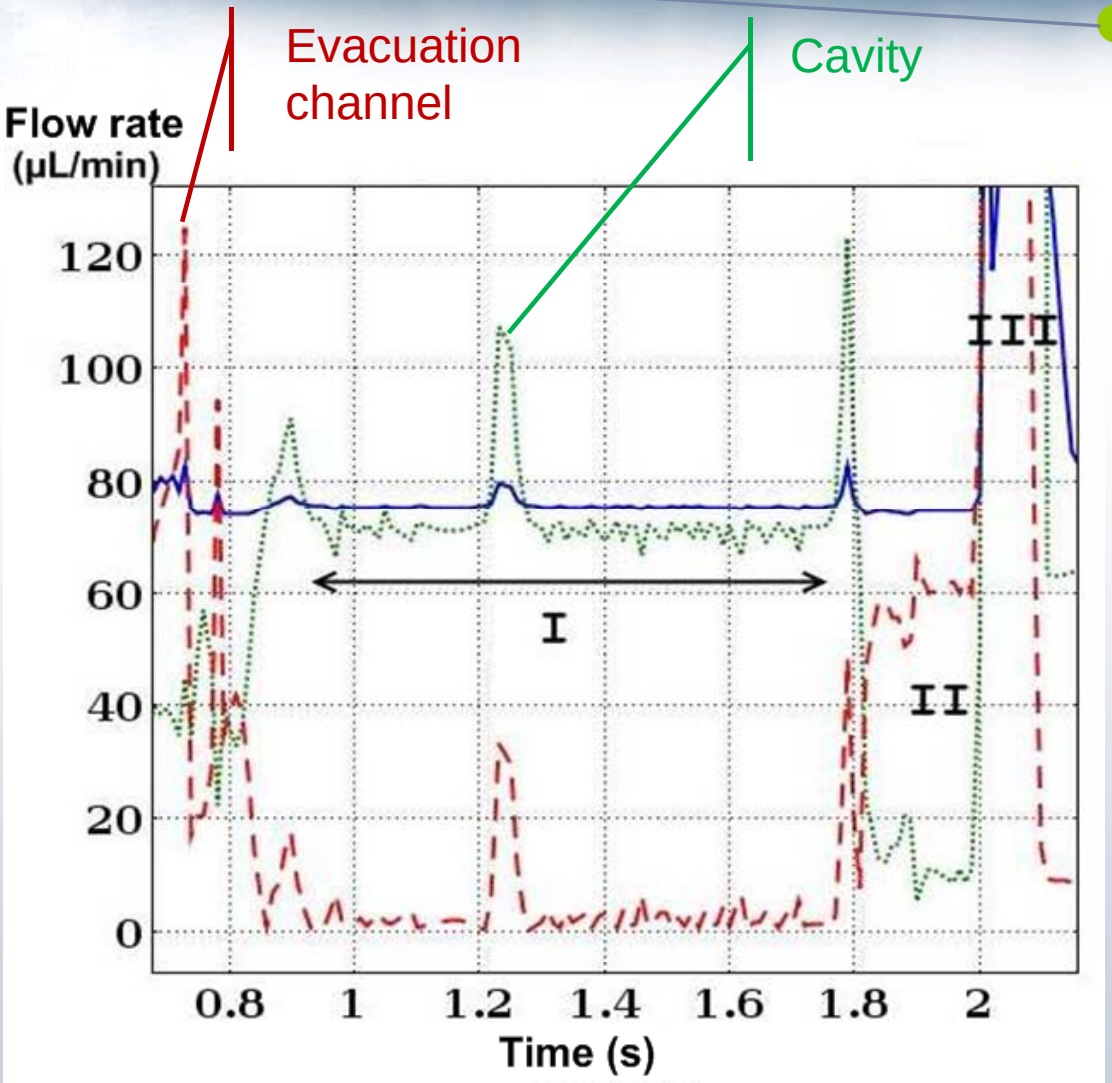
- Wetted walls
- **Inlet** : laminar inflow with constant pressure
  L_entr = 10cm
  P_entr = 1bar
- **Outlet**: atmospheric pressure

Computation

- 30.000 mesh elements
- 500.000 DOFs
- 100 hours computation time on a Sun workstation

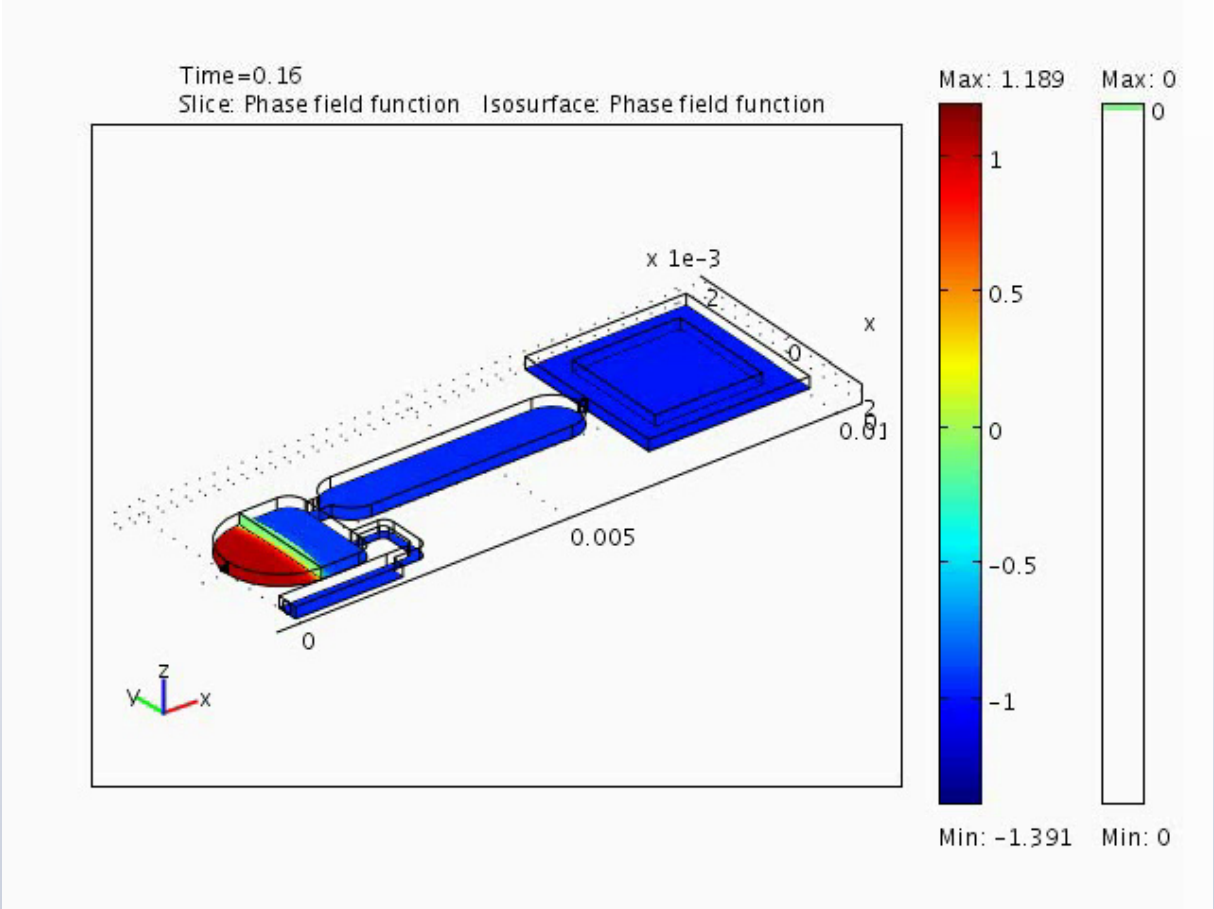
ADMC : results





ADMC : results

80% of the continuous flow converted into droplets



Conclusion

ADMC device advantages:

- ✓Allowing **integration of both Analog and Digital microfluidic** on the same chip
- ✓Delivering of **constant-volume** droplets
- ✓Resistance to pressure variation (evacuation of liquid excess)
- ✓Easy to integrate in an EWOD fabrication process

Further work:

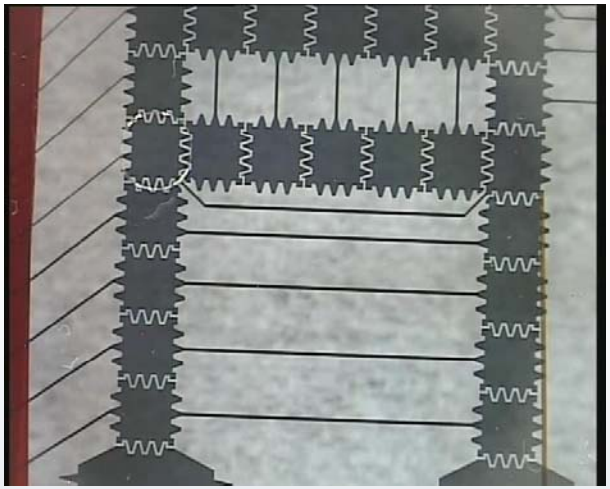
- ➢Geometry and network optimizations to reduce losses
- ➢Device manufacturing and testing

Thank you

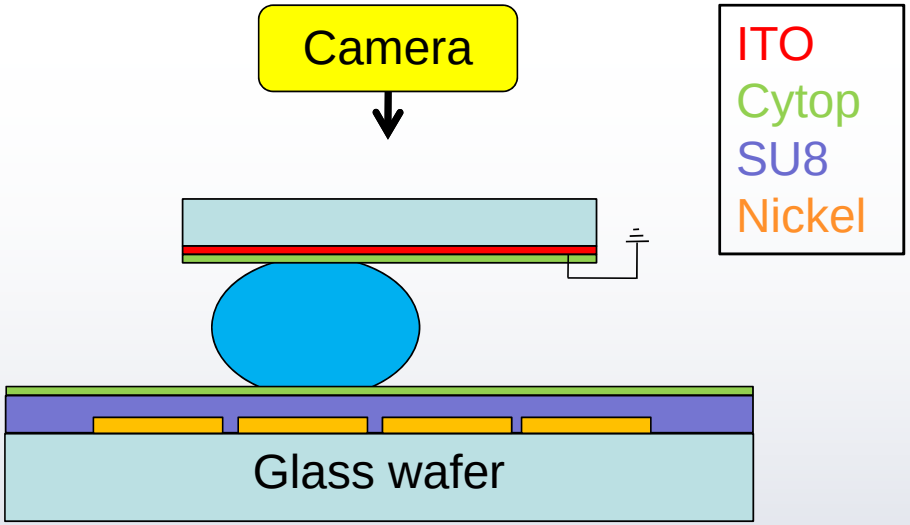
Questions & Answers

Electrowetting on dielectric

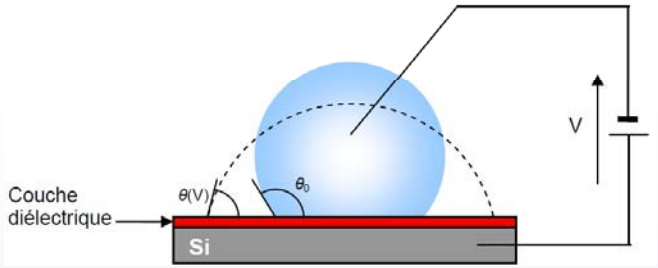
Top view



Lateral view

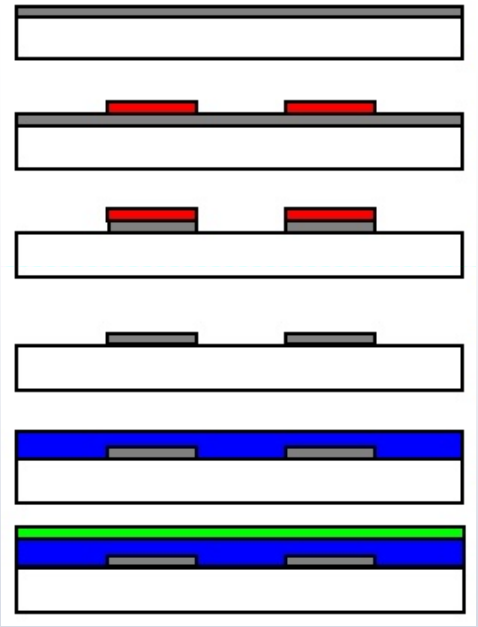


ANNEXE 2



$$\cos\theta(V) = \cos\theta_0 + \frac{\varepsilon_0.\varepsilon_r}{2.\gamma_{LG}.e} * V^2$$

EWOD – Fabrication process



ANNEXE 3: NANOBE

Nanobe Project