

ME 411 / ME 511

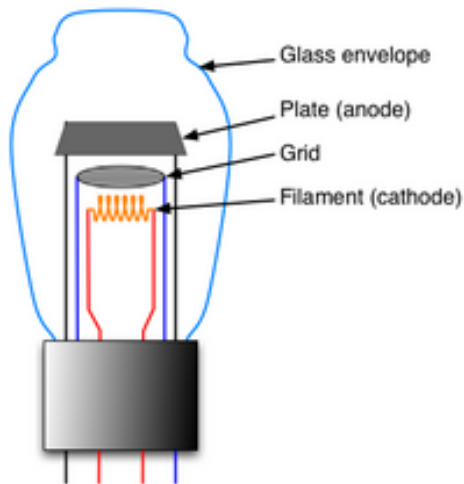
Biological Frameworks for Engineers

ME 411 / ME 511

Micro and Nano Fabrication

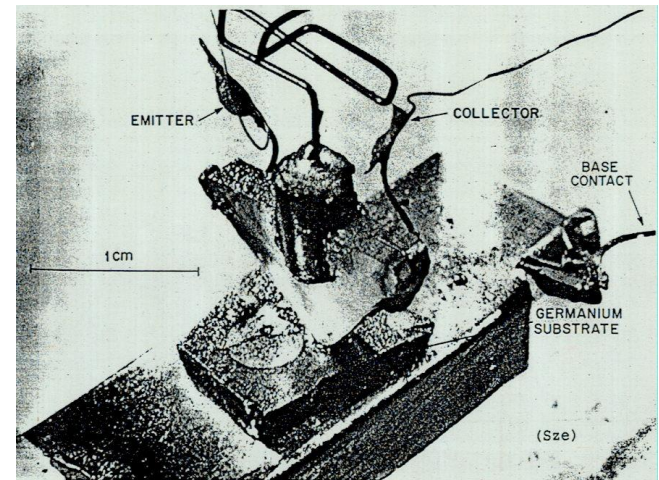
In the beginning...

- Vacuum Tube

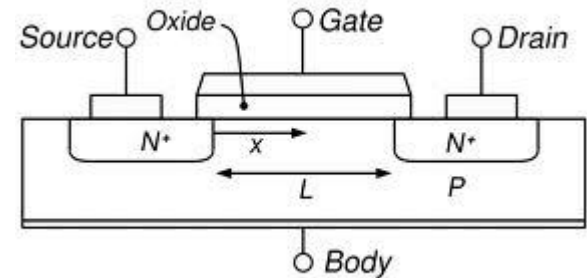


- Gate electron flow
- Warm up
- Glowed! Bugs!

- Solid State Transistor

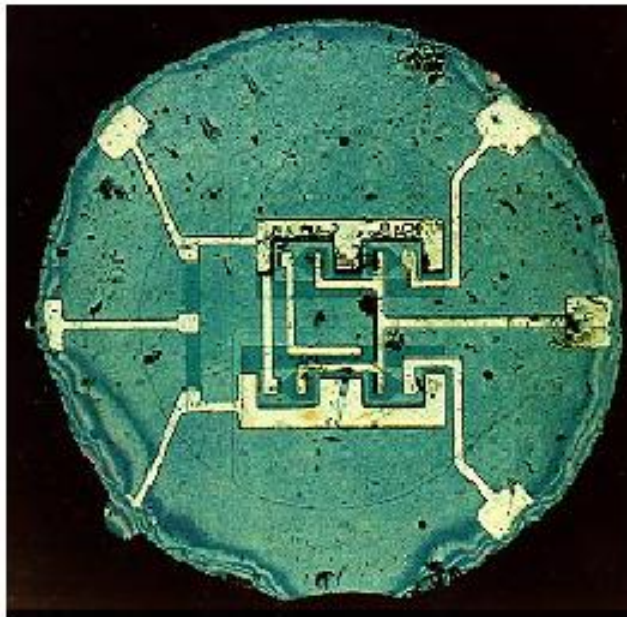


Bardeen & Brattain, *Phys Rev*, 74, 230 (1948)



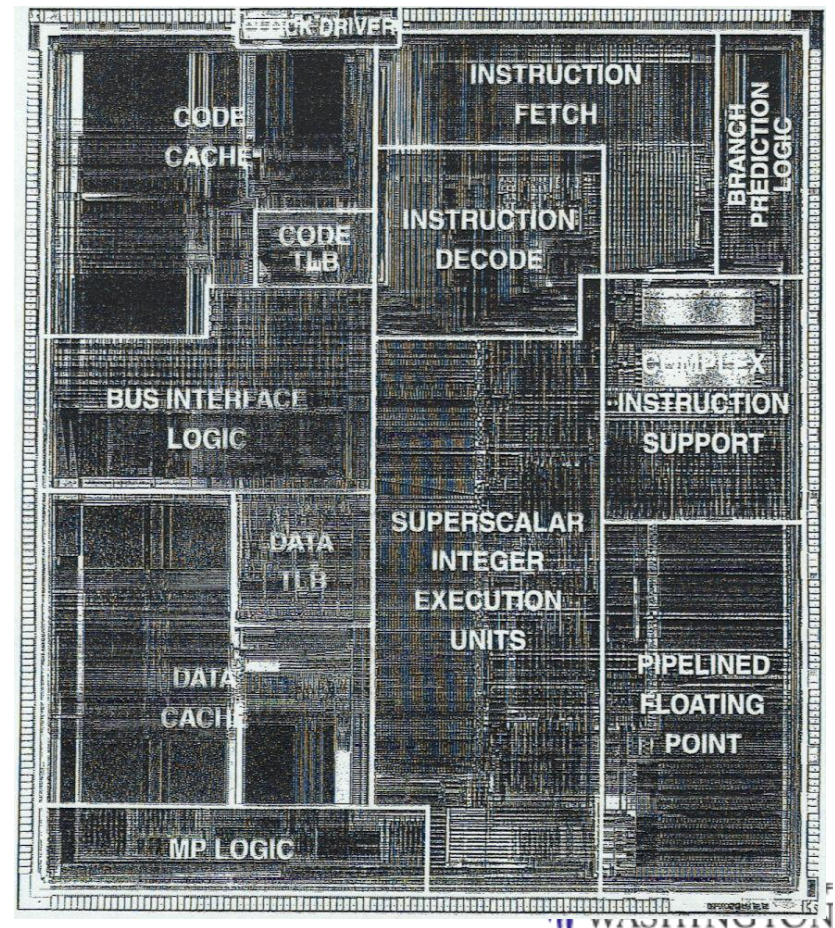
Integrated Circuits

- Circa 1960

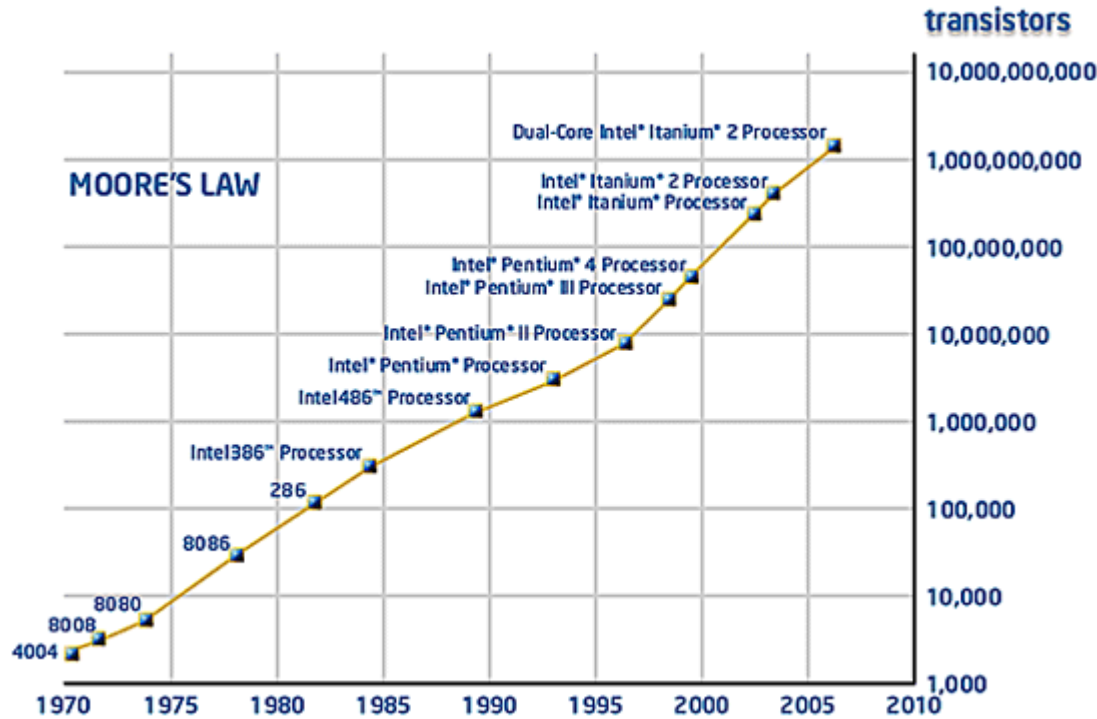
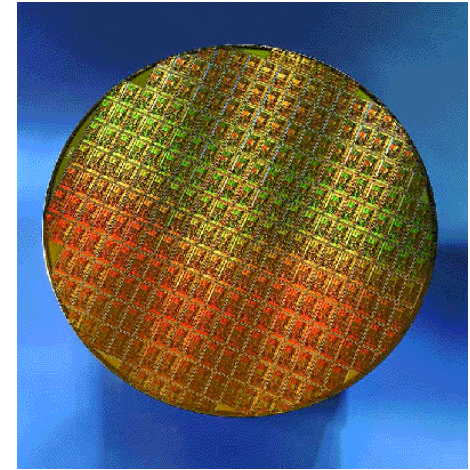


Intel 133 MHz Pentium
3.3 million transistors
0.35 micron Litho
4 layer metalization

- Circa 1990



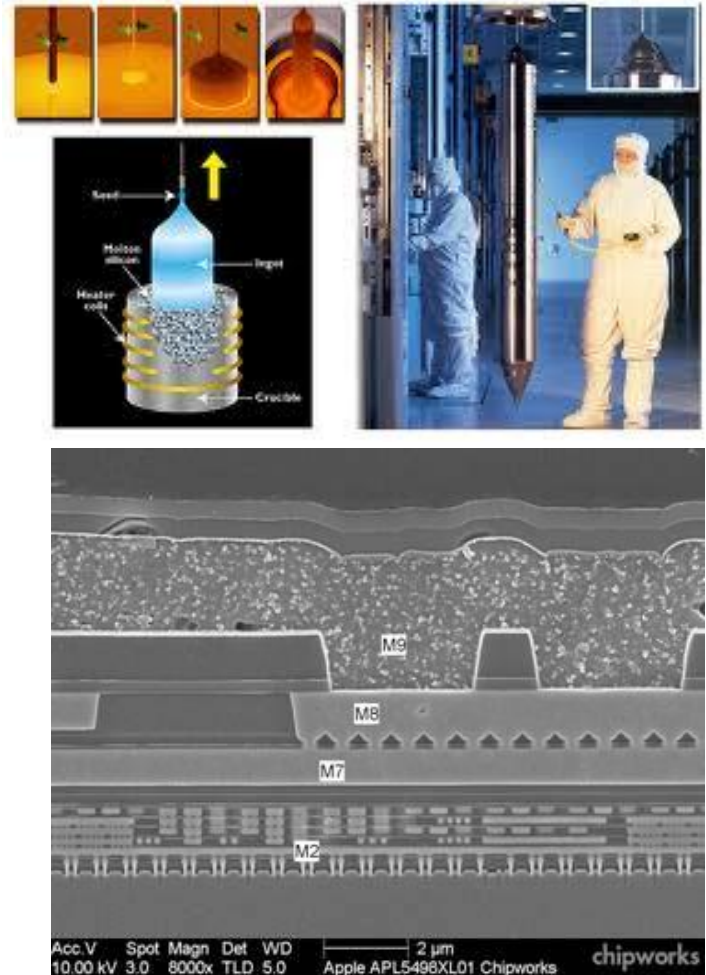
Moore's Law



Gordon Moore, "Cramming more components onto integrated circuits", Electronics, April 19, 1965

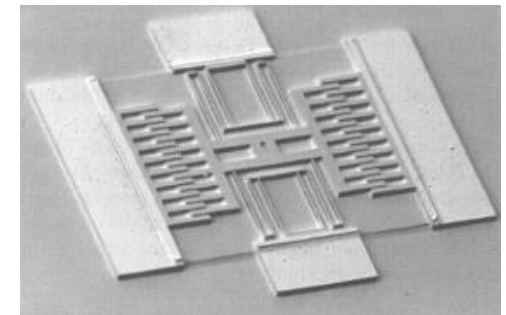
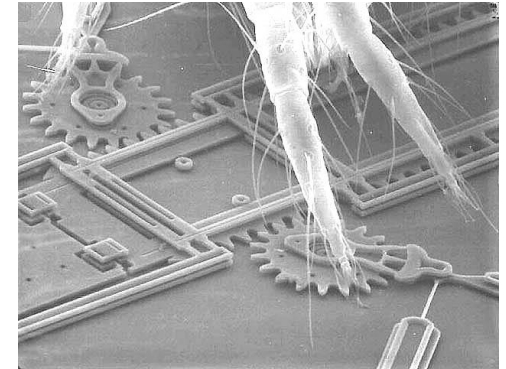
Microelectronic Processes

- Czochralski Process
- Oxide Growth
- Lithography
- Ion Implantation
- Thin Film Deposition
 - Physical Vapor Dep. (PVD)
 - Chemical Vapor Dep. (CVD)
- Chemical Etching
 - Wet Chemical Etching
 - Dry Plasma Etching
- Chemical-Mechanical Polishing (CMP)

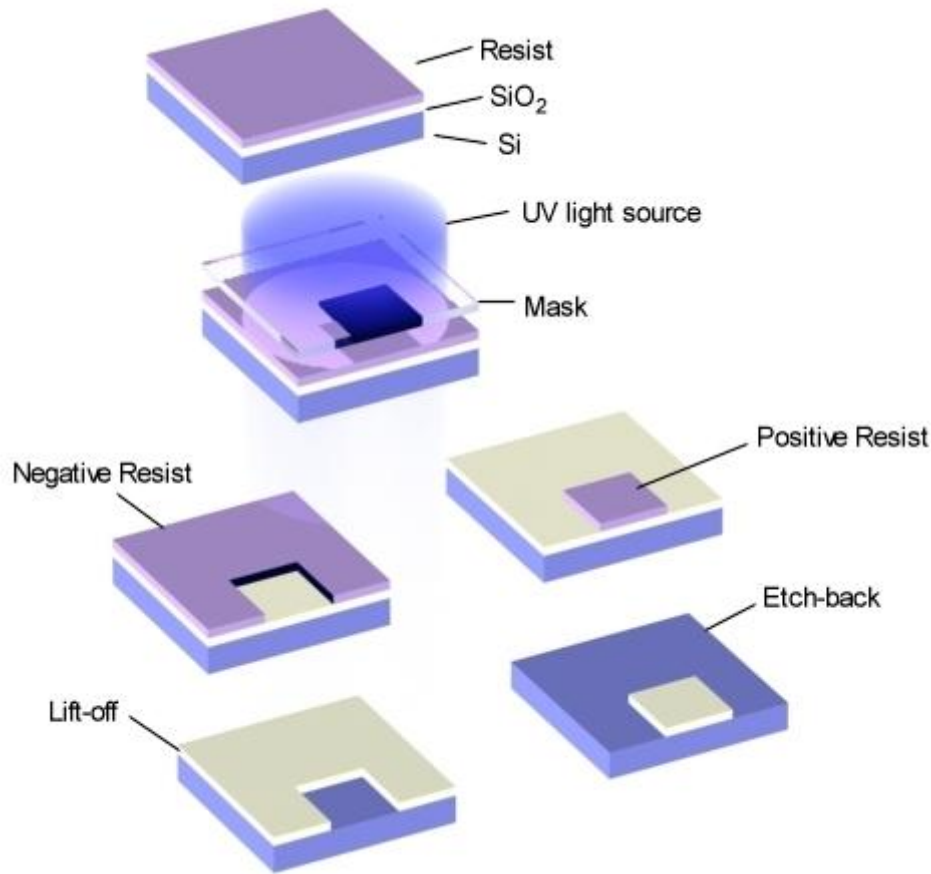


Microfabrication

- Bulk Micromachining
 - Wet Chemical Etching
 - Plasma Etching
 - Inductively Coupled Plasma Reactive Ion Etching (ICP-RIE)
 - Deep Reactive Ion Etching (DRIE)
- Surface Micromachining
 - MEMSCAP's MUMPs Process
 - Sandia's SUMMiT Process
 - ADI's optical iMEMS Process
 - LIGA process



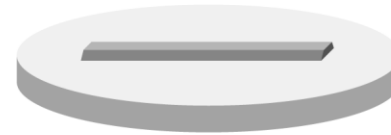
Lithography



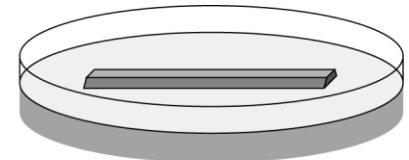
- Patterning
 - Photoresist
 - Expose
 - Develop
 - Etch!
- Positive Resist
 - Light makes it soluble in developer
- Negative Resist
 - Light causes it to polymerize and resist developer

Soft Lithography

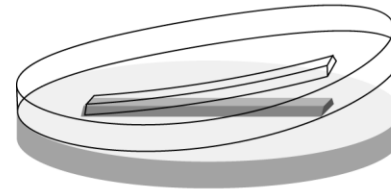
- SU-8
 - Epoxy-like negative photoresist
- PDMS
 - Glass-like silicone rubber
- Applications
 - Microcontact printing
 - Microfluidics
 - Cell-based assays



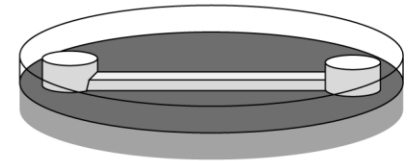
a) Fabricate master mold.



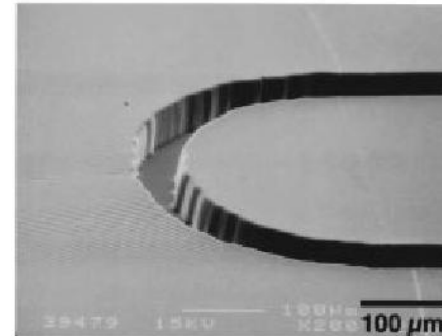
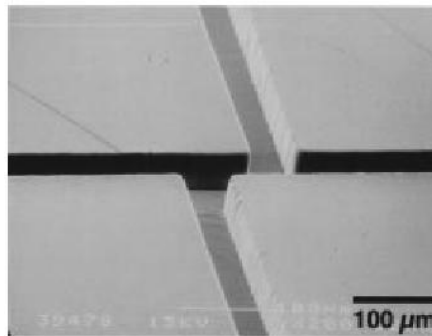
b) Pour PDMS on mold.



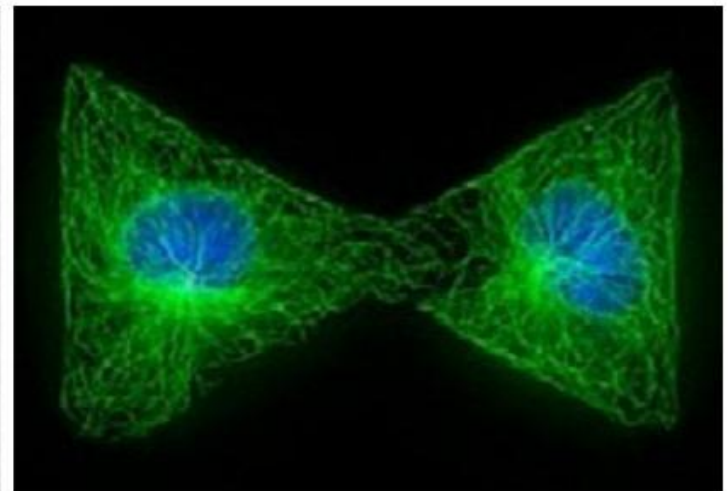
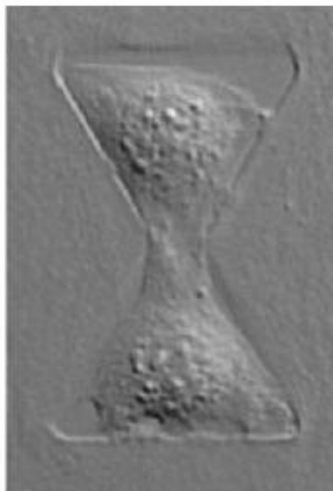
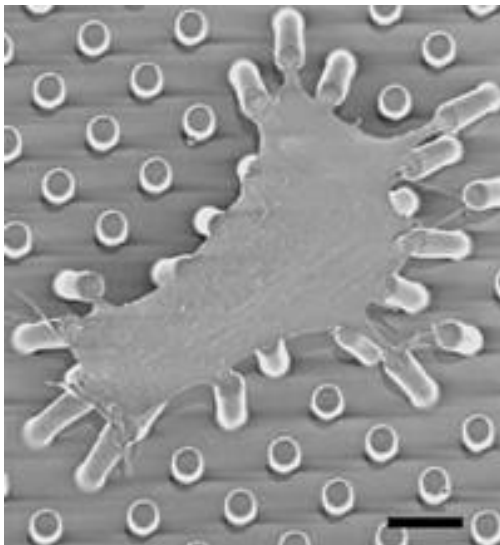
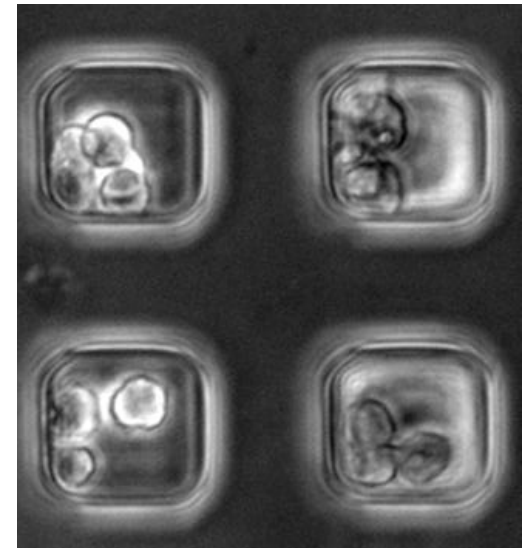
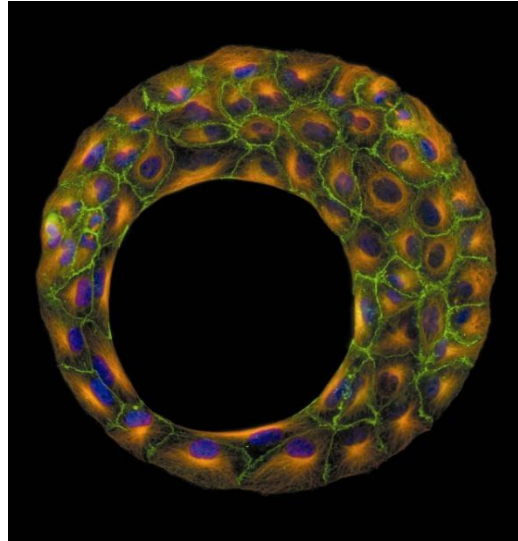
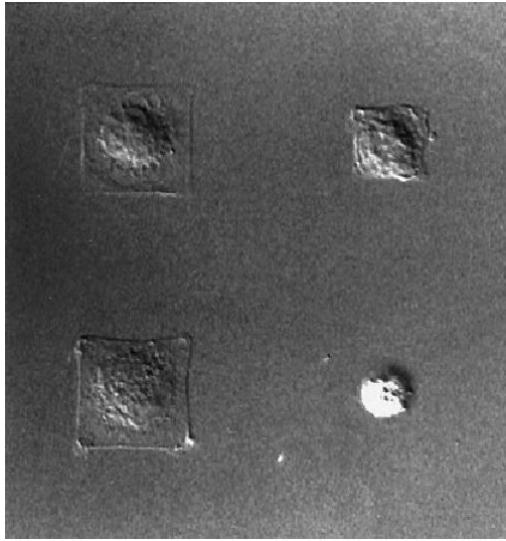
c) Cure PDMS and remove.

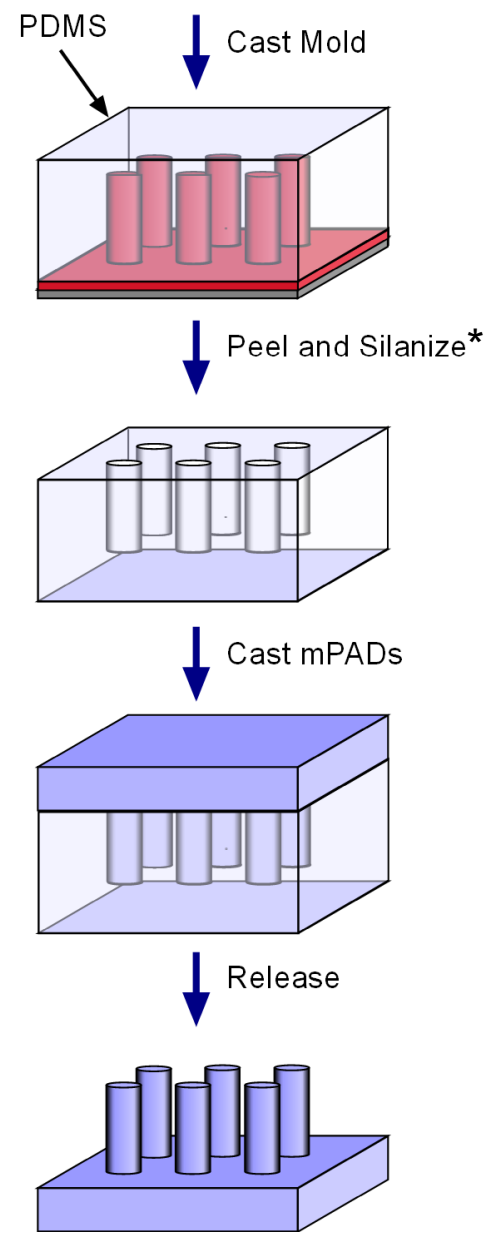
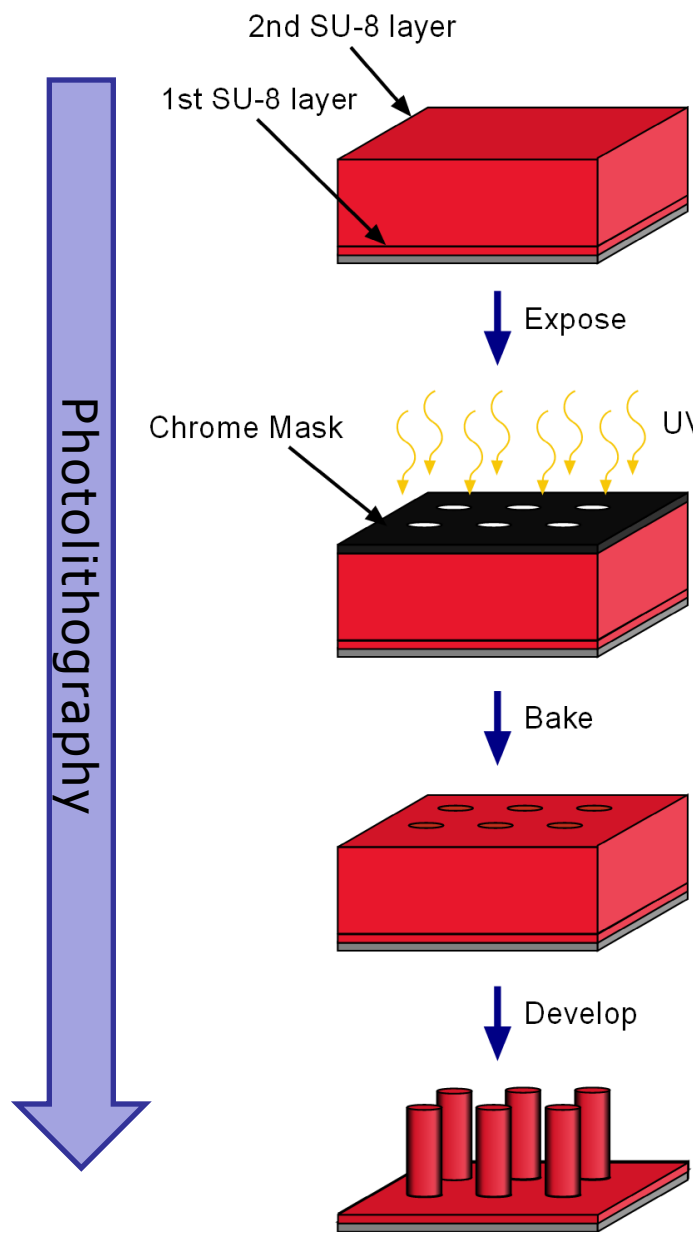


d) Punch-out reservoirs and seal onto bottom wafer.



Tools for Cells

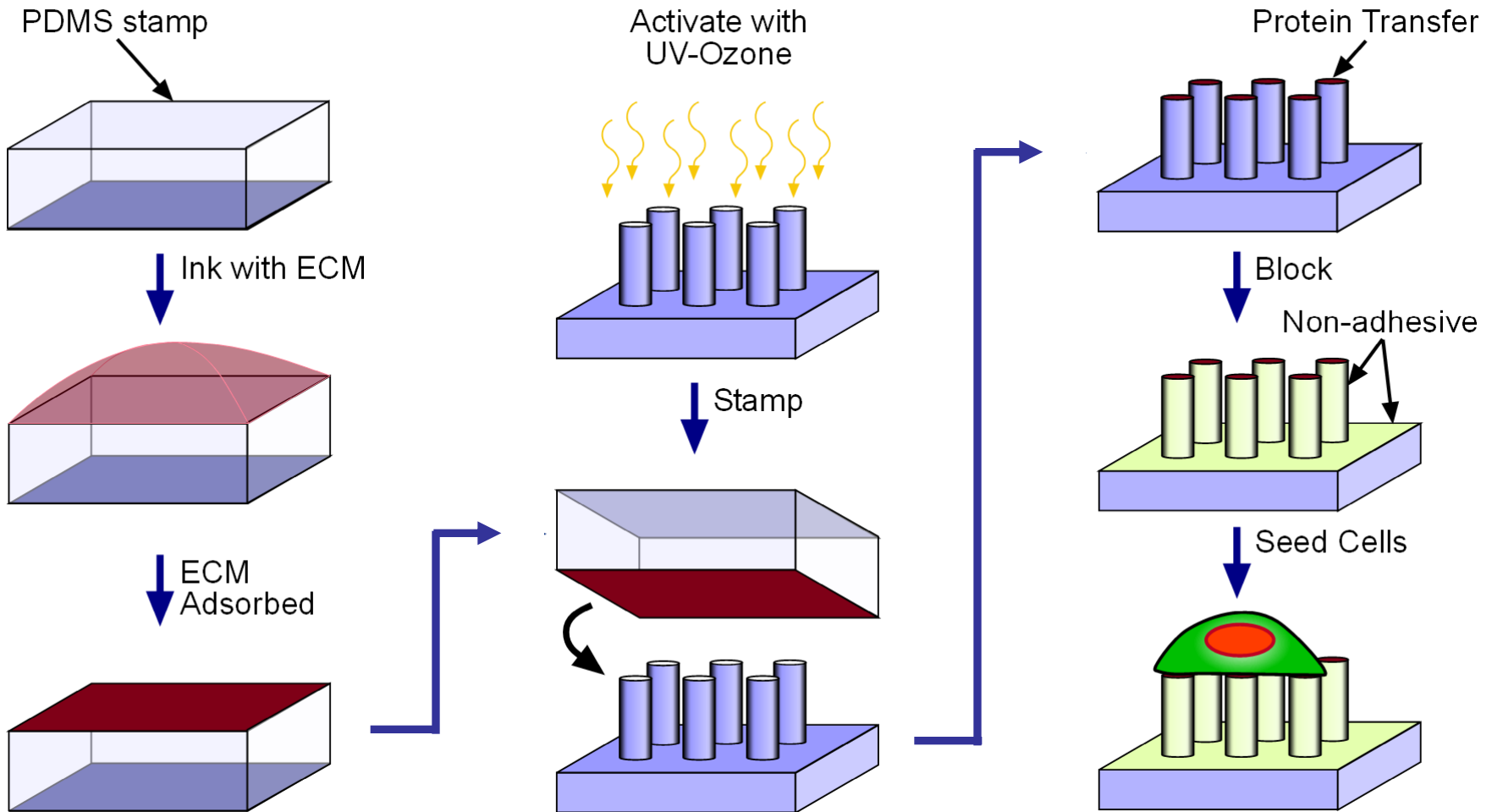




Photolithography

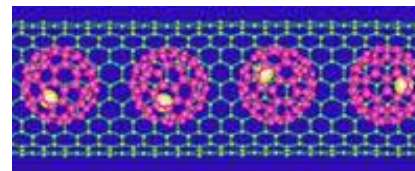
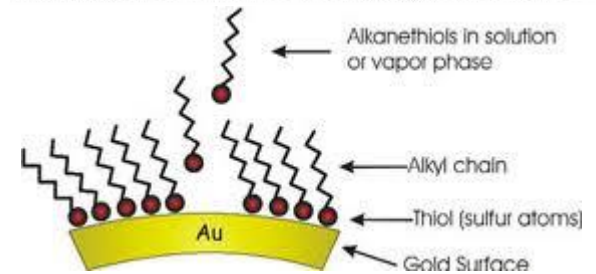
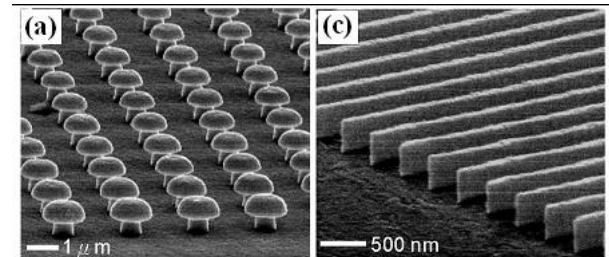
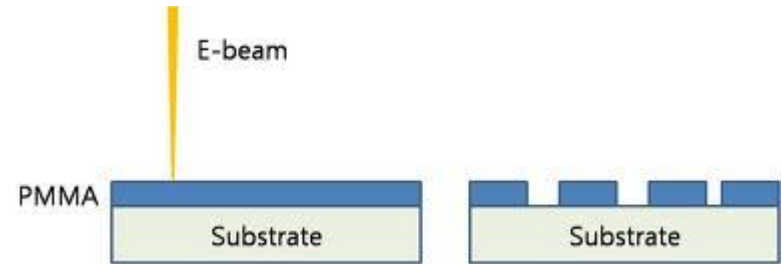
Soft Lithography

Micro-contact Printing



Nanotechnology

- Nanolithography
 - E-beam lithography
 - Nanoimprint lithography
 - Tip-based lithography
- Molecular Assembly
 - DNA origami
 - Alkanethiol monolayers
 - Supramolecular assembly
- Nanomaterials
 - Carbon nanotubes
 - Nanoparticles



Questions?