

The background of the slide is a photograph of the EPFL campus in Lausanne, Switzerland. It shows modern buildings, a large lake, and mountains in the distance under a cloudy sky. A large red rectangle is overlaid on the right side of the image, and a blue rectangle is overlaid in the lower center.

# 2 – Fabrication

ME-426 – Micro/Nanomechanical Devices

Prof. Guillermo Villanueva

# EPFL Introduction

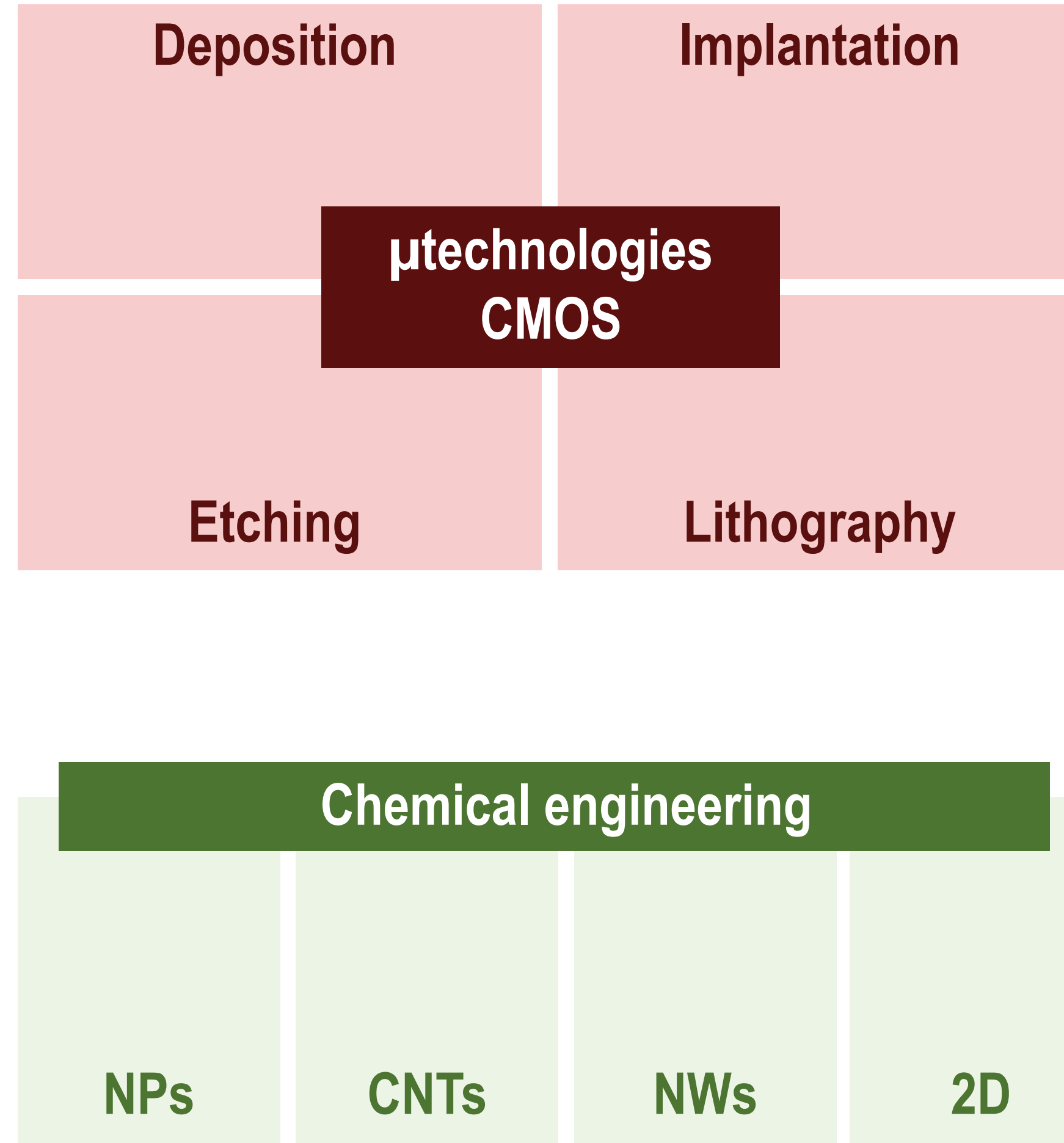
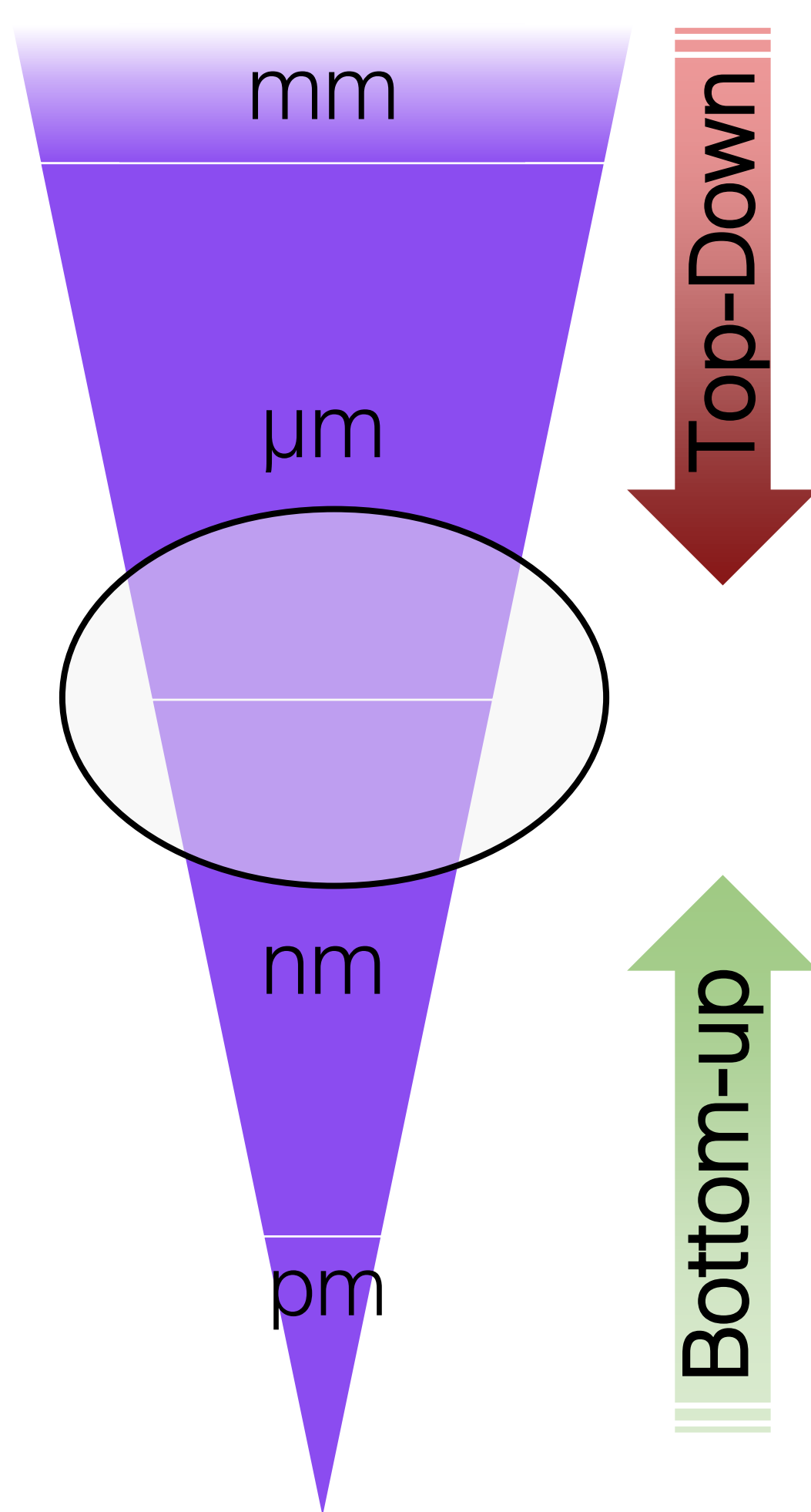
- Fabrication
  - Lithography
  - Implantation
  - Deposition
  - Etching
- Release of mechanical devices
- Selectivity
- Stiction

**EPFL**

An aerial photograph of the EPFL campus in Lausanne, Switzerland. The image shows a large, modern building with a white, undulating roof and several circular openings. To the left, there are older, multi-story buildings with flat roofs. In the background, a large body of water (Lake Geneva) is visible, with mountains in the distance under a cloudy sky. A red rectangular overlay covers the bottom right portion of the image, containing the word "Fabrication" in white text.

**Fabrication**

# EPFL Technologies of Micro/Nanofabrication

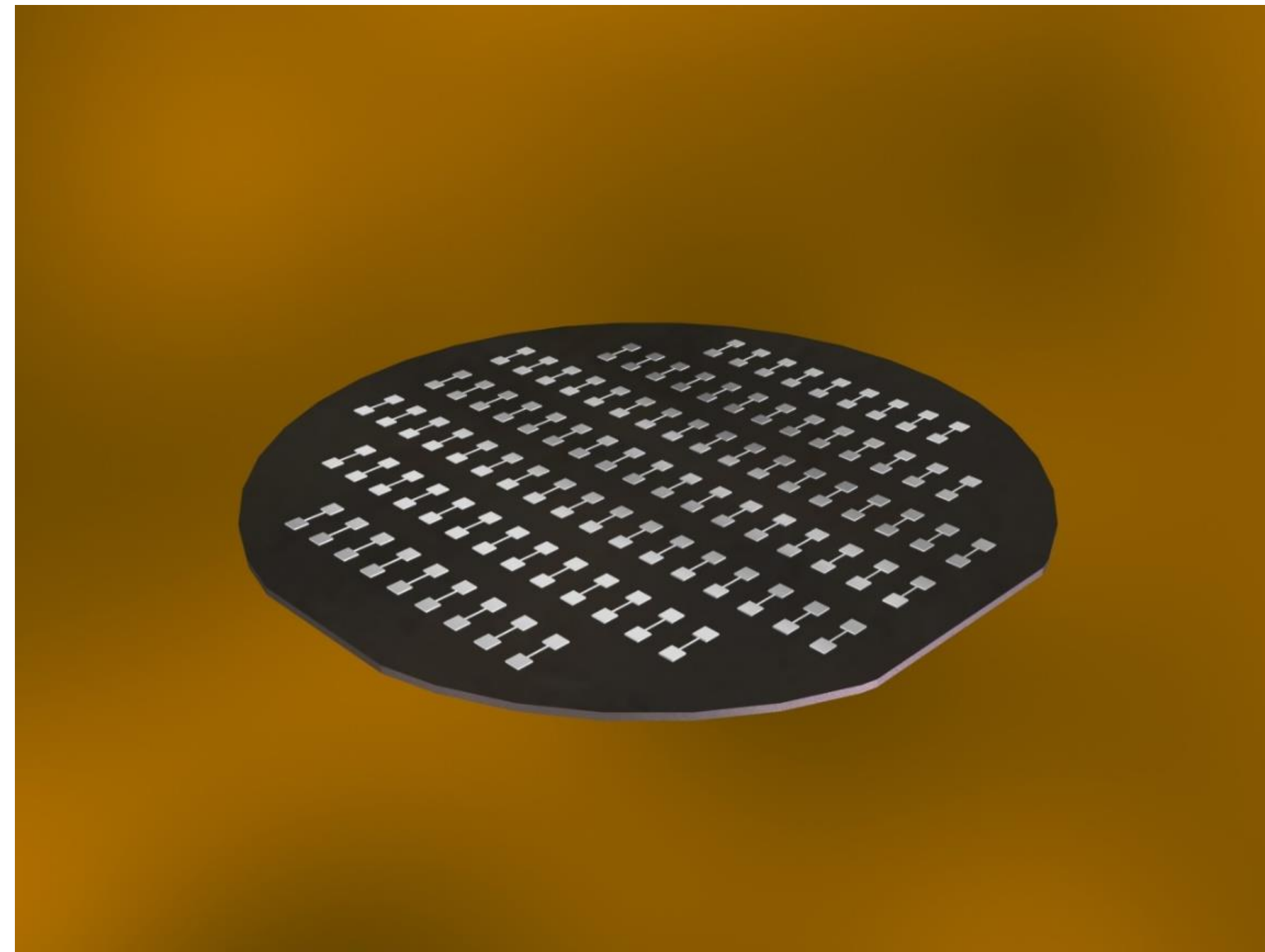


# EPFL Technologies of Micro/Nanofabrication

- 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

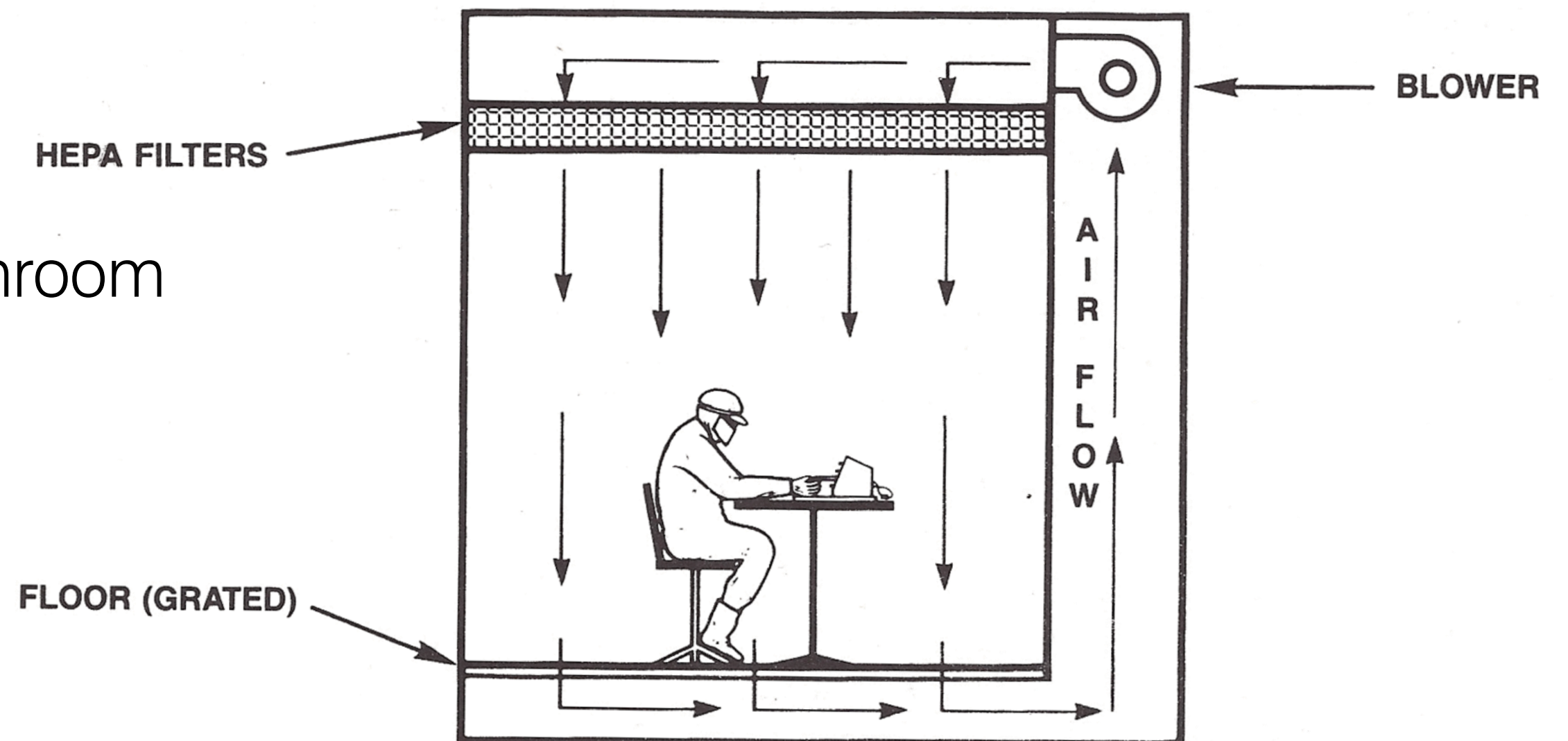
# EPFL Planar technology

- 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



# EPFL 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



# EPFL 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

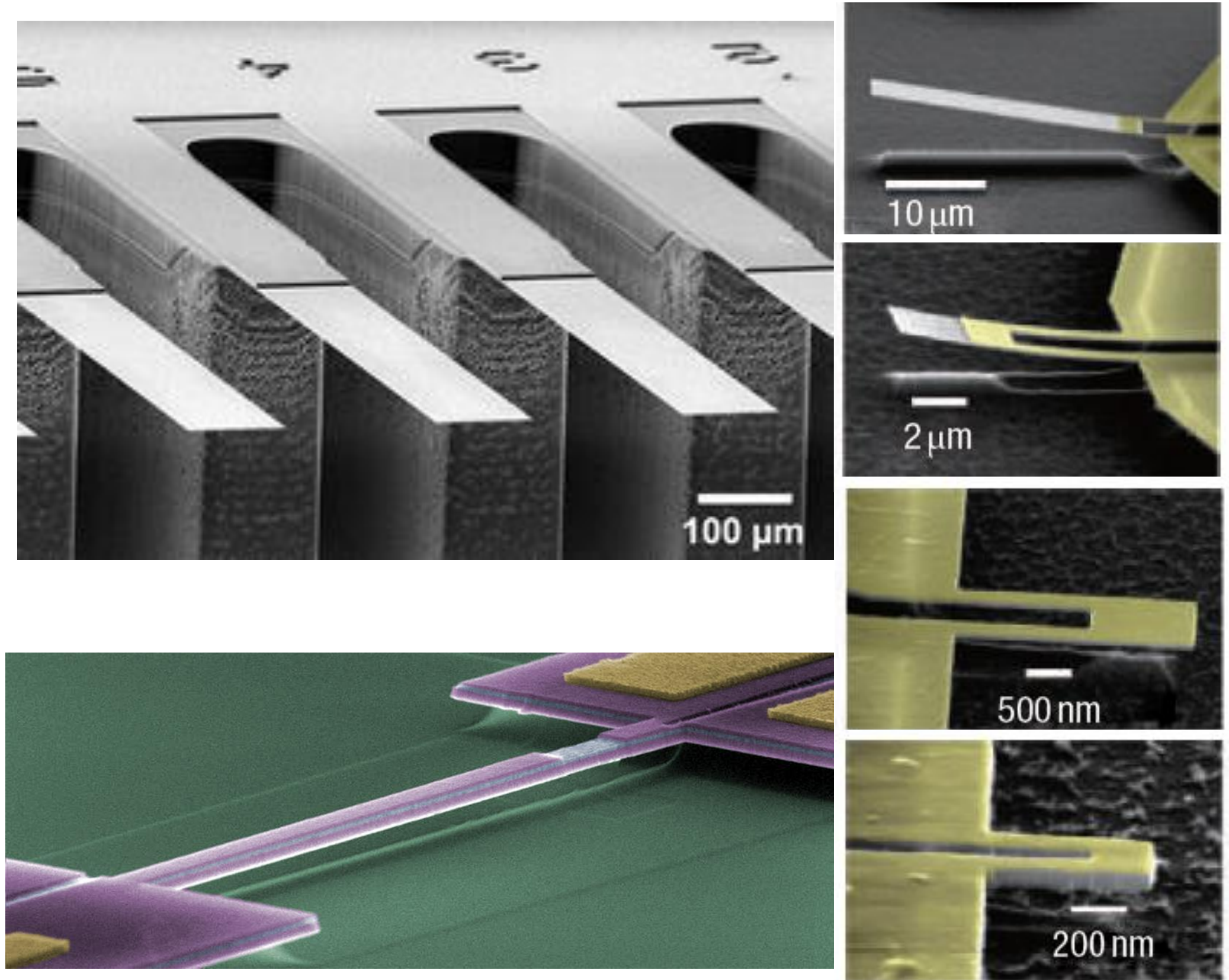
- Method to “draw” on the wafer
- Protects some parts of the wafer
- Basic to do any fab

## Lithography

# EPFL 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.**

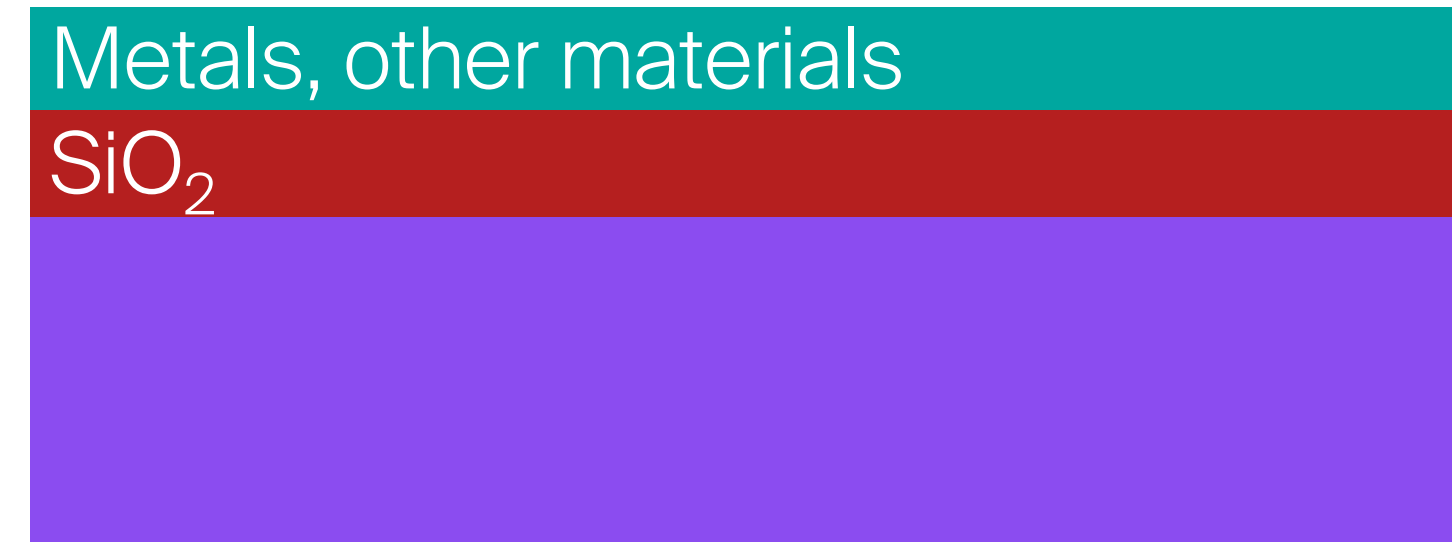


**EPFL**

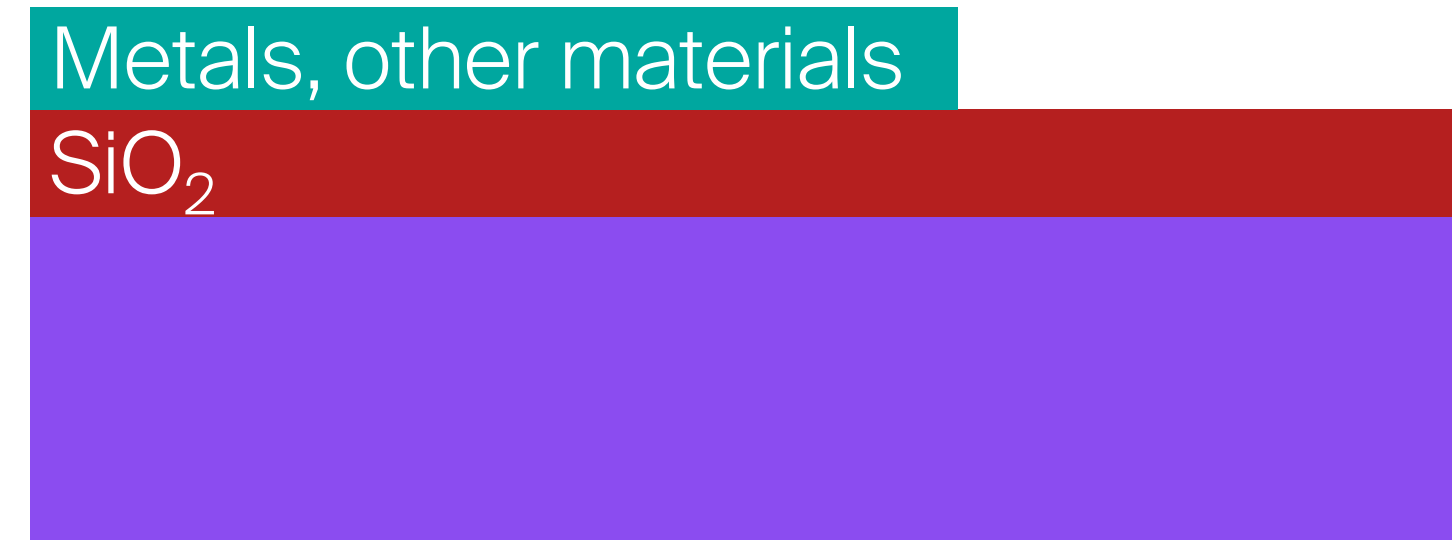
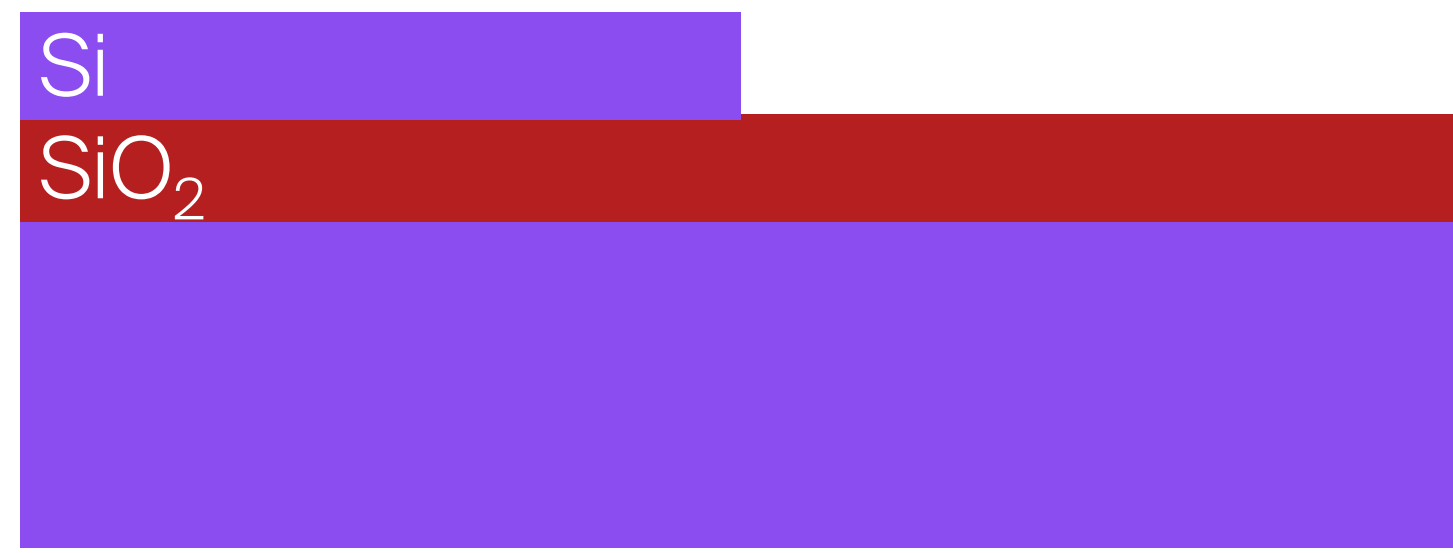
An aerial photograph of the EPFL campus in Lausanne, Switzerland. The image shows a large, modern building with a white, undulating roof and several circular openings. This building is surrounded by other campus structures, including a long building with a colorful facade and several multi-story buildings with flat roofs. In the background, a large body of water (Lake Geneva) is visible, with mountains in the distance under a cloudy sky. A red rectangular overlay covers the bottom portion of the image, containing white text.

**Release of mechanical devices**

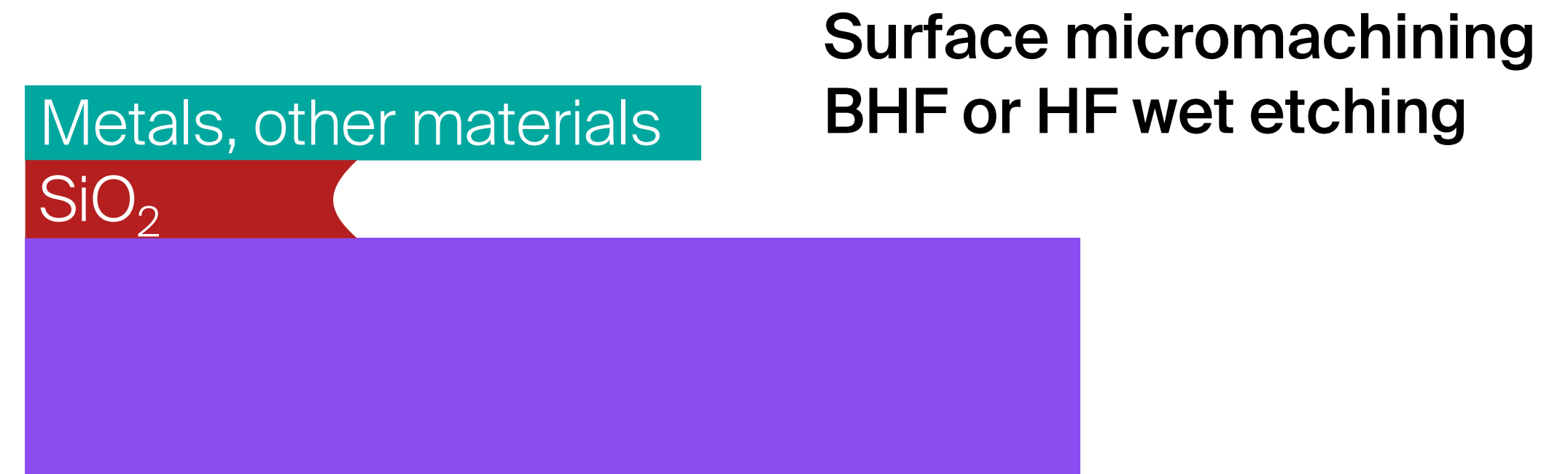
# EPFL Sacrificial layer below – Etching selectivity



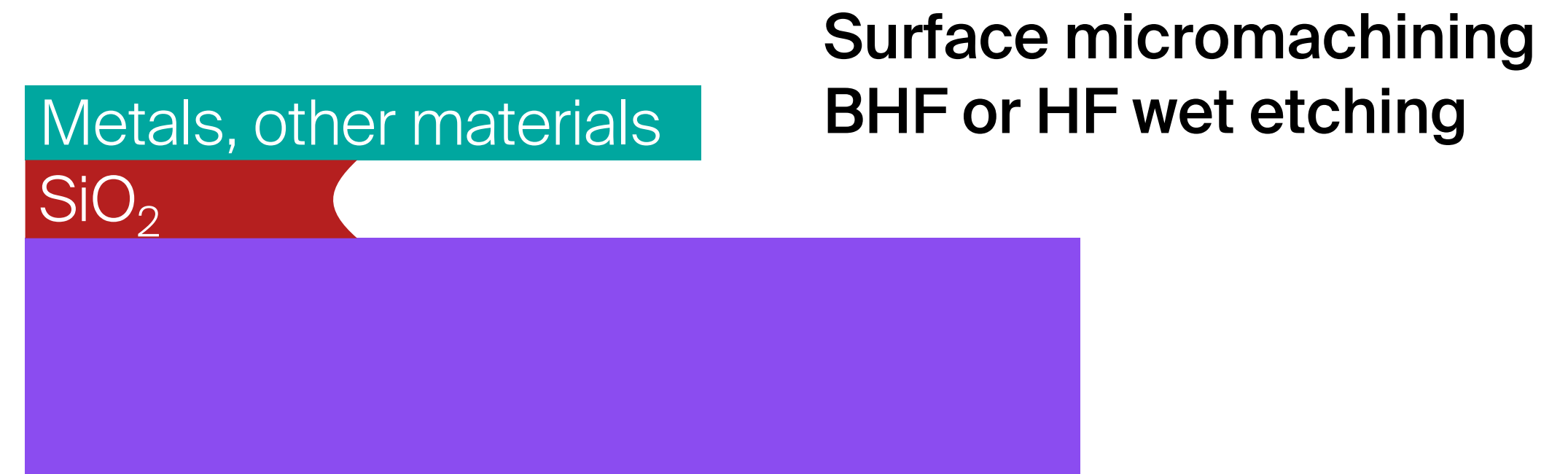
# EPFL Sacrificial layer below – Etching selectivity



# EPFL Sacrificial layer below – Etching selectivity



# EPFL Sacrificial layer below – Etching selectivity



# EPFL 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

