Microfluidic Cell Counter

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Outline

- Microfluidics
- Physics of microfluidic flow
- Reynolds number
- Fabrication technique
- Paper based microchannel
- Cell counting principle
- Future plans
- References

Microfluidics

- Microfluidics deals with the behaviour, precise control and manipulation of fluids within sub-millimeter scale region.
- It involves **laminar flow** of liquid.
- Useful platform for fabricating low cost sensing and detecting device.

Why microfluidics?
(1) Cost efficient
(2) Faster diagnosis
(3) Low sample volume

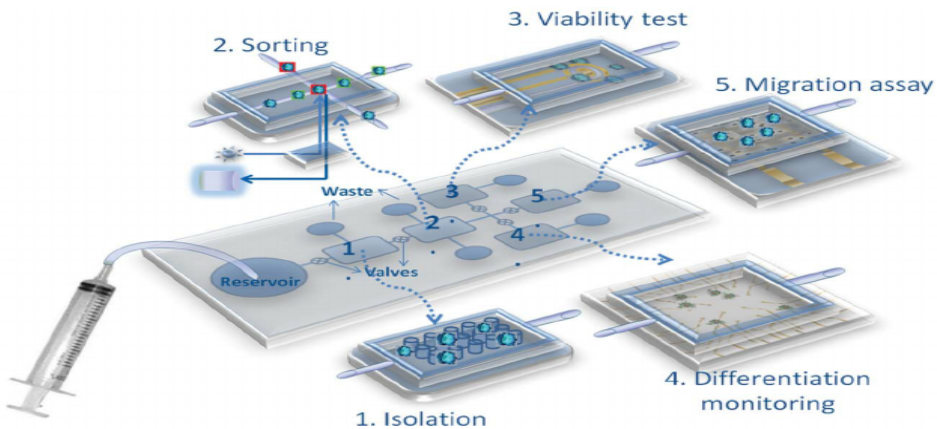


Figure 1: Lab on a Chip for stem cell studies
J. R. Soc. of Chem.,Lab on Chip,vol: 13,3789–3802(2013)

Physics of microfluidic flow

Navier-Stokes Equation

- Conservation of momentum or force equation

$$\frac{\partial v}{\partial t} + v.\nabla v = -\frac{1}{\rho}\nabla p + \frac{\mu}{\rho}(\nabla^2)v \tag{1}$$

- Non-linear PDE's, difficult to solve.
- Writing NS equation in terms of the dimensionless variables

$$t^* = ft, \vec{x^*} = \frac{\vec{x}}{L}, \vec{v^*} = \frac{\vec{v}}{v}, \vec{\nabla} = \frac{\nabla^*}{L} and, p^* = \frac{LP}{v\mu}$$

$$(\frac{fL}{v})\frac{\partial v^*}{\partial t^*} + \vec{v^*}(\vec{\nabla}^*.\vec{v^*}) = -(\frac{\mu}{\rho vL})\vec{\nabla}^* p^* + (\frac{\mu}{\rho vL})\nabla^{*2} v^* \tag{2}$$

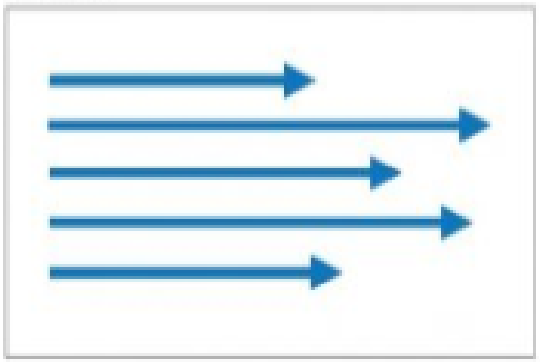
where $\frac{\mu}{\rho vL}$ $\rightarrow$Inverse of Reynolds number(Re)

Reynolds Number

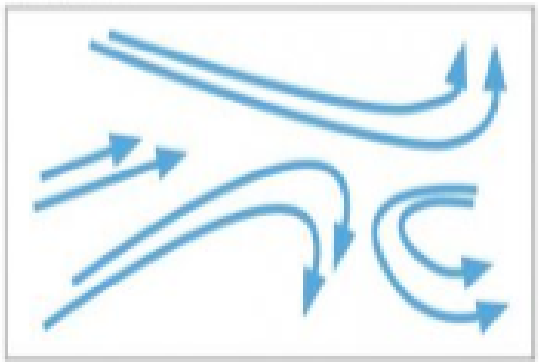
Ratio of inertial to viscous forces

- $$\boxed{Re = \frac{F_i}{F_v} = \frac{\rho v L}{\mu} = \frac{\text{v x L}}{\nu}}$$

  Where $\nu (= \frac{\mu}{\rho})$ is kinematic viscosity
- **Laminar flow**-dominated by viscous forces
- **Turbulant flow**-dominated by inertial forces



If Re is small, Laminar



If Re is large, Turbulent

Fabrication technique of microfluidic devices

Photolithography

- Process that transfers the shapes from template onto a surface using light.

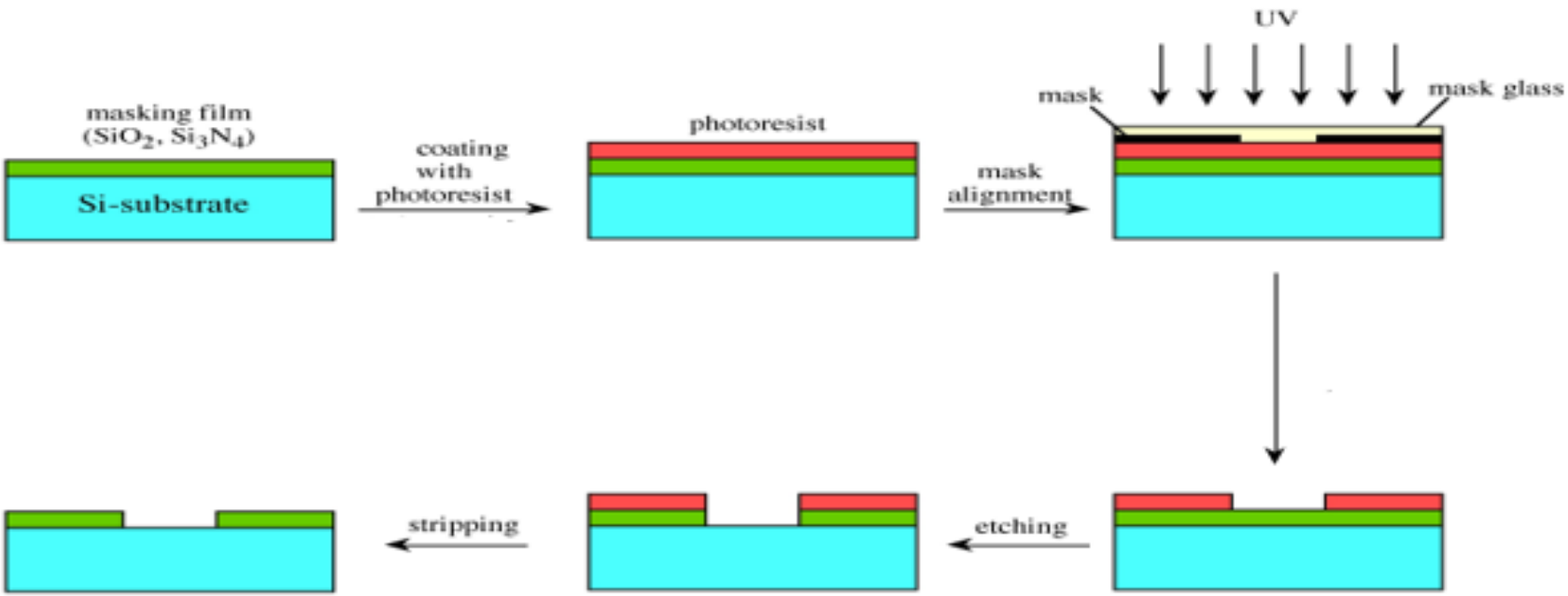


Figure 3, M. Born, E. Wolf, Principles of Optics 6th Edi. , New York(1980)

Paper based microfluidic devices

Advantages

- Easily available material
- Low cost and light weight
- Quicker fabrication

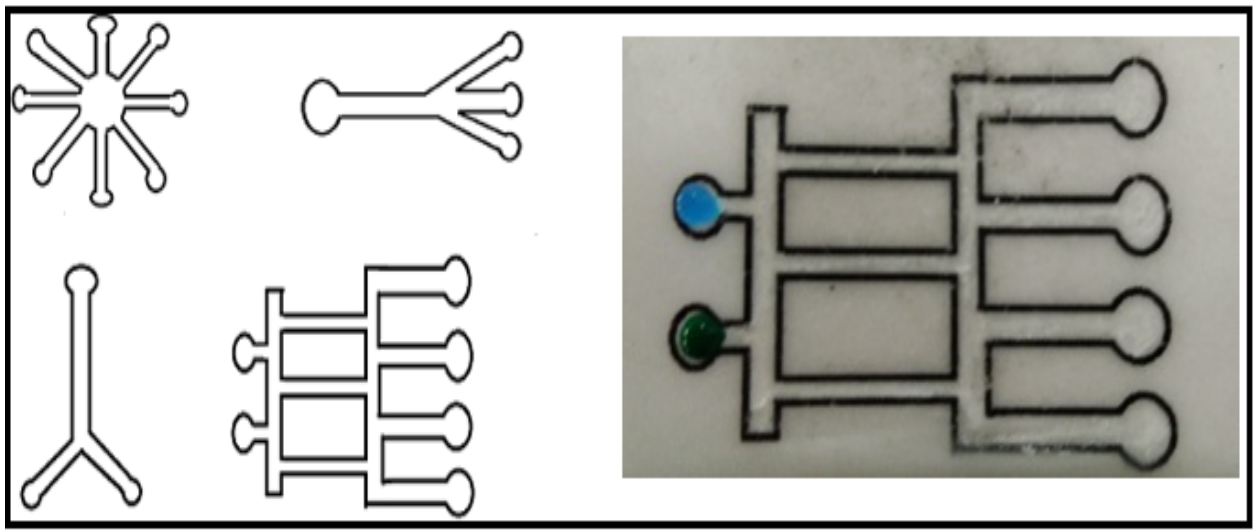
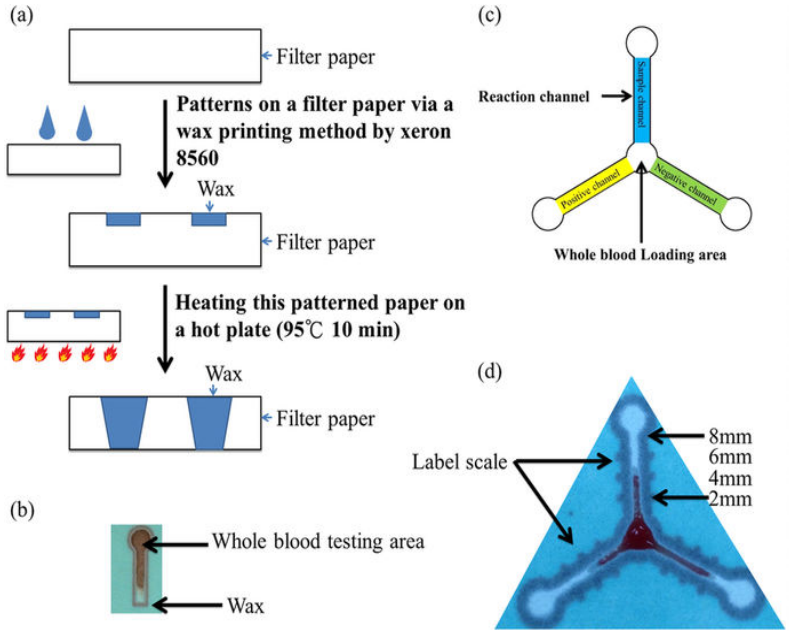


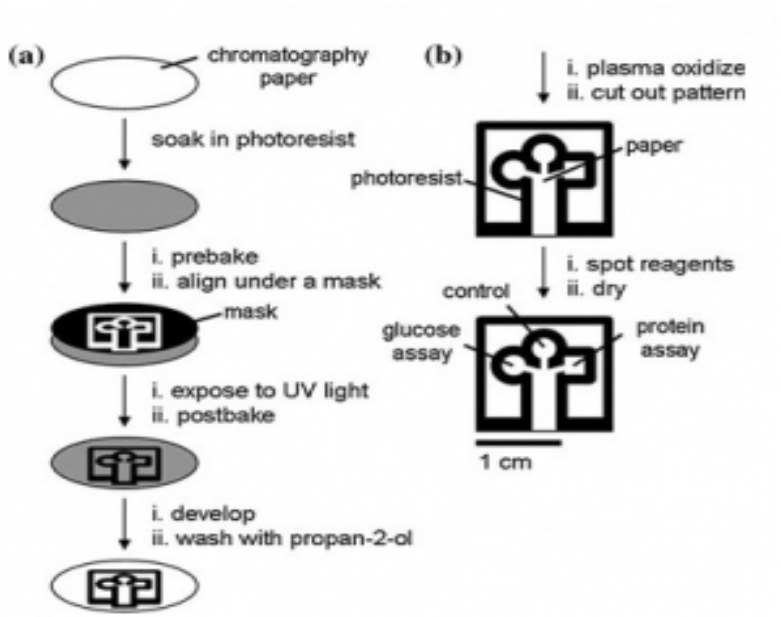
Figure 4, Microchannel designs and Laboratory prepared channel

Paper based fabrication techniques

Methods

- Wax Printing
- Photolithography





Cell Counting Principle

Measure cells size and transit time by coulter counter

- Cells are less conductive when passes through electrodes resistance increases.

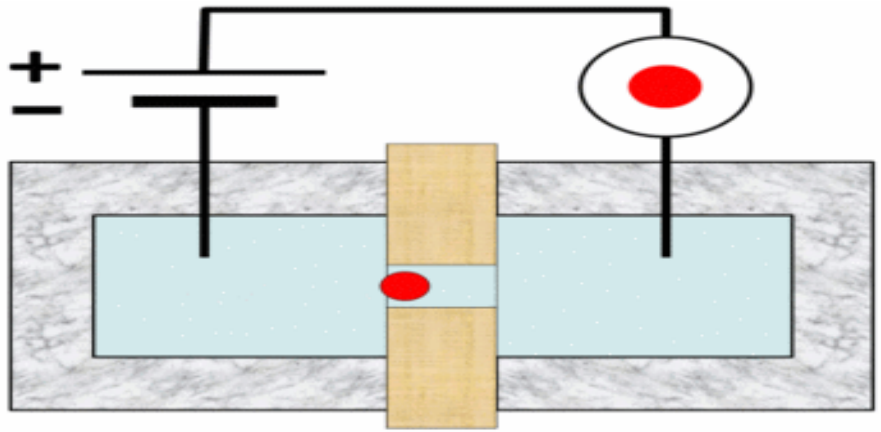


Figure 5, M. D. Graham, J. Labo. Auto.,8(6): 72–81(2003)

- Resistive pulses are generated for each cell.
- Each cell's size is measured as pulse amplitude.
- Transit time is measured as pulse width.

Fabrication of paper based microfluidic devices for accurate cell counting

PDMS based coulter counter

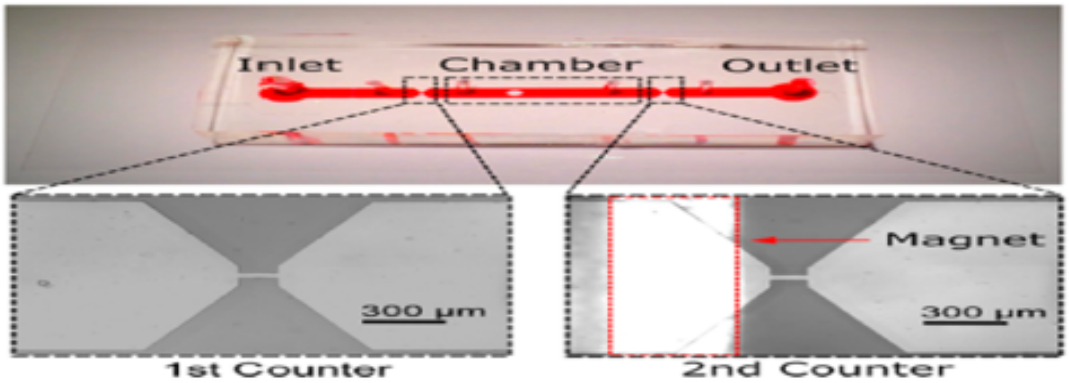


Figure 6, F. Liu, K.C. Pawan.et. al,J. Anal.Chem.,vol. 88 (1), 711−717, 2016

- Can we fabricate a paper based microfluidic cell counter?
- Experiments plans
  - Conductive paper electrode
  - Integrate with microfluidic channel
  - Detect transit time of cells or smaller particles

References

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- F. Liu, K.C. Pawan,G.Zhang,Z. Jiang,J.Anal.Chem.,vol:88 (1), 711–717,2016
- `http://www.elveflow.com/microfluidic-tutorials/`

Thanks for your attention!