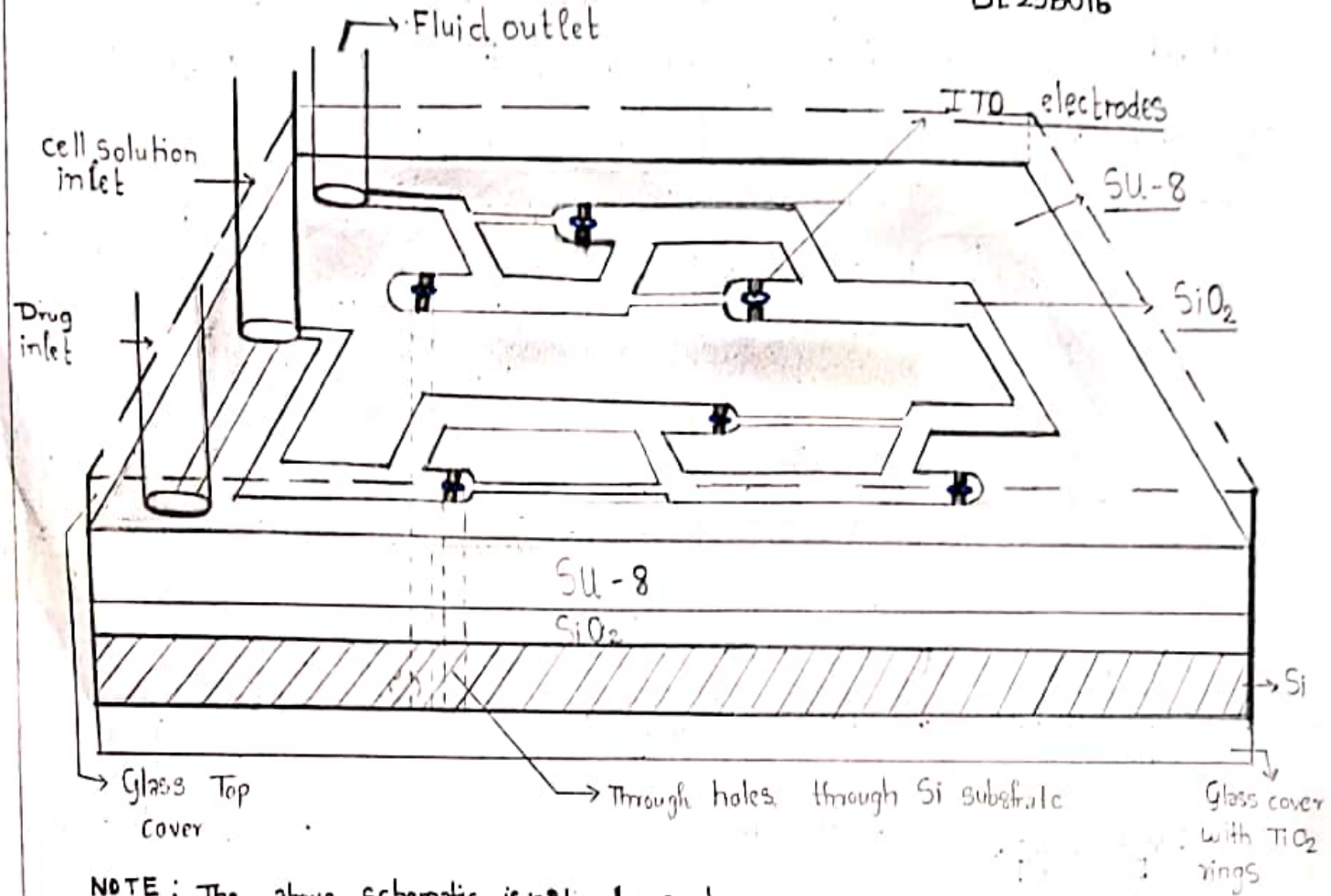
ED5016 ; Assignment - 5

06/05/2025

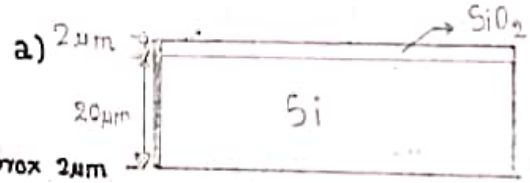
K. Varunkumar
BE23B016

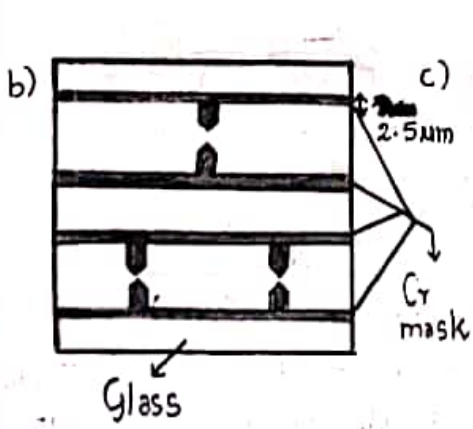


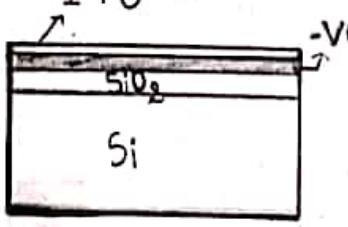
NOTE: The above schematic isn't to scale; proper dimension are provided with the fabrication process; a zoomed version is used in the process diagram below

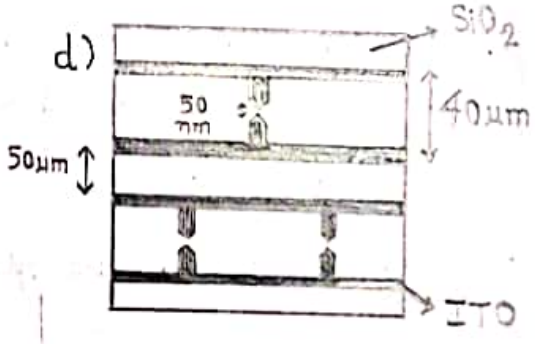
i) Take the Si wafer, clean it using piranha soln, followed by clean rinse in DI water

ii) SiO_2 formation, using thermal oxidation of approx 2μm





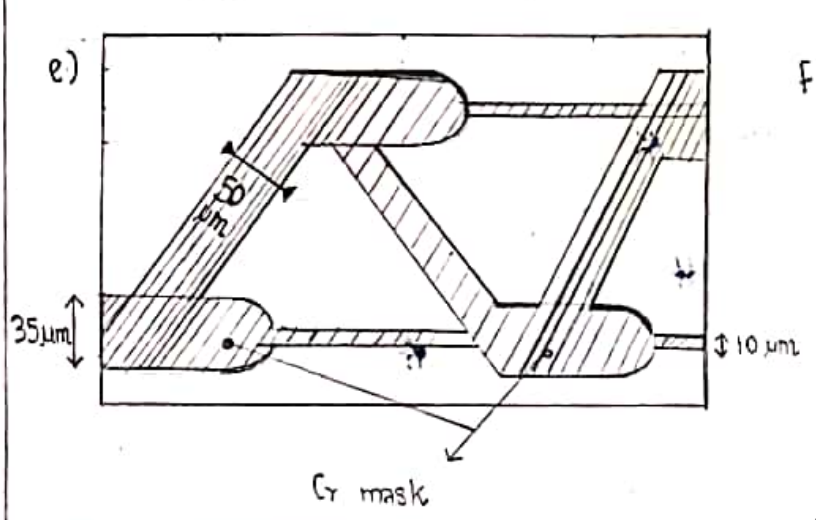


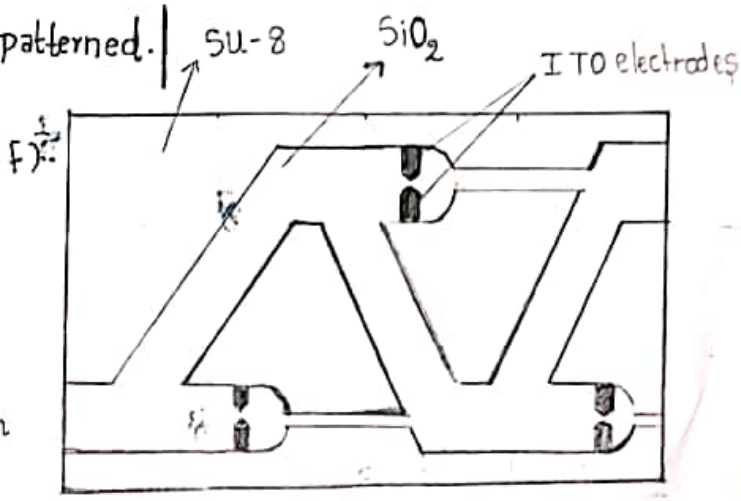


iii) a) primer treatment (HMDS) ; b) Spin coating of -ve PR ; c) Soft bake ; d) Allign mask shown in fig (c) with the setup ;

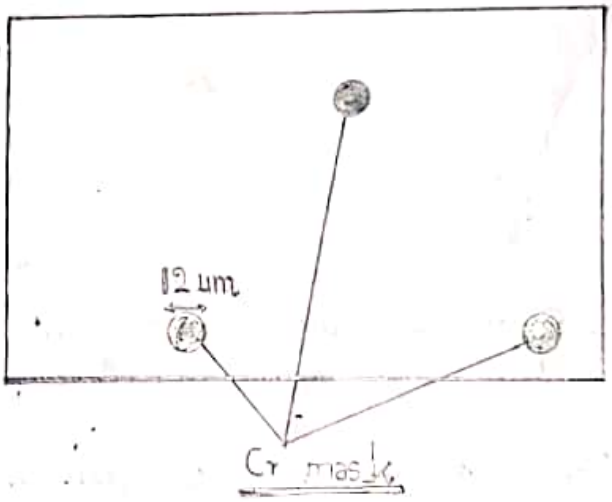
e) UV ~~treatment~~ exposure ; f) PR development followed by hard bake in a hot plate ; g) Standard cleaning ; h) Deposition of ITO via E-beam evaporation ; i) Removal of PR (Acetone) → Lift-off

Now the ITO electrodes have been patterned.





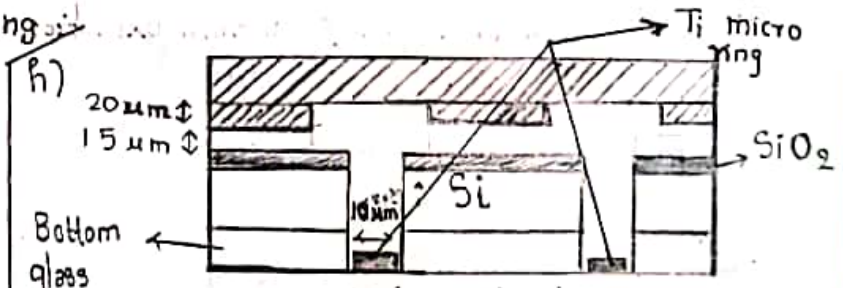
iv) Primer treatment → Su-8 spin coating (HMDS)
↓
Soft bake
↓
Mask Alignment [figure (e)]
↓
UV exposure → PR development
↓
Hard bake
↓
Standard clean.



Now the cell traps are made using Su-8 ; → figure (f)

v) The substrate is now flipped over to ensure the through can be drilled.

Primer treatment → SU-8 spin coating (HMDS)
↓
Soft bake
↓
Mask Alignment figure (g)



Side sectional view of device (CTMR, diameter = 10μm)

The section is through the midpoint/center of the cell trap, thus ITO and SU-8 aren't visible

Contd..

Mask Alignment → UV exposure → { PR development + Hard bake } → DRIE of Silicon

removal of PR using tweezers ← RIE of SiO_2

NOTE: PR is removed using tweezers to ensure the SU-8 trap stays intact / Alternatively only the bottom PR can be exposed to Acetone for it's selective removal.

vi) The top is sealed with a glass that reduces the headspace for the fluid flow through the narrow channels as shown in fig (h).

The bottom is sealed with glass, which contains Titanium micro-rings for photoporation.

Working mechanism :

- This device integrates, photo-poration with electroporation to ensure high transfection efficiency, as well as high cell viability.

- Cells are trapped in nearly spherical regions of 35 μm dia, using hydrodynamics, the gap channels ensure low resistance when uncovered & high resistance when covered,

This along with the appropriate dimensioning ensure high efficiency single cell trapping.

• Once the cells are positioned, from under the substrate IR light of approx 1050 nm is pulsed at regular intervals. (The wavelength also ensure minimal cell damage $E \propto 1/\lambda$)

The laser excites the TiO_2 ring which concentrates the energy and forms photothermal bubbles. These photothermal bubbles then lyse the cell walls, which allows drugs to enter via diffusion

• Finally we have the, ITO nanogap electrodes. The nanogap, ensure a concentrated electric field near the tip of the electrode, causing the cell-wall lysis in it's locality. Drugs once again enter the cell through this via diffusion.

Expected outcomes

• Certain methods of drug delivery prove to be inefficient against certain cell types, however, by combining 2 techniques, we can ensure regardless of cell type, there is a high transfection efficiency

• Both methods combined here are very localised and as such don't lead to multiple pores generating simultaneously which can cause cell death.

• Through the combination of the 2 techniques, if a particular method is found to be more effective, it can carry the larger burden. This compact design also allows for 1 million cells in less than 100 cm^2 area.