Wang Chu Chien-Wen Research Presentation

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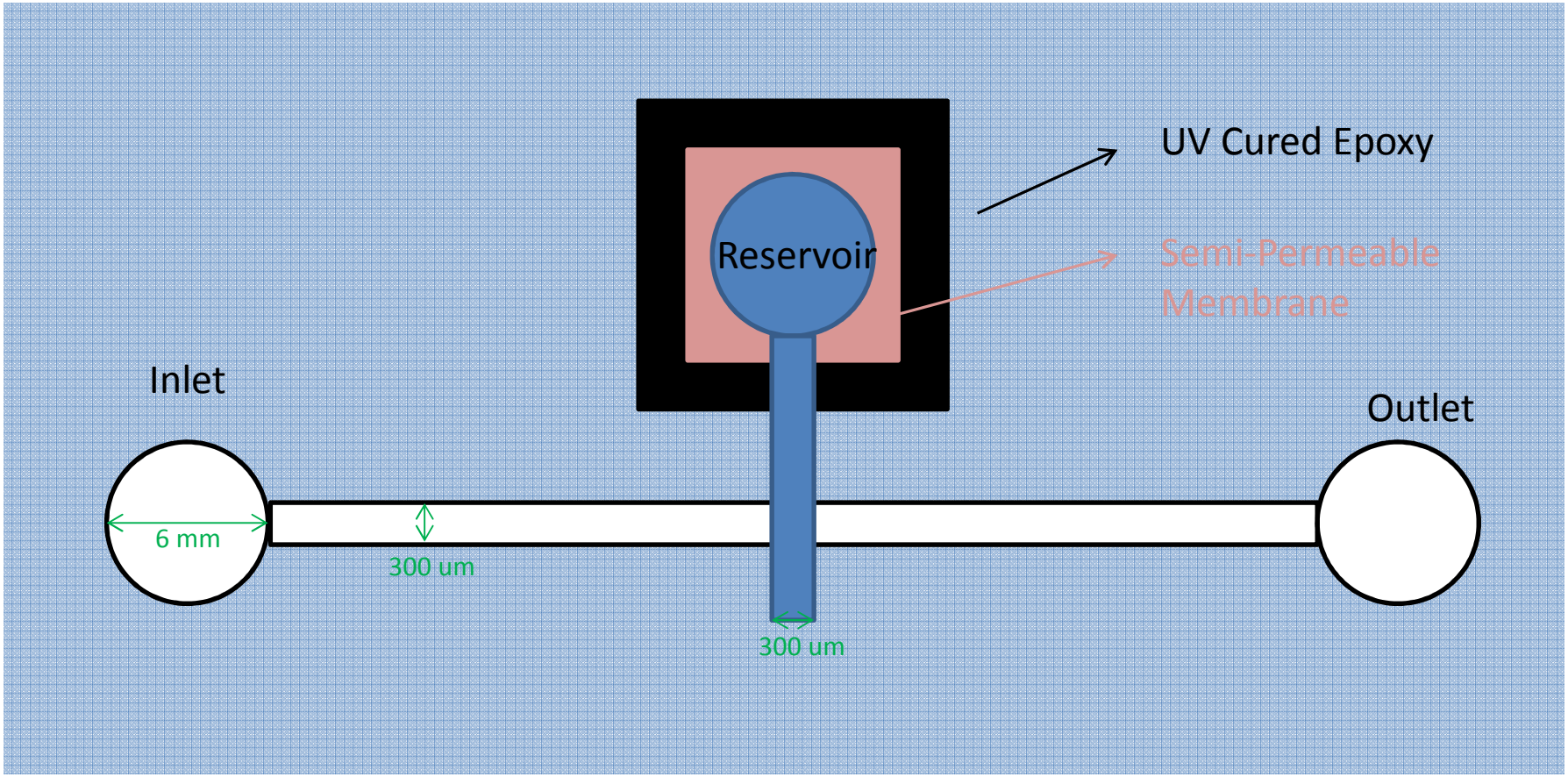
Outline

- Introduction/Goal
- Fabrication/Mechanism
- Proposed Ideas/Approach
- Results
- Future Works

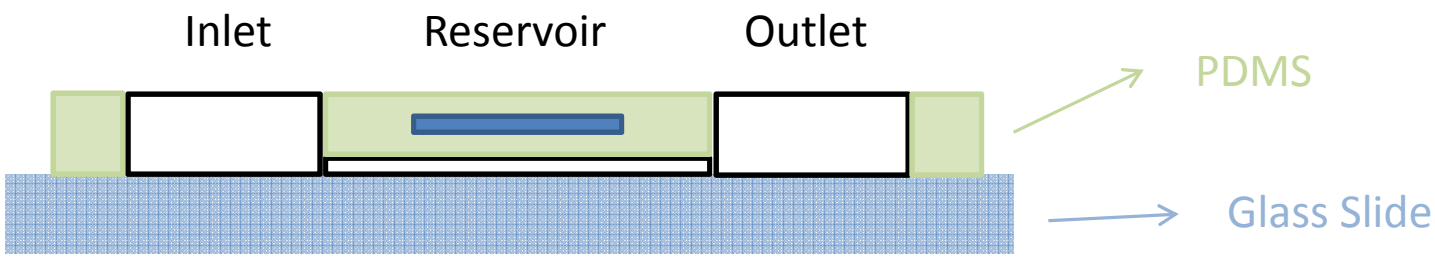
Introduction

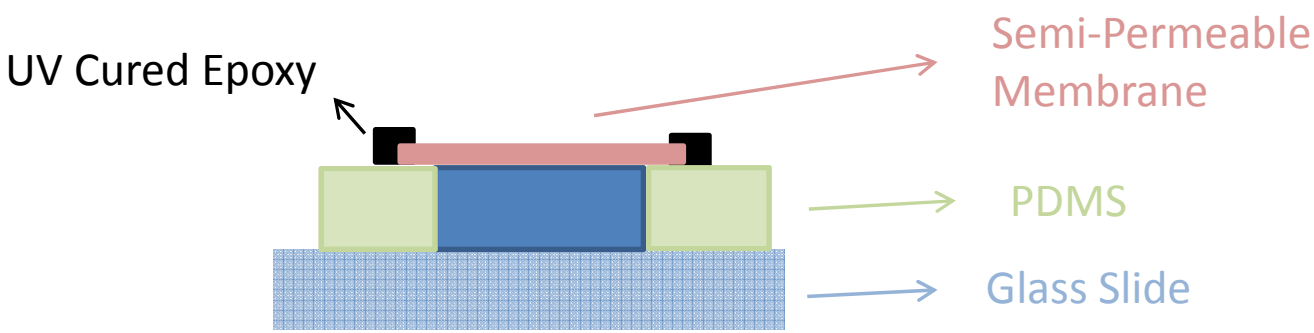
- Osmotic Valve:
  - Part of Osmotic Actuation Device
    - Fully Integrated Device
    - Utilizes Osmosis to Activate the devices
- Goal:
  - Achieve faster response time of the osmotic valve by having faster osmotic flow rate
  - Improve the reliability of the device fabrication

Osmotic Valve Top View



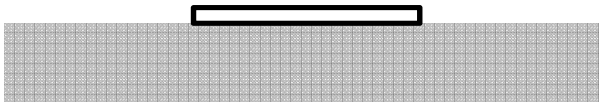
Osmotic Valve Side View



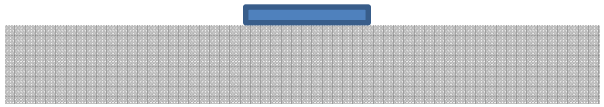


Fabrication

Membrane SU-8 Mold

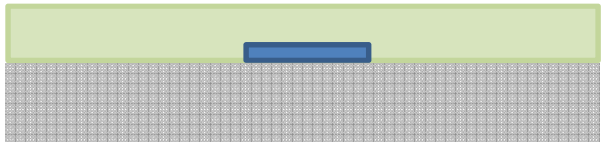


Reservoir SU-8 Mold



Spin Coat PDMS

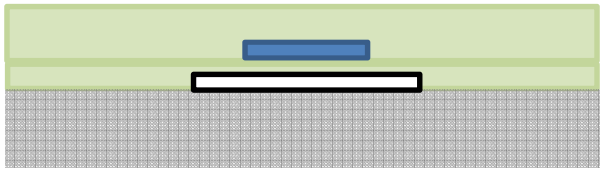
PDMS Mold



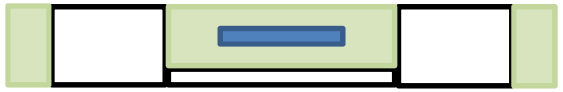
Remove PDMS Mold

Fabrication

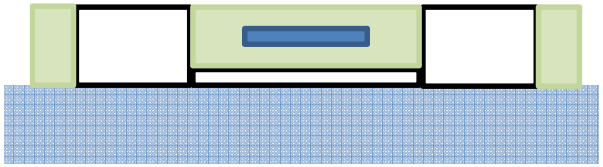
PDMS-PDMS Bonding



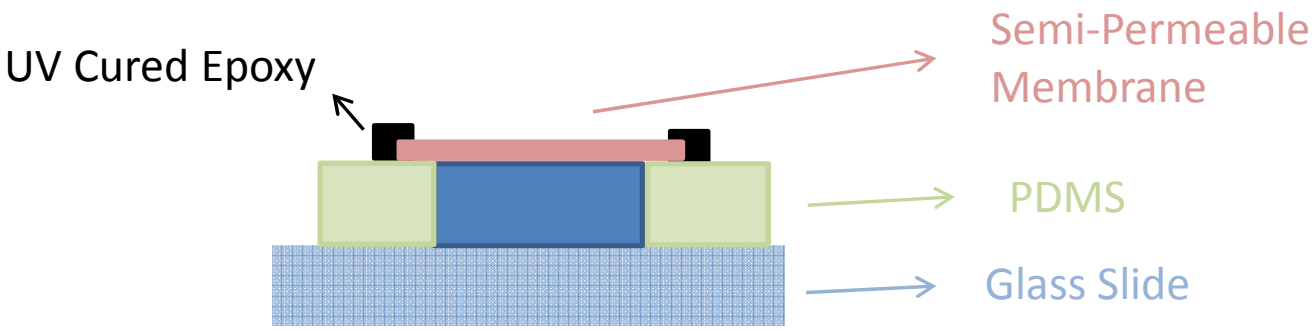
Release and punch openings

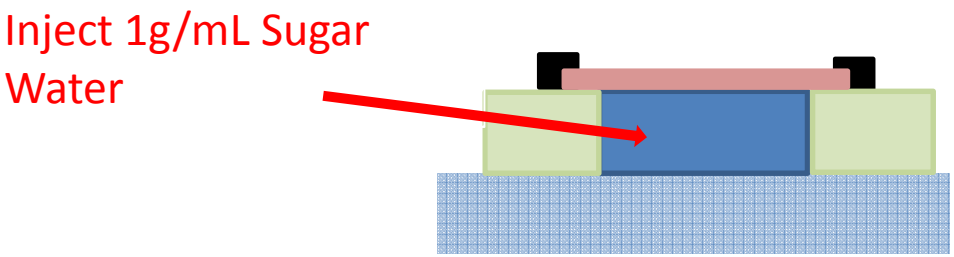


PDMS-Glass Bonding

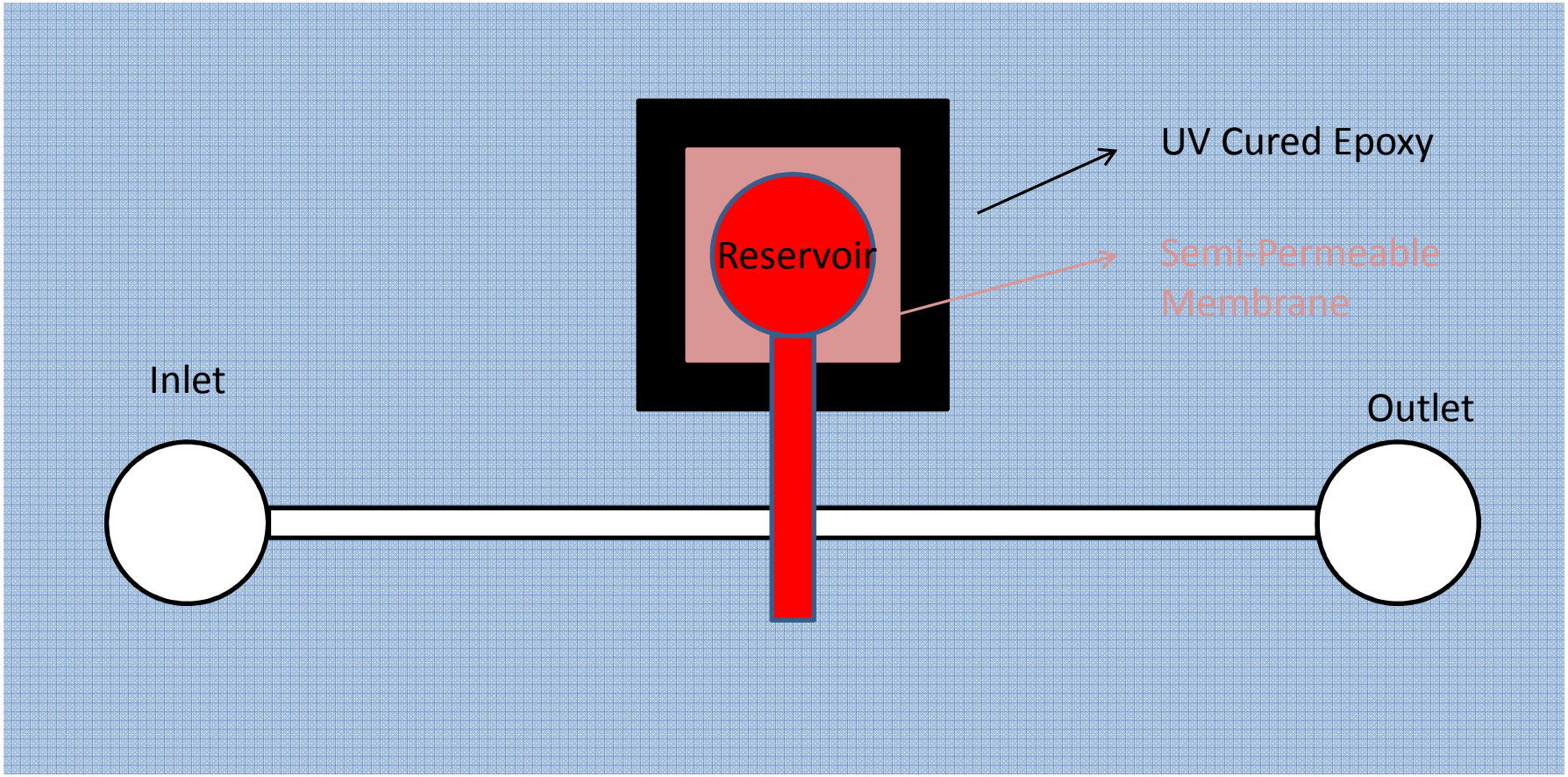


Mechanism

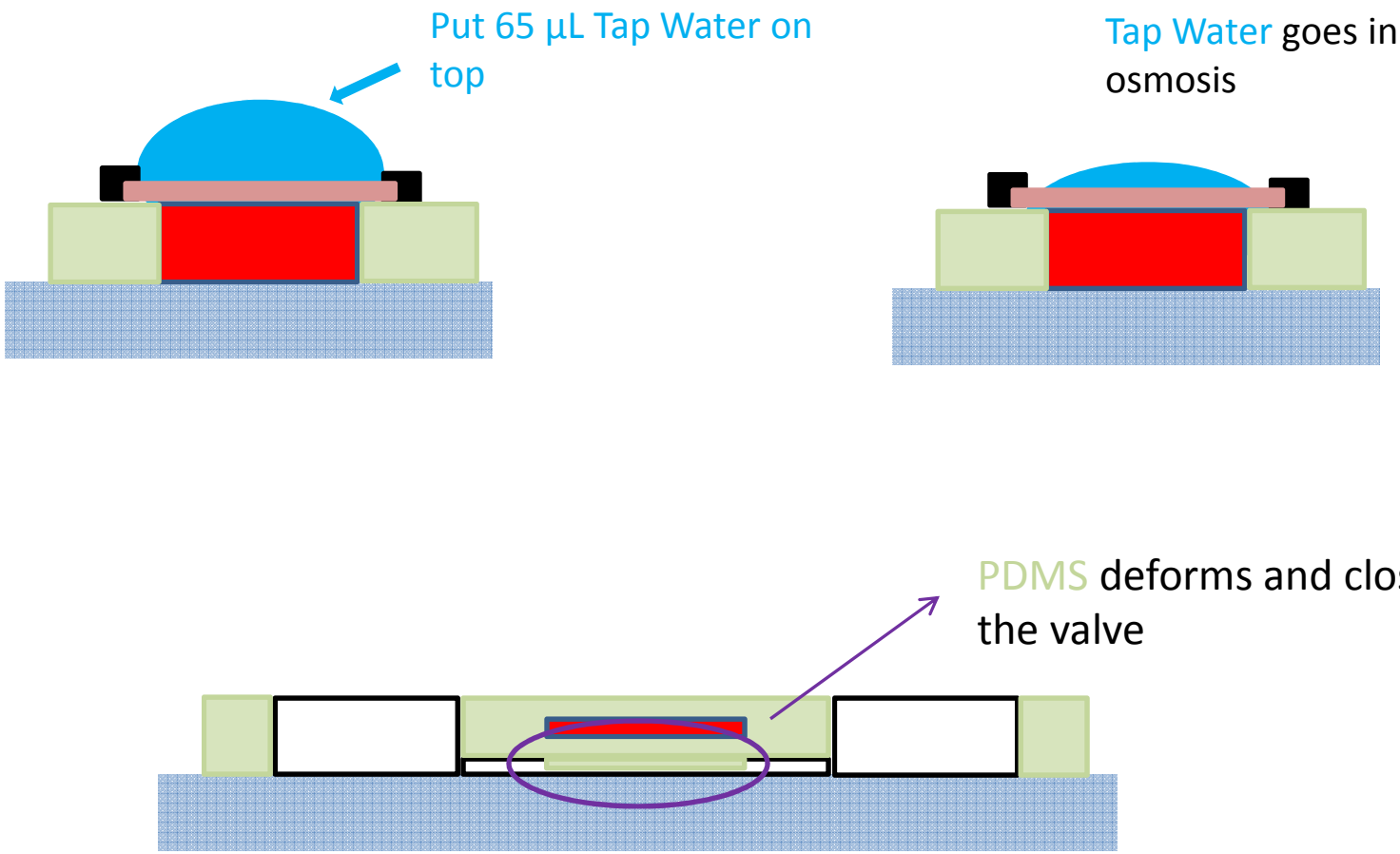

UV Cured Epoxy
Semi-Permeable Membrane
PDMS
Glass Slide


Inject 1g/mL Sugar Water

Mechanism


UV Cured Epoxy
Reservoir
Semi-Permeable Membrane
Inlet
Outlet

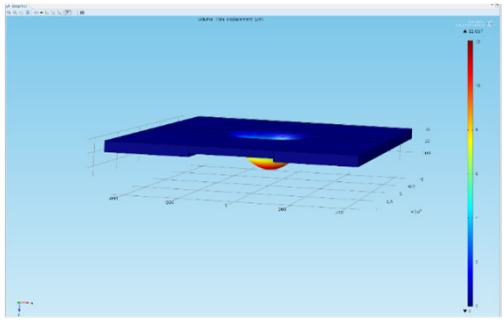
Mechanism


Put 65 µL Tap Water on top
Tap Water goes in due to osmosis
PDMS deforms and closes the valve

Proposed Idea

- Since Osmotic Flow Rate is proportional to the surface area, change the opening of the valve
  - Faster Osmotic Flow Rate
  - Faster Pressure increase in reservoir channel
  - Faster Response Time

Valve Closing Pressure

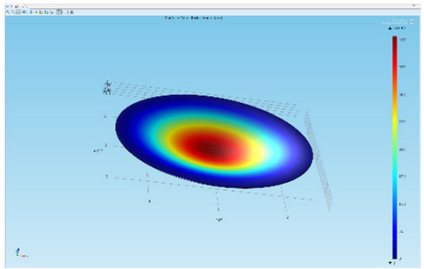


- Pressure: 500 Pa

Opening Simulations

Circle

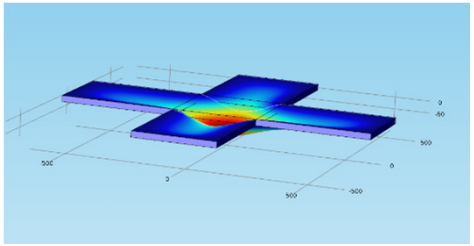
- Diameter: 6 mm



- Response Time: 2.7 min

Cross

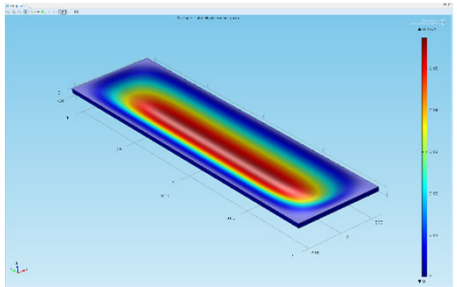
- 1500 um x 6000 um per rectangle



- Response Time: 3.2 sec

Small Rectangle x 10

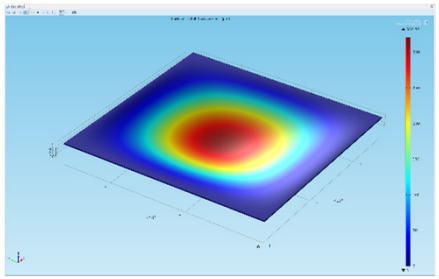
- 2000 um x 500 um



- Response Time: 0.03 sec

Square

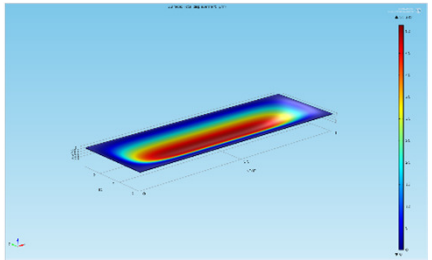
- Side Length: 5.3 mm



- Response Time: 1.97 min

Rectangle

- 1 cm x 2.8 mm

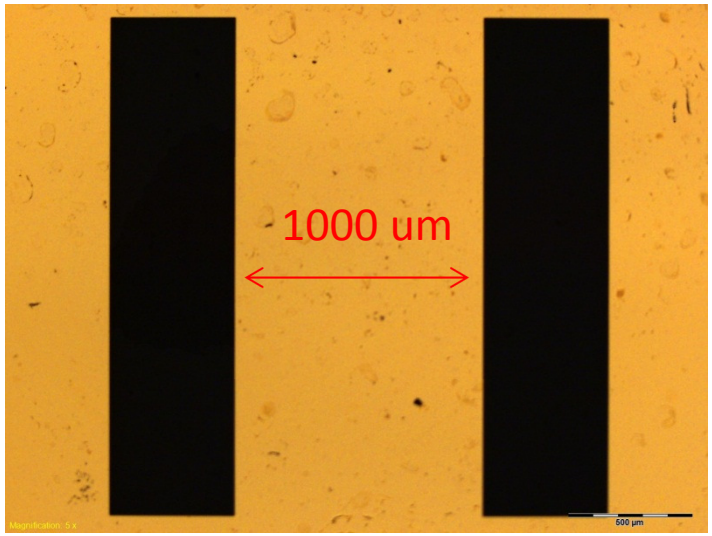
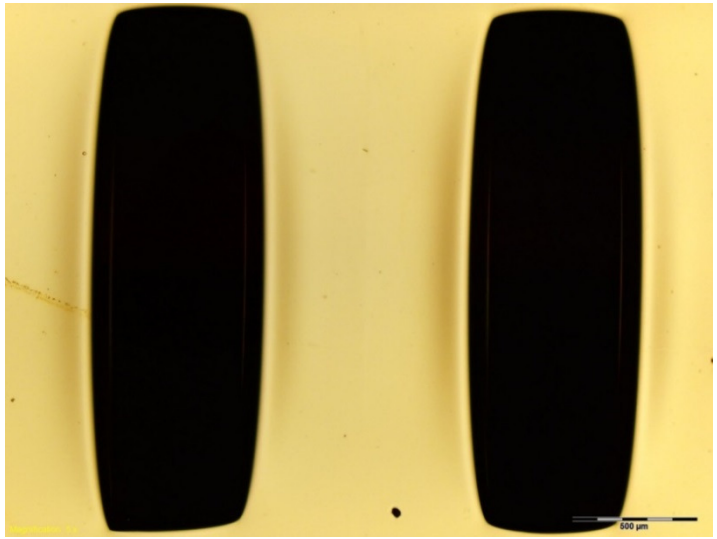


- Response Time: 26 sec

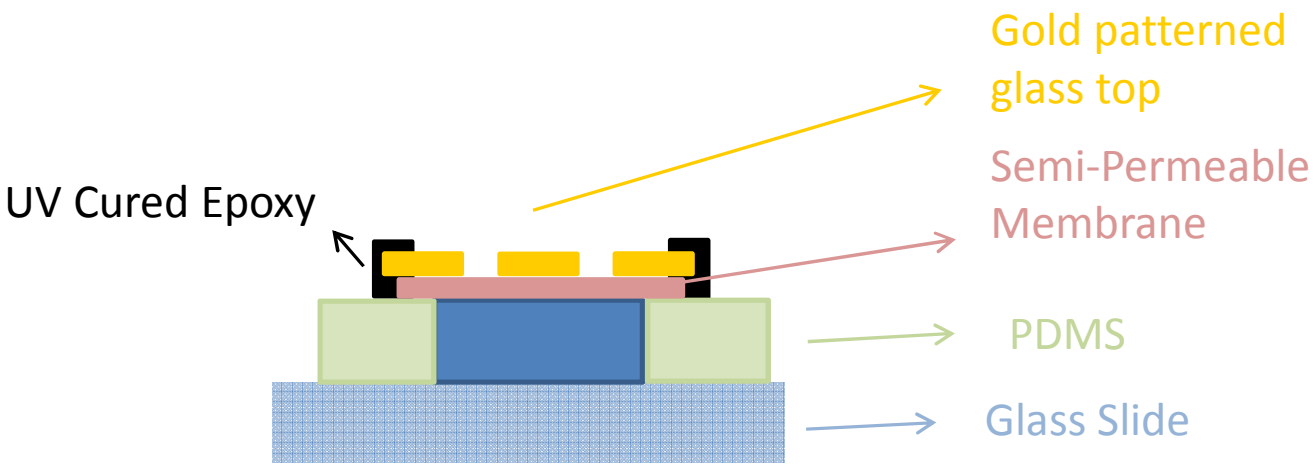
Approach

- At first, we tried to pattern it by manually drawing with the epoxy.
  - Inconsistent
  - Hard to control
  - Not Reliable
- To make it more reliable, we decided use etched gold patterned glass wafer as a top cap on the opening.

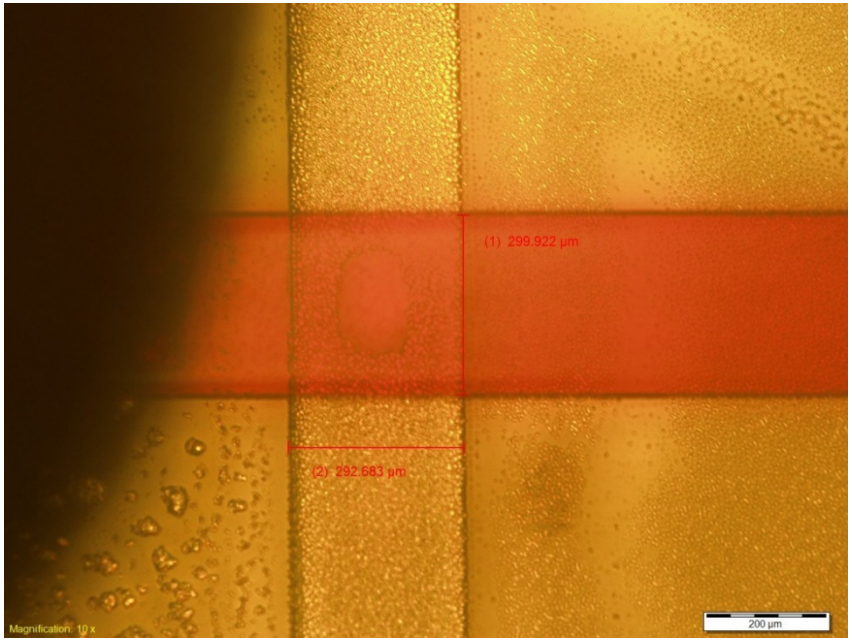
Gold Patterned Glass Wafer

Pattern	Etching
• 500 um X 2000 um rectangle on 1 cm x 1 cm square. • 1000 um spacing between each rectangle  	• Etchant: Hydrofluoric Acid • Etch Rate: 7 um/min per side • Etch Time: 40 min • Final Thickness: Avg. 233 um 

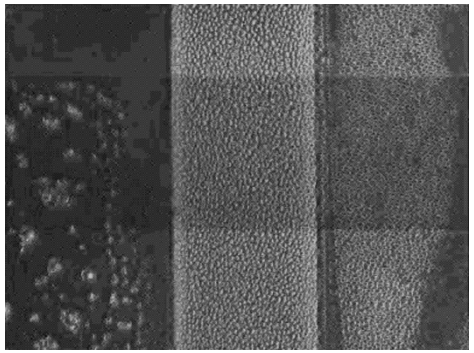
New Design


Gold patterned glass top
Semi-Permeable Membrane
UV Cured Epoxy
PDMS
Glass Slide

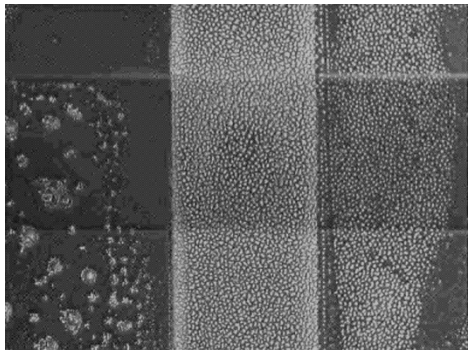
Result

Closing Channel	Dimensions
• Response Time: ~ 15 min.  	• Inlet SU-8: 12 um tall • Spin Coat: 40 um thick • Reservoir SU-8: 36 um tall • PDMS Mold: 5 mm thick • Cross Section: 300 um x 300 um

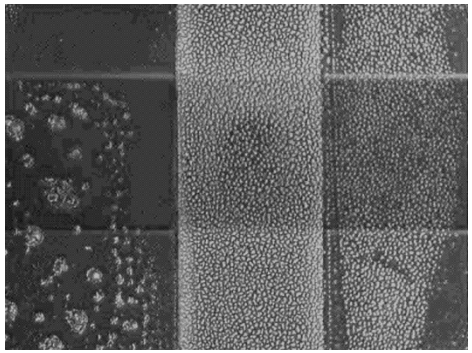
Result



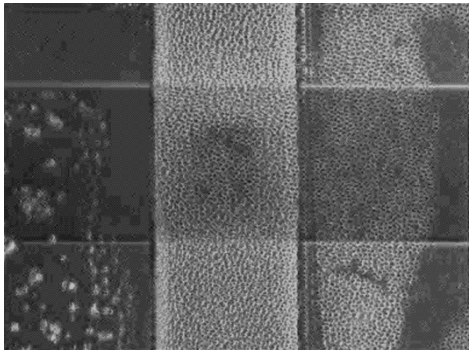
5 min after Injection



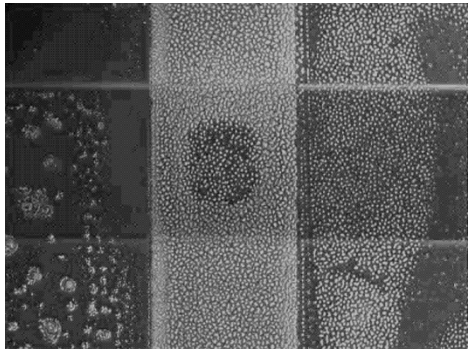
15 min after Injection



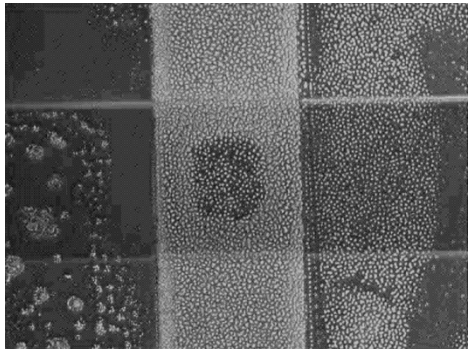
30 min after Injection



45 min after Injection



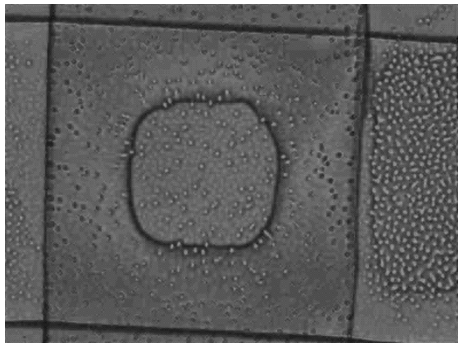
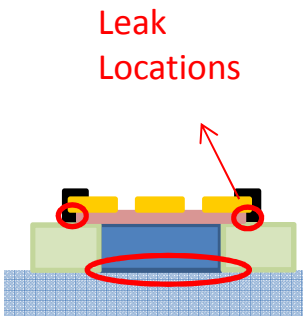
60 min after Injection



75 min after Injection

Problems

- The Response Time is not close to the simulation data.
  - Device fabrication is not reliable:

Sealed Channels	Leakage
• After PDMS-PDMS bonding, the cross-section is already sealed.  • Must be careful when bonding them together	• During the testing process, the devices are very leaky. 

Other Approaches and ideas

- Other Approaches and Ideas that I have tried and failed:
  - Bonding glass top to the valve opening
    - Not enough bonding area so does not work
  - PDMS top cover utilizing PDMS Etching
    - Etch rate is very slow: ~20 um/hr
    - Cannot get high thickness

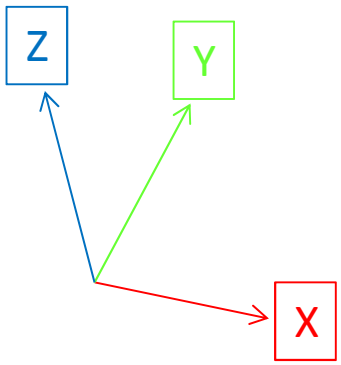
Future Works

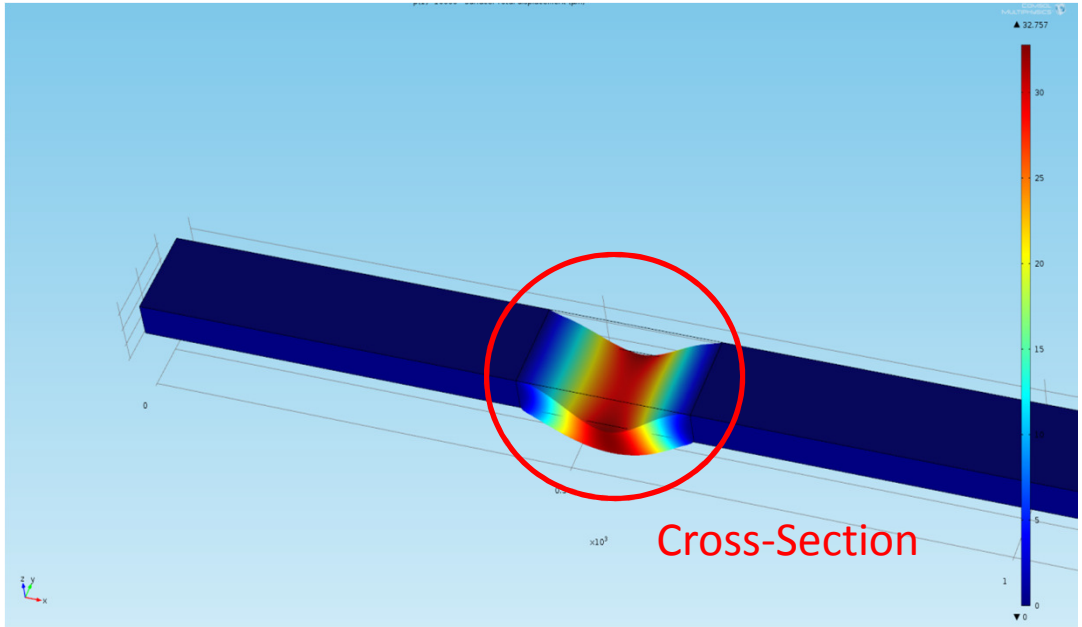
- Find a reliable way to seal the Sugar Water in the reservoir.

- Achieve faster Osmotic Flow Rate and then can optimize the design of the valve to close it faster.
  - Simulations to see at what pressure the channels would close in the cross section of the valve.

Valve Simulations

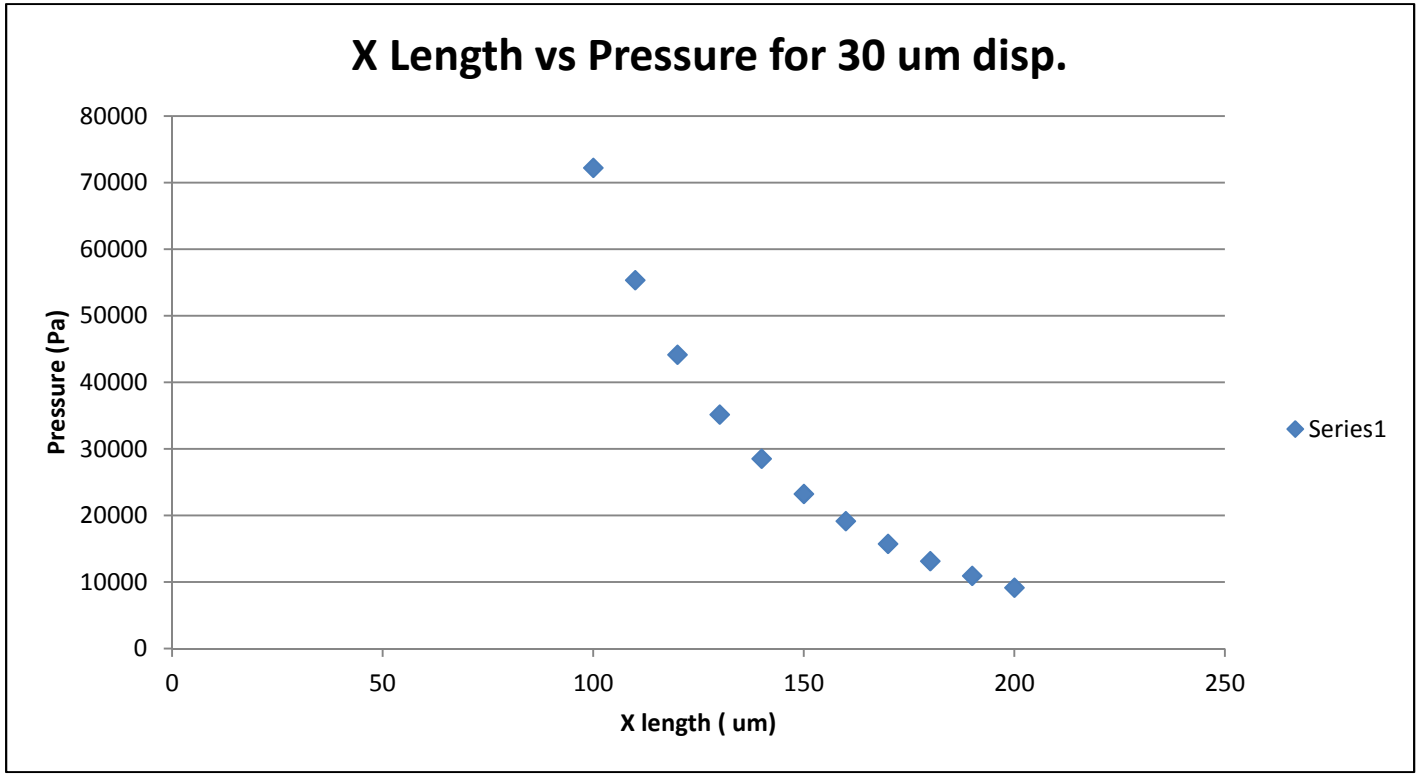
- To determine, I used 30 um displacement as a control value and changed the lengths (x, y) and thickness (z) of the cross sections.

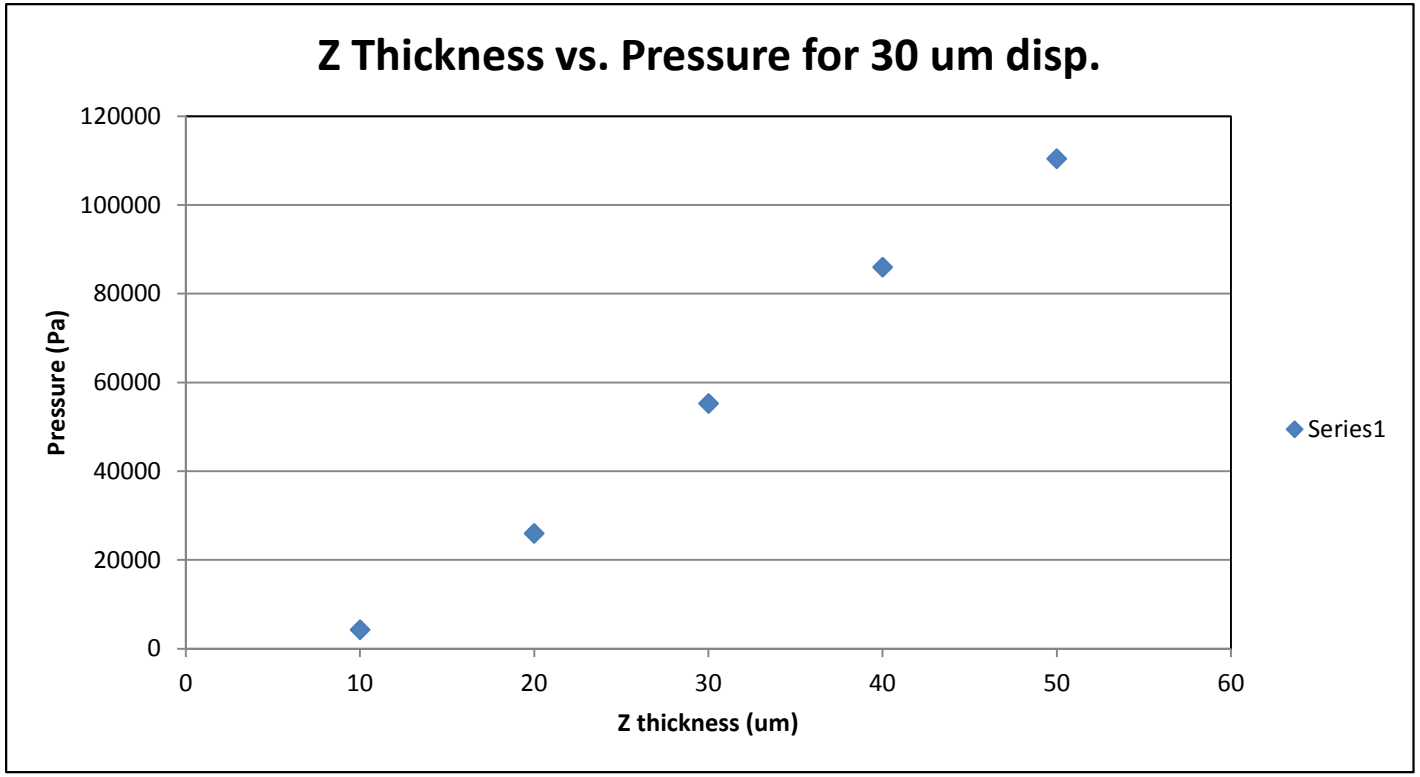




Variable x length

- Fixed y = 100 um and z = 35 um



Variable z thickness

- Fixed x = 100 um and y = 100 um