2 – Fabrication

ME-426 – Micro/Nanomechanical Devices

Prof. Guillermo Villanueva

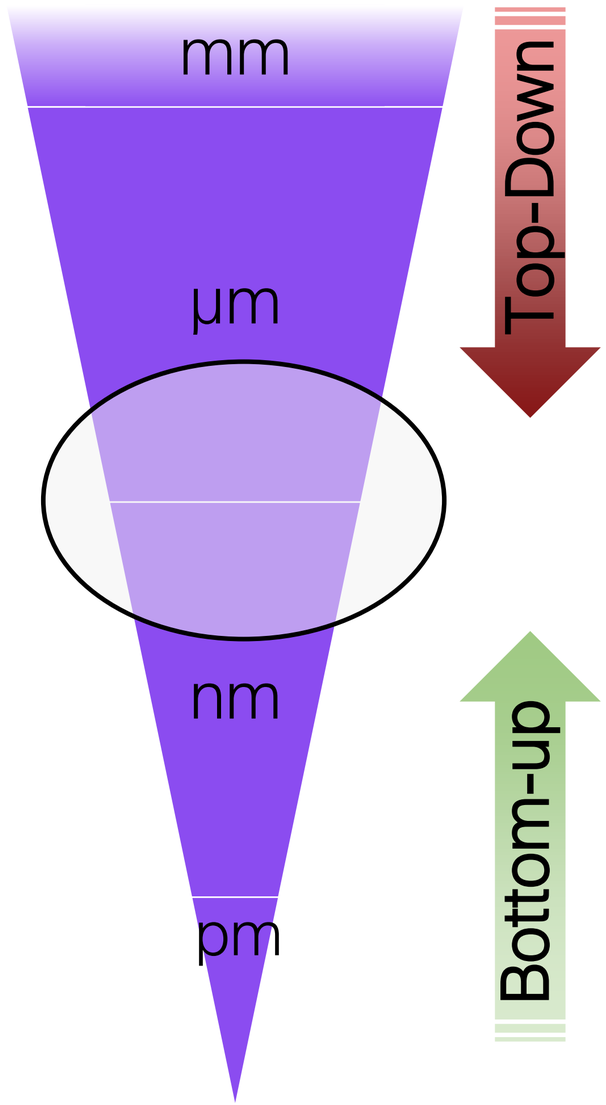
École
polytechnique
fédérale
de Lausanne

Introduction

- Fabrication
  - Lithography
  - Implantation
  - Deposition
  - Etching
- Release of mechanical devices
- Selectivity
- Stiction

Fabrication

Technologies of Micro/Nanofabrication



Top-Down

Bottom-up

Deposition

Implantation

µtechnologies
CMOS

Etching

Lithography

Chemical engineering

NPs

CNTs

NWs

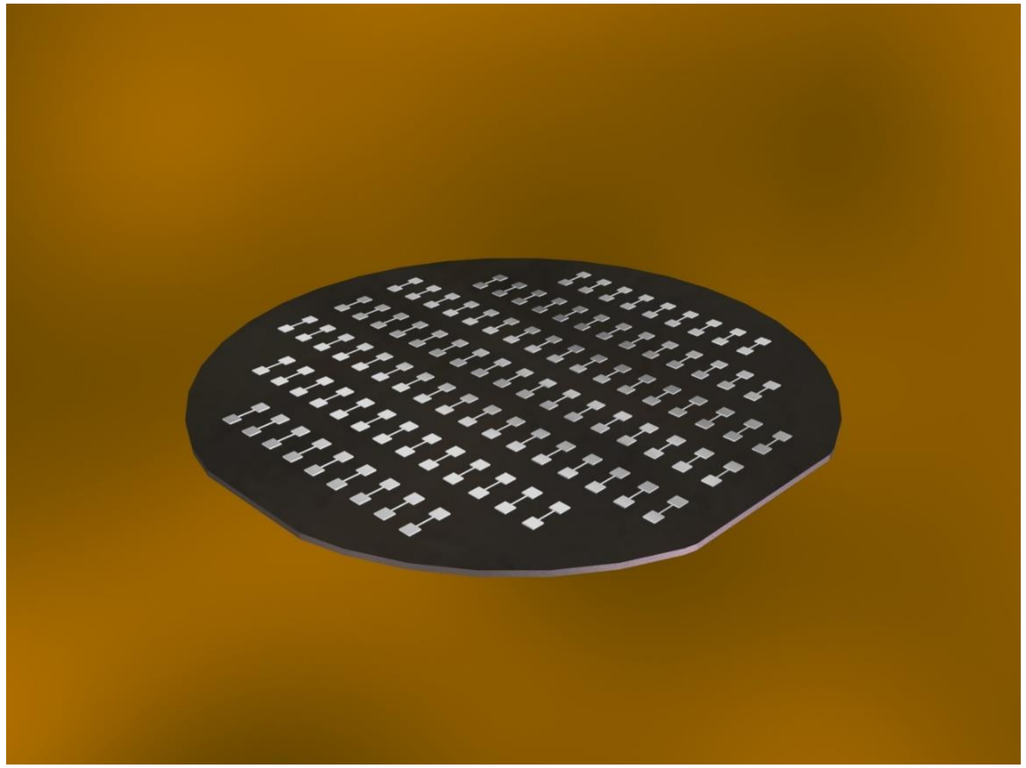
2D

Technologies of Micro/Nanofabrication

- This lecture is an overview of the topic
- In SwitchTube there are 4h20’ on fabrication (from another course)
- If you already know about how micro/nano devices are fabricated – no need to watch those videos
- If you don’t, please watch them
- When discussing the Papers, you will reinforce what you saw in the videos

Planar technology

- Silicon wafers are the main substrate
- Everything is fabricated by adding layers of different materials which are later partially removed
- Most processes affect the whole surface simultaneously

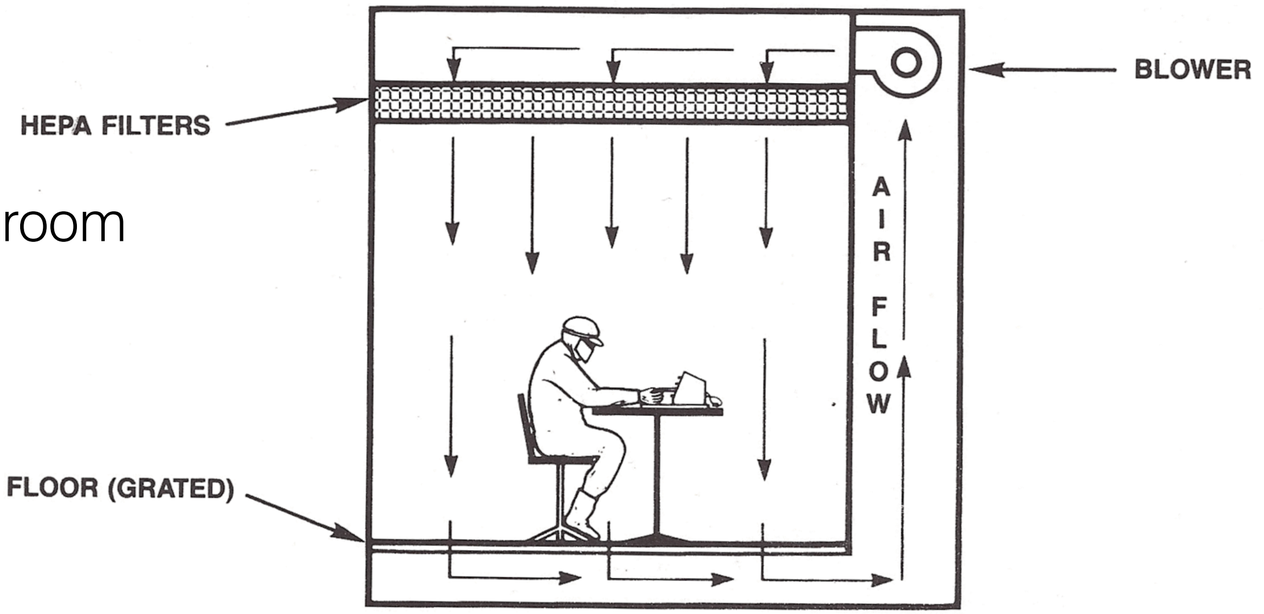


Cleanroom

- Controlled environment to perform the processes
  - Temperature and humidity are kept constant
  - P above 1 atm
  - Air filtered continuously
- Classified as a function of # of particles

  $\leq 0.5\mu m$ in a *cubic foot*, e.g.
  - Class 100
  - Class 10000

  - Higher class # = worse cleanroom



Summary table

Deposition

- Adding material on wafer
- Chemical processes
- Physical processes

Implantation

- Implants atoms/ions into wafer
- Dope Si – transistors, etc.
- Generate new substrates – SOI

TOP-DOWN

- Removing material from wafer
- Wet etching – Purely chemical
- Dry etching – can be tuned between chemical and physical

Etching

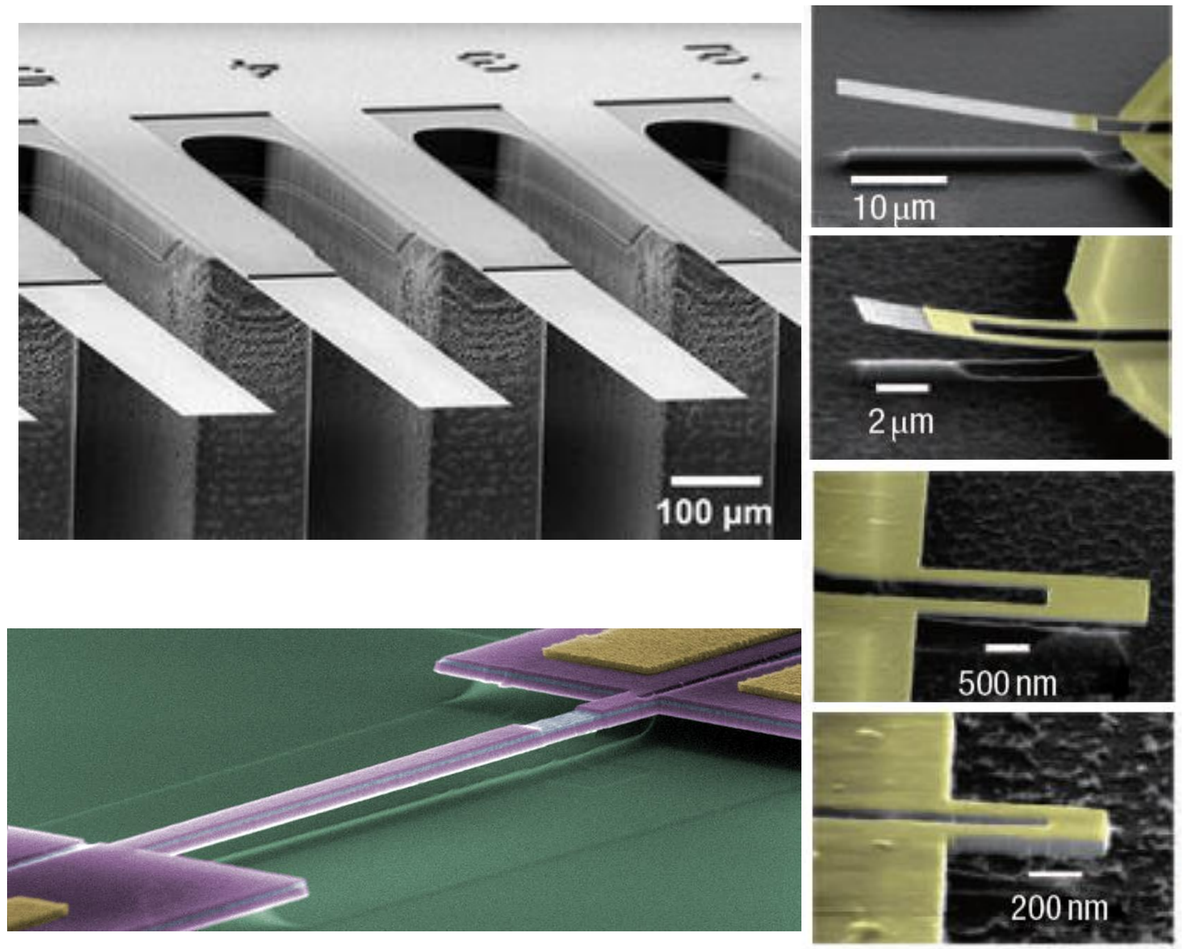
- Method to “draw” on the wafer
- Protects some parts of the wafer
- Basic to do any fab

Lithography

Caveat for Mechanical Devices

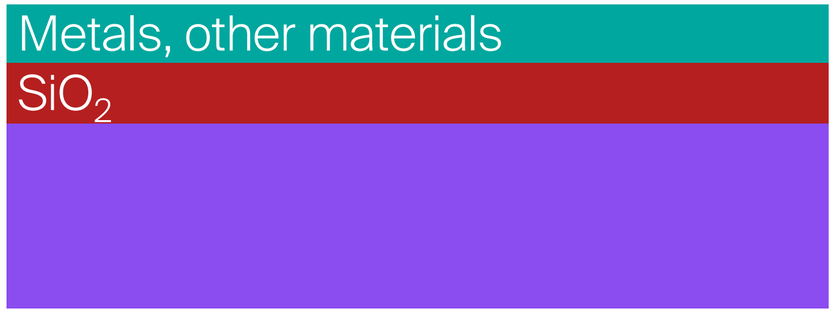
- We need to *release** the mechanical parts so that they can move

Release is removing the underlying material without damaging our device.

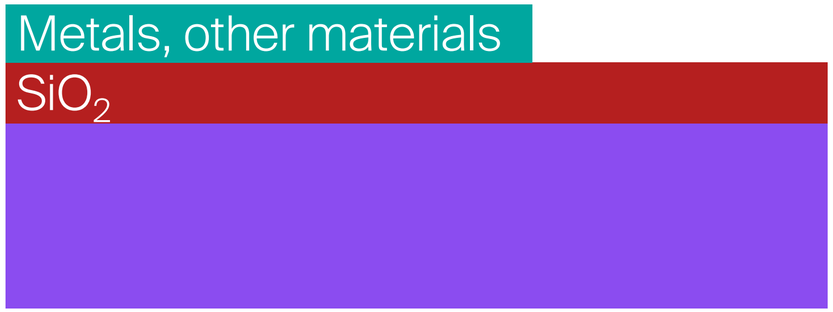


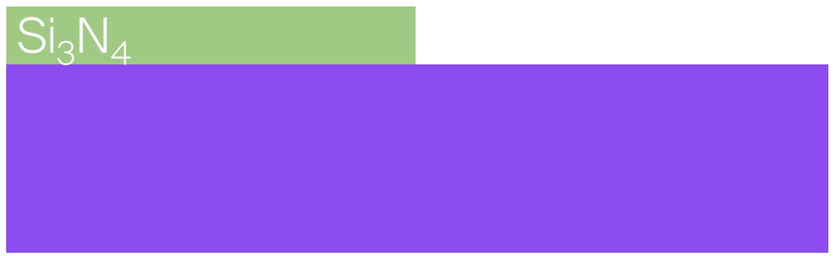
Release of mechanical devices

Sacrificial layer below – Etching selectivity



Sacrificial layer below – Etching selectivity



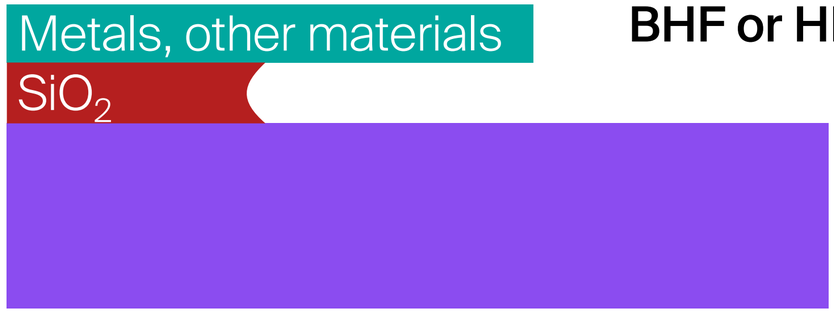


Sacrificial layer below – Etching selectivity

Bulk micromachining
“Deep” RIE

Bulk micromachining
KOH wet etching

Surface micromachining
BHF or HF wet etching

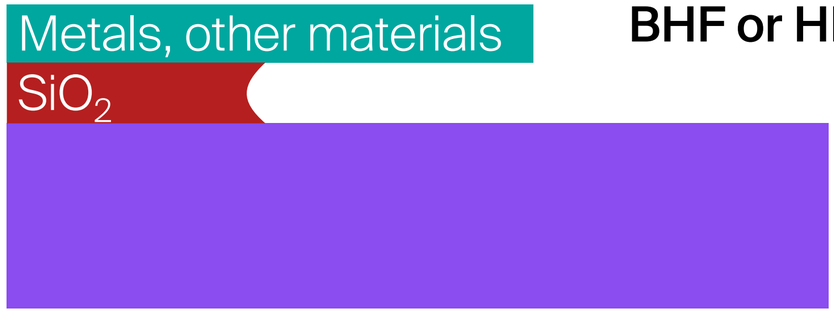


Sacrificial layer below – Etching selectivity

Bulk micromachining
“Deep” RIE

Bulk micromachining
KOH wet etching

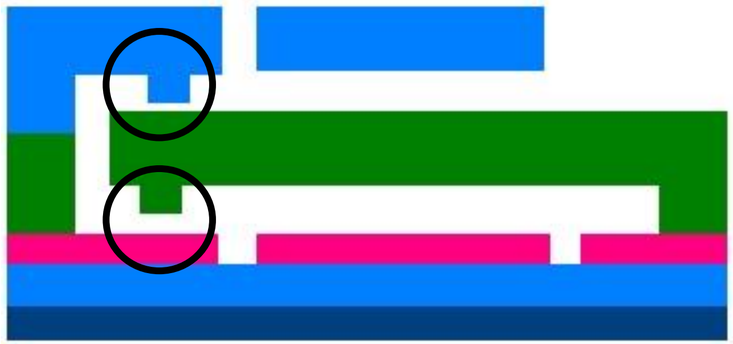
Surface micromachining
BHF or HF wet etching

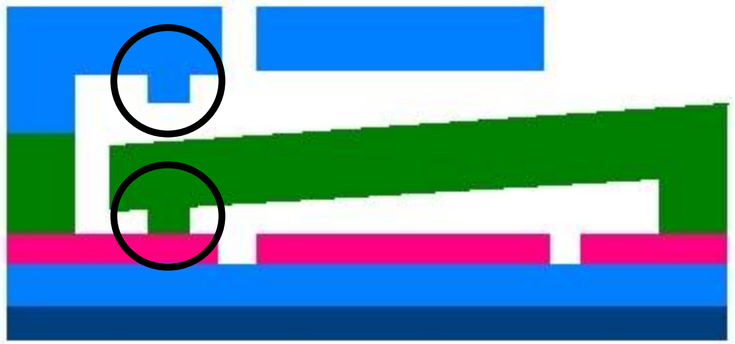


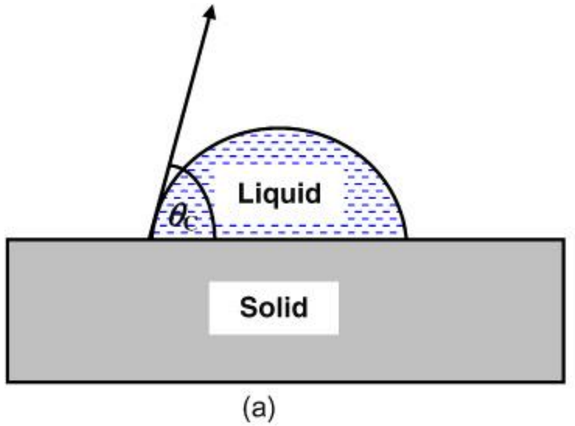
Avoiding stiction

- Wet etching
- After etching – rinsing in water
- Surface tension pulls the structures

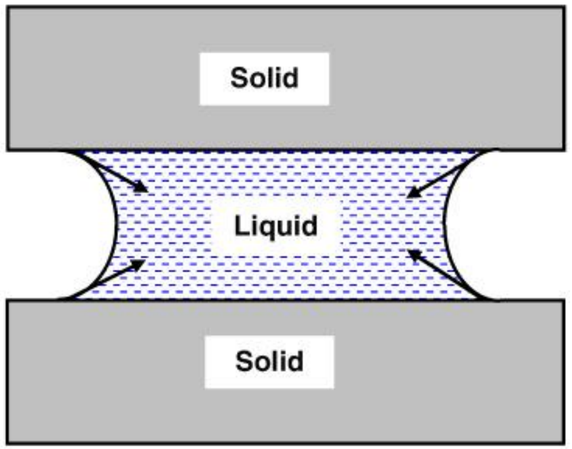
- Solutions
  - Smaller surface tension liquid while drying
  - Critical Point Drying
  - Designs to minimize stiction







(a)



(b)