N.CHEUNG **EE143, S2006**

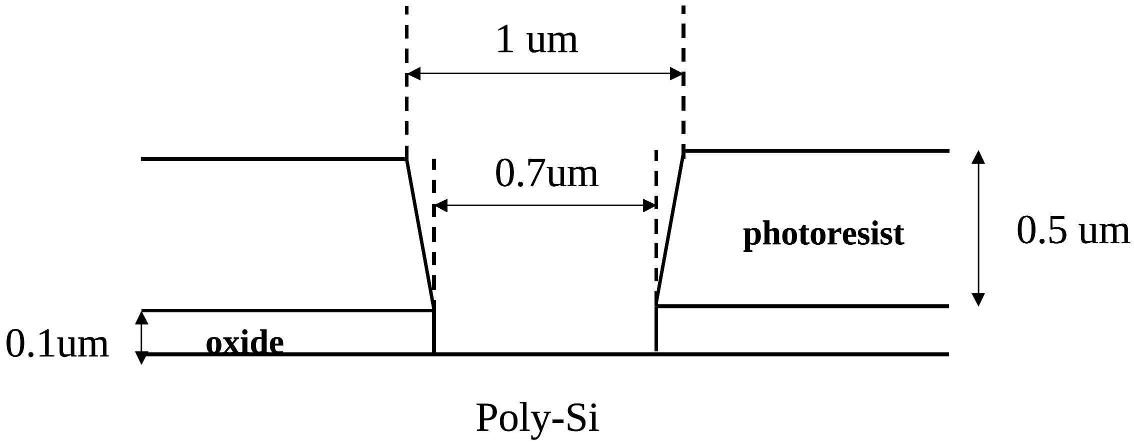
Homework Assignment # 7 (Due March 16, Thursday 8am)

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 µm /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

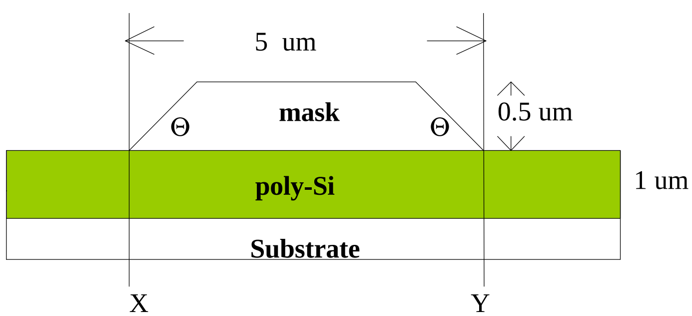
Vertical mask etching rate = 0.01 µm/min

Vertical poly-Si etching rate = 0.1 µm/min

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

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

$\theta = 60°$



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

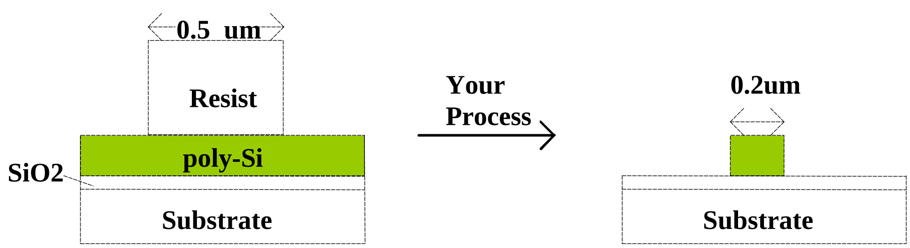
(i) After the poly-Si has just been cleared at points X and Y, **sketch** the cross-sections of the poly-Si and mask. Include the original two vertical dash lines at X and Y for reference.
(ii) Find the **maximum** width of the poly-Si line cross-section?
(iii) Find the **minimum** width of the poly-Si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

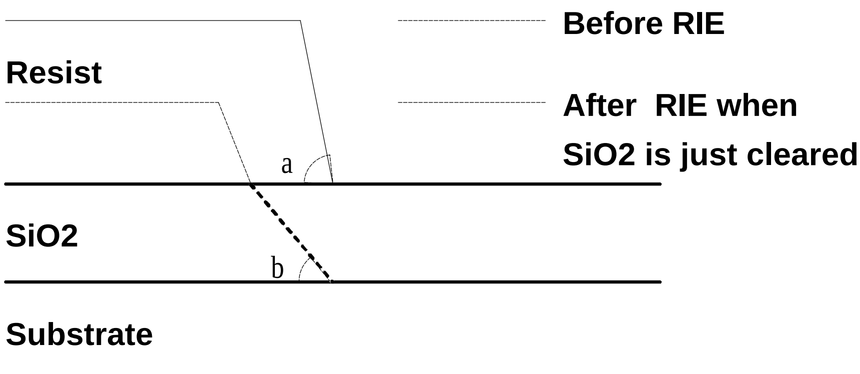
We would like to fabricate devices with deep-submicron dimensions but our lithography equipment can only pattern resist linewidths down to 0.5 µm at best. For resists with vertical sidewalls, propose a simple process flow which can give 0.2 µm poly-Si linewidth with **vertical sidewalls**. You cannot 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 SiO_2, we can vary the slope angle of SiO_2 contact holes. The following schematic shows the resist and SiO_2 cross-sections before (solid lines) and after (dash lines) reactive ion etching. Given:

$\alpha = 80°$
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 SiO_2 after etching is a **straight line** with constant β.
(ii) If V_{Rv}, V_{Rl}, and V_{Ov} all have a variation of ±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 .