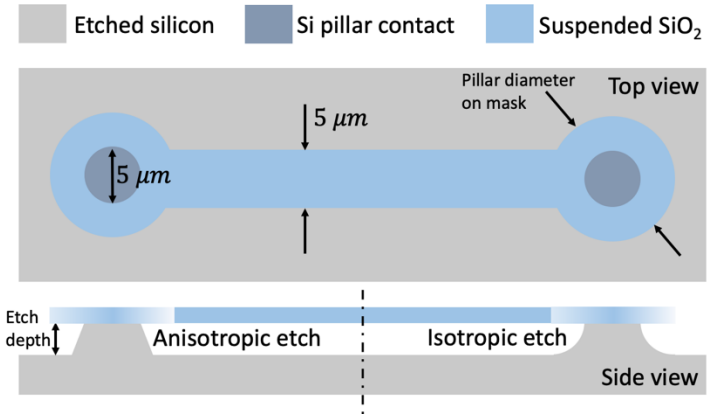
Jupyter Notebook Exercise

Objective

This exercise will guide you through some aspects of the etching processes. First, we are going to see how we calculate etching parameters to produce a fully released structure depending on the isotropy of the etching technique. Then we will look into the particular case of plasma etching, and how the choice of process parameters such as bias power, pressure, etc., play a role in polymerization point and selectivity.

Part 1: Etching processes for MEMS release

We want to design a free-standing beam with two clamping pillars. The starting point was an oxidized Si wafer, where the oxide layer was patterned as shown in the next image.



The beam is to be released by using a process which is 100% selective, meaning that only Si is attacked (the oxide is unaltered). The requirements are that the free-standing beam has width of 5 μm, and that the pillars at both ends have at least a 5 μm diameter region of contact between the Si and the SiO2.

We have a few processes available, but mainly two families:

- Isotropic Si etch: this process etches silicon at the same rate in all directions, regardless of crystal orientation.
- Anisotropic etch: the etch rate depends on the orientation with respect to the surface. Can be characterized by a geometric factor relating the etch rates in the two directions (parallel and perpendicular to the surface).

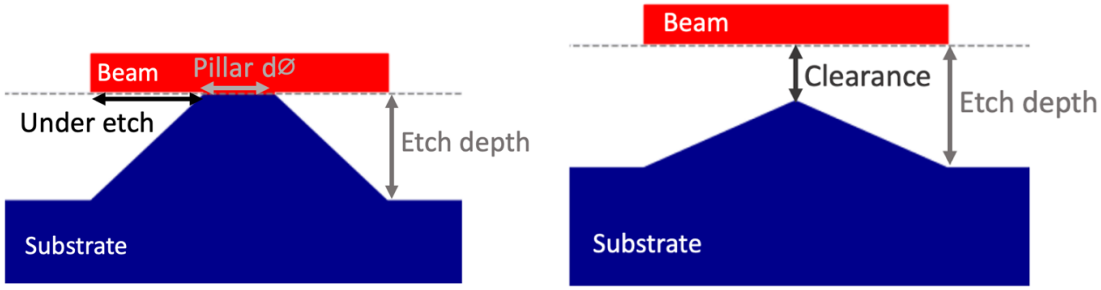
Do not hesitate to play with the animation in the notebook, trying the different types of processes and parameters, to visualize what each of these processes means in term of final profile for the given mask.

Questions:

1) Etch depth: How deep do we need to etch when using each of the processes in the table below for a good release of the beam? A good release means a clearance under the suspended beam of 70% the etch depth.
2) How wide must be the patterns on the SiO_2 mask giving origin to pillars, so that the remaining Si under the SiO_2 has a top diameter of 5 μm.

Process	Etch depth	Pillar pattern diameter
Isotropic		
Anisotropic 0.5		
Anisotropic 1.0		

NB: The values 0.5 and 1.0 refer to the under etch coefficient: under etch / etch depth.



Pillar cross section **Suspended part cross section**

Part 2: Dry etching parametric study

By analyzing the data provided in the notebook for different ICP processes, estimate the polymerization limits for the given processes.

ICP power	Bias min.	Max selectivity
600		
775		
950		

Part 3: Selectivity and etching times

You need to transfer a pattern by etching to a SiO_2 layer, with a minimum depth of 1 µm. Due to other constraints, you only have available a 200 nm thick photoresist mask. What processes of all the ones provided are suitable to achieve this? For each of them calculate the required etching time and the remaining mask thickness.

Hint: The concept of selectivity is explained in the Notebook.