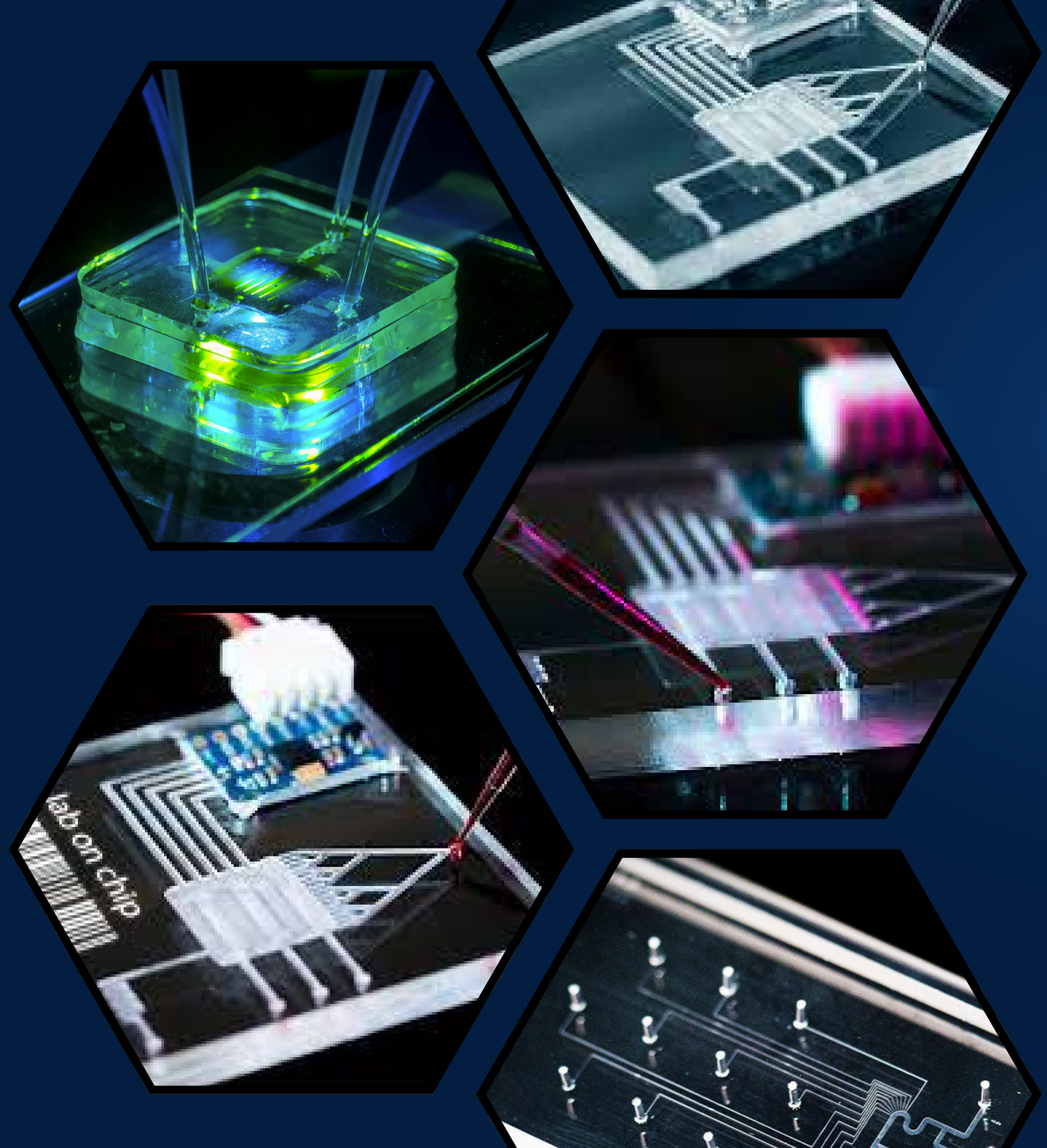
ME 224 -FUNDAMENTALS OF MICROSCALE FLOWS

PROJECT 8

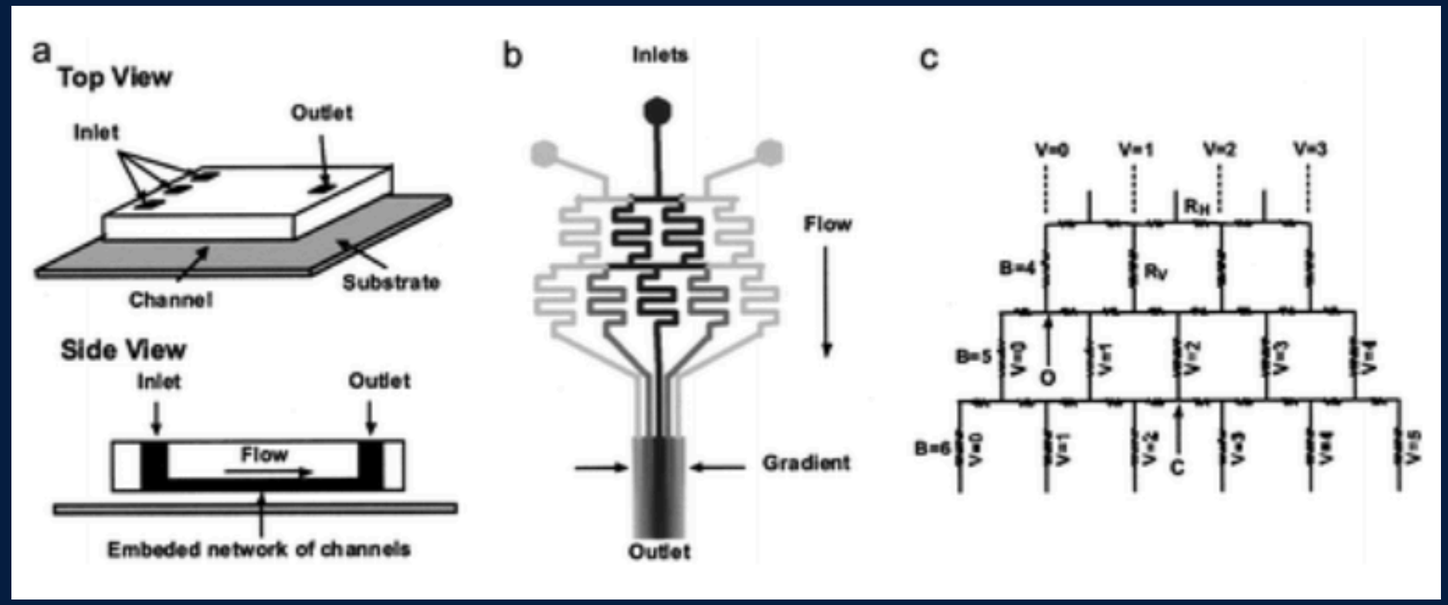
Studying Diffusion and Fluid Flow for Gradient Formation in Microfluidic Platforms



Literature Review

1 . Generation of Solution and Surface Gradients Using Microfluidic Systems
by Noo Li Jeon, Stephan K. W. Dertinger

Introduced a microfluidic system that generates precise gradients using controlled mixing of laminar flows in microchannels.
This system creates gradients by splitting, mixing, and recombining fluid streams. It can produce static gradients (fixed profiles) or dynamic gradients (adjustable profiles by changing flow rates).



Literature Review

LINK

2 . **Concentration gradient generation methods based on microfluidic systems**
by Xiang Wang , Zhaomiao Liu * and Yan Pang

Different type of Gradient generators in Microfluidics with there respective advantages and disadvantages
Namely-
Tree Shape Networks - Network involving branching and recombining streams to create gradient
Altered Tree Shape Network - Modified tree-shape networks aim to reduce limitations of traditional designs.
Y Shape Junctions - generates gradients through molecular diffusion between streams.
Membrane system - use porous materials to seperate flowing streams from the gradient chamber
Pressure Balance system - these systems balance inlet and outlet pressures to eliminate convection in gradient chamber

Literature Review

Tree-Shape Design along with Y-Shape Design

Advantages:

- High Gradient Resolution – Produces smooth and continuous gradients with fine concentration variations.
- Scalability
- Simple & Easy Fabrication
- Cost-Effective
- Suitable for Complex Gradient Profiles

Other Ways

Membrane-Based Gradient Generators

Disadvantages:

- Fabrication Complexity
- Slow Response Time

Pressure Balance Method

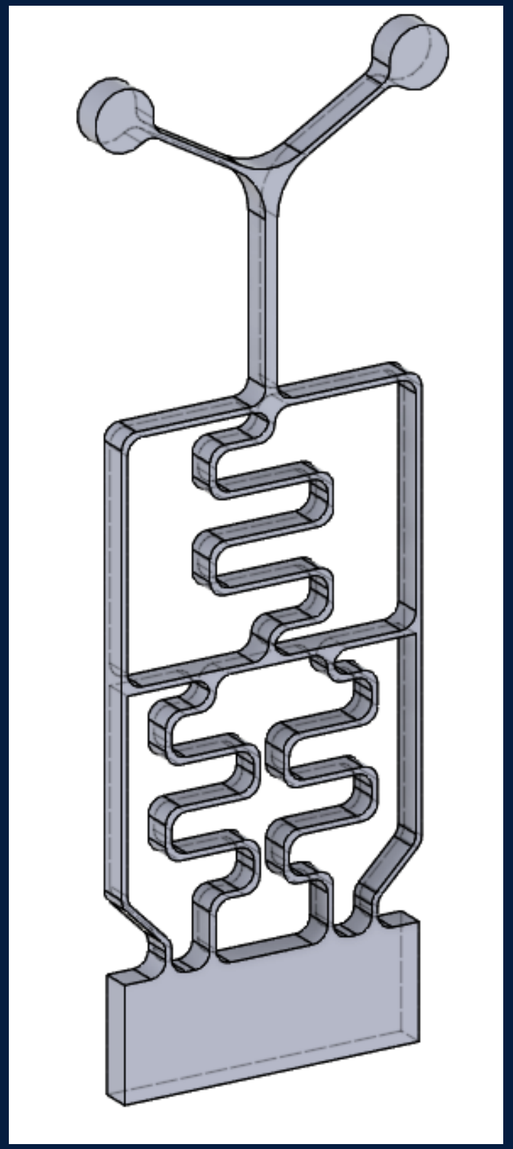
Disadvantages:

- Requires Precise Pressure Control
- Complex Experimental Setup
- High Cost

Design

Conjugate of Altertree tree and Y

- 1️⃣ Uniform Flow Distribution – Y-shape ensures balanced initial split, while Altertree refines it, preventing uneven flow.
- 2️⃣ Lower Pressure Drop – Y-branches reduce sudden pressure changes, and Altertree's gradual narrowing maintains smooth flow.
- 3️⃣ Better Mixing – Y-shape introduces controlled flow paths, and Altertree’s branching would help the mixing.



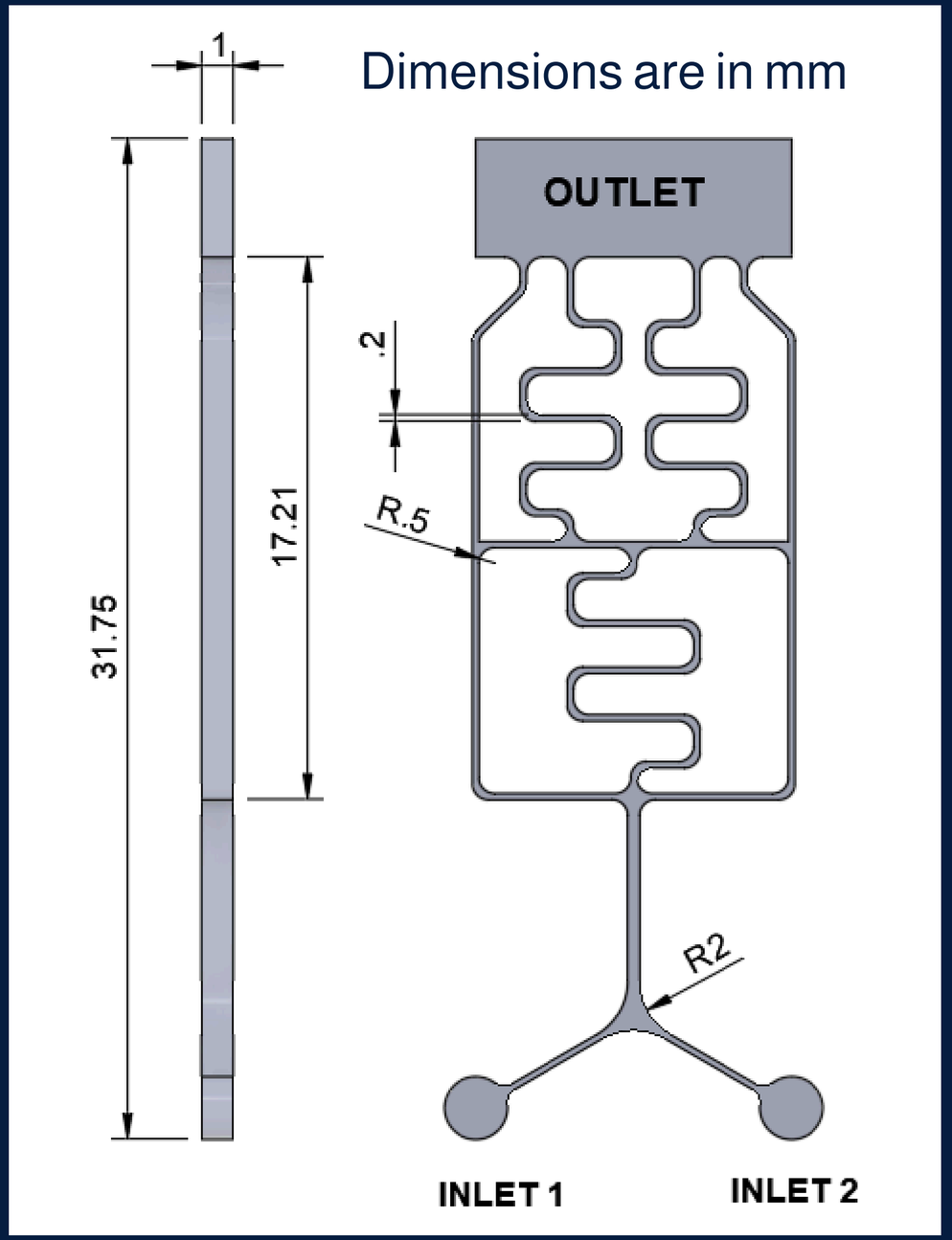
Design

Rounded Corners

- Prevents sharp transitions
- Reducing vortex formation
- Minimize entry turbulence
- Prevents dead zones

Serpentine Width

- Controlled microfluidic movement
- Laminar flow
- High Surface Area-to-Volume Ratio
- Low Pressure Drop



Methodology

Simulation

- We have used fluent(species transport,Euleiran model in multiphase).
- Eulerian-Eularian Laminar Model in COMSOL Multiphysics.
- Laminar model as reynold number will be less .
- Inlet velocity would be 10^-4 m/s,Slip at walls and guage pressure is set to 0.

Parameters on which variation will be checked

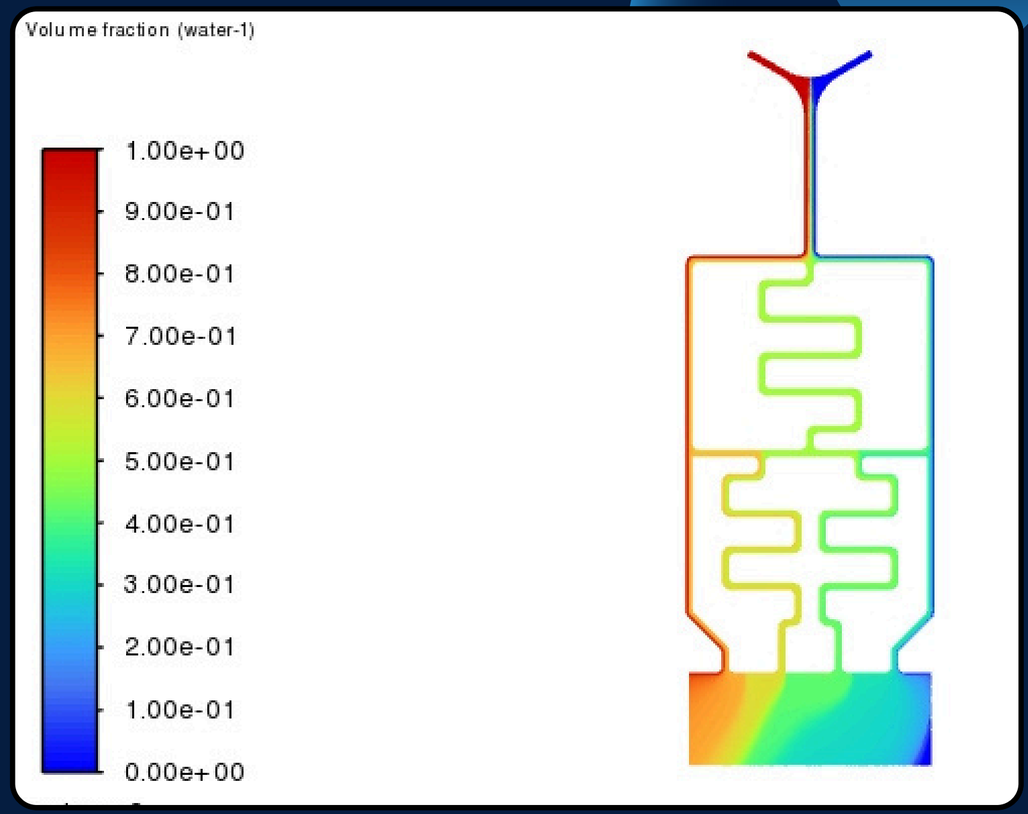
- Length of serpentine channel
- Width of channel
- Velocity Ratio
- Density Ratio
- Viscosity Ratio

From simulation we will be gathering information about how different parameters affect the gradient formation

Then final design modifications based on the output and finally will verify it by fabricating the microfluidic deivce using PDMS

Metrics

- Resolution of gradient
- Diffusion Length of Device
- complexity in design
- Material requirement for manufacturing(cost)



Tentatives

First week

Simulation will be completed

Second week

Fabrication of final design

Third week

Experimental Verification

THANK YOU

Shreeyut
Sri Varsha
Sumit Sarkar

Reference

https://pubs.rsc.org/en/content/articlehtml/2017/ra/c7ra04494a