N.CHEUNG EE143, F2005

Homework Assignment # 6 (Due Oct 20, Thur 9:30am , together with HW#5)

Reading Assignment

A. Chapter 6 of Jaeger (Sections 6.4.2 and 6.4.3 are not required)

B. EE143 Reader: Week #6

1) "Vaccum Technology" and " Sputtering Basics" reprints

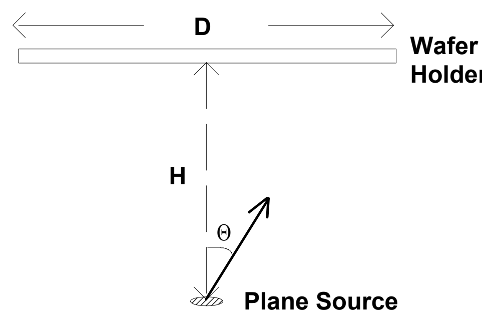
2) Chapter 13 of Campbell on CVD (qualitative) .You can skip Section 13.2

3) Optional :"Gas Systems" reprint

C. Special EE143 Handout - Notes on CVD Kinetics

Problem 1 Evaporation Uniformity using a small Planar Source

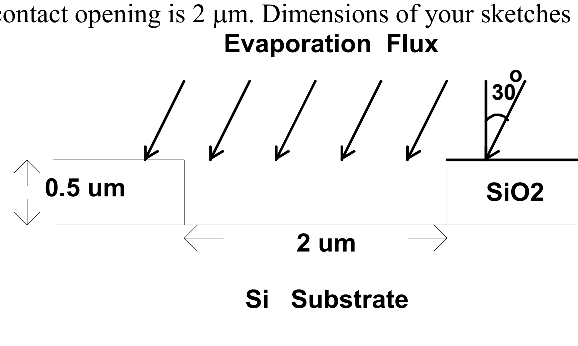
(a) A Si wafer of diameter D is placed at a height H above a small planar evaporation source. The evaporation flux is proportional to $\cos\theta$ where θ is the angle the flux makes with the normal to the plane source. Derive an expression for the ratio of the deposited film thickness at the center of wafer to the deposited film thickness at the edge of the wafer in terms of D and H.



(b) E-beam evaporation of aluminum is modeled as a small planar source. For a 300-mm-diameter wafer, the center of wafer receives a 0.6 μm thick aluminum. If the aluminum thickness difference between center of wafer and edge of wafer has to be less than 0.06 μm, what will be the minimum source-wafer distance (i.e., distance H shown in figure)?

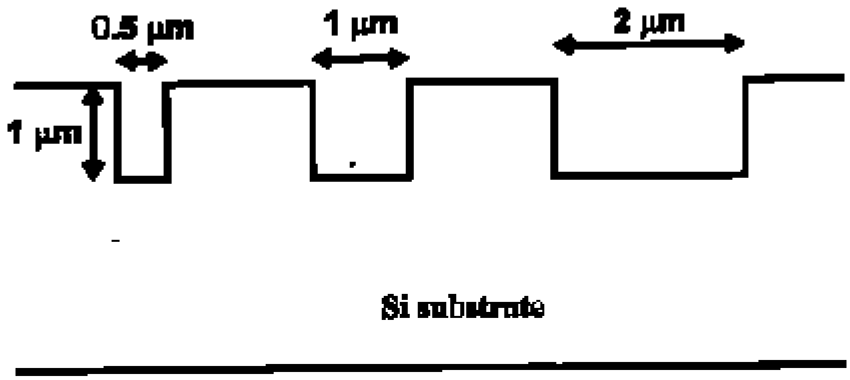
Problem 2 Evaporation Shadowing

If the evaporation source is very far from the wafer, we can treat the evaporation fluxes to be uniform and parallel. The following contact opening has vertical SiO_2 sidewalls and the evaporating flux is making an angle 30° with respect to the normal of the wafer's surface. If the film deposition rate is 1000Å/min, sketch the cross-sectional profile of the film over the SiO_2 and Si after (a) 1 min, and (b) 2 min. The SiO_2 step height is 5000Å and the contact opening is 2 μm. Dimensions of your sketches have to be proportional.



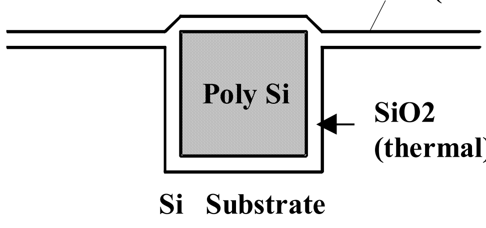
Probelm 3 Conformal Deposition

(a) Complete conformal coverage will have identical deposition rates **normal** to the suface for all surface topography. With a deposition rate of 0.1 micron/min on planar surfaces, sketch the cross-sections of the deposited film for a completely conformal deposition (e.g. CVD) at time = 1 min, 2 min, 3 min, and 4min.



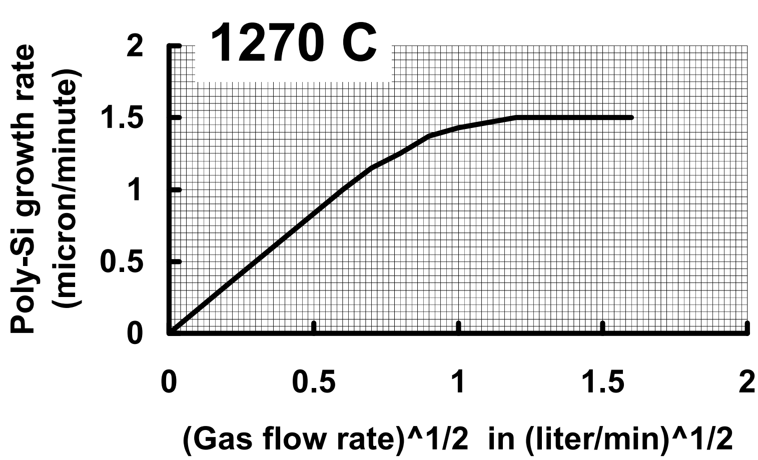
(b) Briefly comment on the deposited thickness required to obtain a planarized surface for substrate with various trench aspect ratios (i.e., height/width ratio).

Problem 4 Poly Refill Planarization
Suppose we would like to fabricate the following structure for oxide isolation. The poly-Si is just used as a filler to planarize the surface.



Suggest a process sequence which can achieve such a structure. Starting with a blanket Si wafer, only **ONE** lithography step is allowed. You have to be specific with the processing techniques used in the DESCRIPTION column and sketch the cross-sections at each critical step. [Hint : You may want to use the results in Problem 3]

Problem 5 CVD
Poly-Si is deposited by CVD at 1270°C. The concentration of Si atoms in the gas stream is 4×10^{16} /cm^3. The growth rate versus (gas flow-rate)$^{1/2}$ curve is shown below.



(i) Explain briefly why the deposition rate is linearly proportional to the square-root of the flow rate at low flow-rates

(ii) Explain briefly why the deposition rate is independent of the flow rate at high flow-rates

(iii) Use the Grove model to **estimate** the gas transport coefficient h_G at a deposition rate of 0.1 μm/min .
[Hint: atomic density of poly-Si is 5×10^{22} / cm^3]

(iv) The following sketch shows the mass depletion problem of CVD can be minimized by using a higher flow rate while keeping the same pressure. Explain why ? [Hint : it is not due to h_G]