

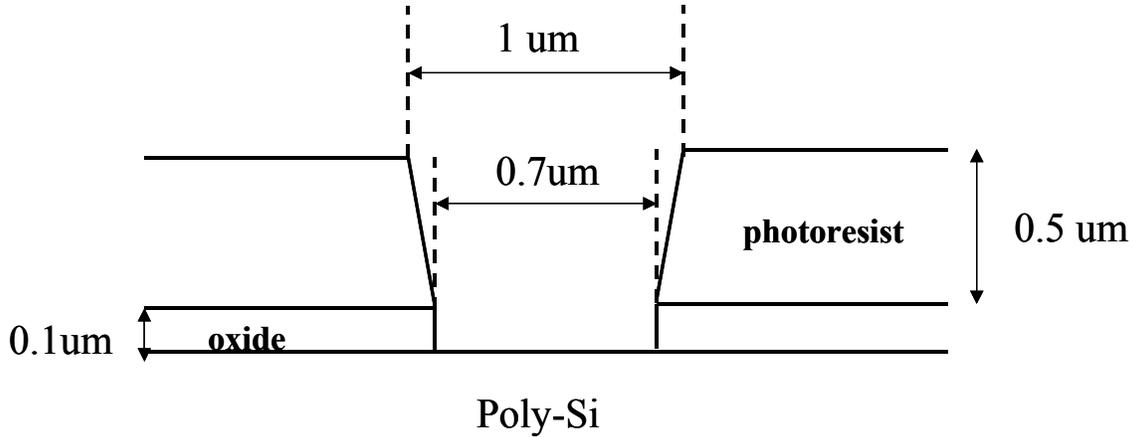
Homework Assignment # 7 (Due Oct 27, Thursday ,9:30am)

Reading Assignment

- 1) EE143 reader Week #8 : Chapter on Etching by G. Anner, “Planar Processing Primer”
- 2) EE143 Lecture Notes

Problem 1 Etching Profile

(a) Poly-Si of the following structure is to be etched using a **completely anisotropic** dry-etch process, to remove poly-Si at a rate of $0.1 \mu\text{m} / \text{min}$. However, this etch process has poor selectivities: selectivity to SiO_2 is 5; selectivity to photoresist is 2.



- (a) Sketch the cross-section after 5 minutes of etching.
- (b) Calculate the angle of the SiO_2 sidewalls after 5 minutes of etching.

Problem 2 Poly-Si cross-section if mask is also etched

The structure shown below is subjected to an etching process to form a poly-Si line with the following etching characteristics

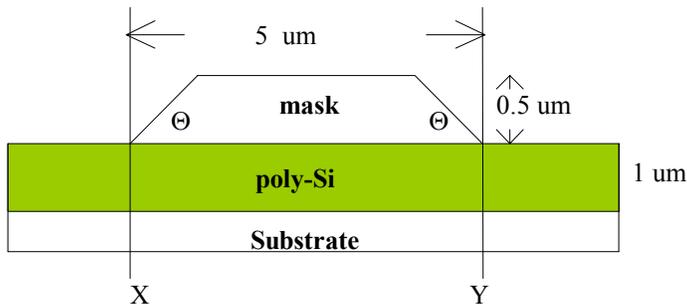
Vertical mask etching rate = $0.01 \mu\text{m} / \text{min}$

Vertical poly-Si etching rate = $0.1 \mu\text{m} / \text{min}$

Degree of anisotropy for mask etching, $A_m = 1$

Degree of anisotropy for poly-Si etching, $A_p = 0$

$\theta = 60^\circ$



* The mask and poly-Si have absolute uniform thicknesses.

* The mask and poly-Si have absolute uniform etching rates.

- (i) After the poly-Si has just been cleared at points X and Y, **sketch** the cross-sections of the poly-Si and mask. Include the original two vertical dash lines at X and Y for reference.
- (ii) Find the **maximum** width of the poly-Si line cross-section?
- (iii) Find the **minimum** width of the poly-Si line cross-section?
- (iv) Find the **maximum** linewidth of the mask cross-section?
- (v) Find the **maximum** thickness of the mask cross-section ?

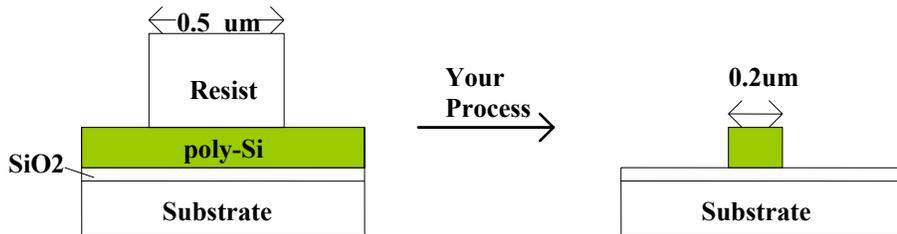
Problem 3 Worst-case design considerations

A 0.5 μm SiO₂ on a Si substrate is to be etched away. It is known there is a ±5% variation of the oxide thickness and a ±5% variation in the oxide etch rate.

- (a) How much overetch (in % etch time) is required to ensure all oxide on Si is removed?
- (b) What minimum selectivity of the oxide etch rate to the Si etch rate is required so that a maximum of 5nm (= 0.005 μm) of Si etched with the overetch calculated in part (a).

Problem 4 Deep submicron patterning by overetching

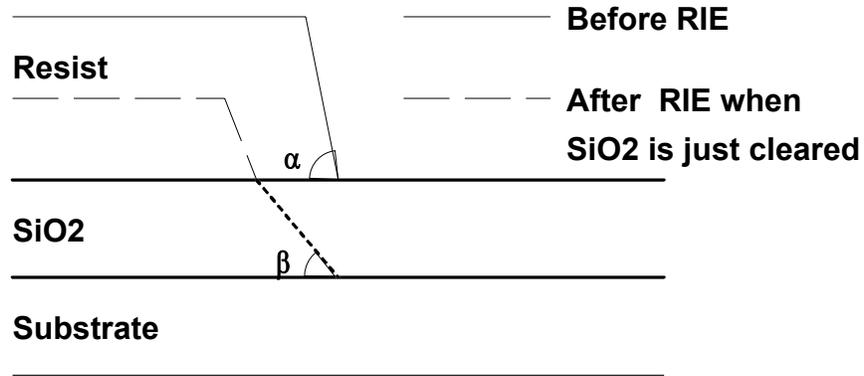
We would like to fabricate devices with deep-submicron dimensions but our lithography equipment can only pattern resist linewidths down to 0.5 μm at best. For resists with vertical sidewalls, propose a simple process flow which can give 0.2 μm poly-Si linewidth with **vertical sidewalls**. You cannot use undercut with wet etching because the sidewall will be curved.



Problem 5 Sidewall slope of contact holes

Taking advantage of photoresist erosion during reactive ion etching of SiO₂, we can vary the slope angle of SiO₂ contact holes. The following schematic shows the resist and SiO₂ cross-sections before (solid lines) and after (dash lines) reactive ion etching. Given:

- $\alpha = 80^\circ$
- V_{Rv} = vertical etching rate of resist = 1000 Å/min
- V_{Rl} = lateral etching rate of resist = 500 Å/min
- V_{Ov} = vertical etching rate of oxide = 1000 Å/min
- V_{Ol} = lateral etching rate of oxide = 0 Å/min



- (i) Use algebra to prove that the slope of SiO₂ after etching is a **straight line** with constant β .
- (ii) If V_{RV} , V_{RL} , and V_{OV} all have a variation of $\pm 10\%$ from run to run. Find the **maximum** and **minimum** values of β .

Problem 6 RIE Questions

- (a) How can we increase the degree of anisotropy in reactive ion etching?
- (b) Selectivity in reactive ion etching can be increased by using gas mixtures. Quote one example to illustrate the principle.
- (c) In class and in the reader, we discuss the formation of an inhibitor during RIE can enhance etching anisotropy. However, with *excessive* inhibitor deposition rate, the sidewall of the etch film can be **more tapered** than less inhibitor deposition (illustrated in the attached figures). Fill in the intermediate cross-sections to show progression of the etching process .

