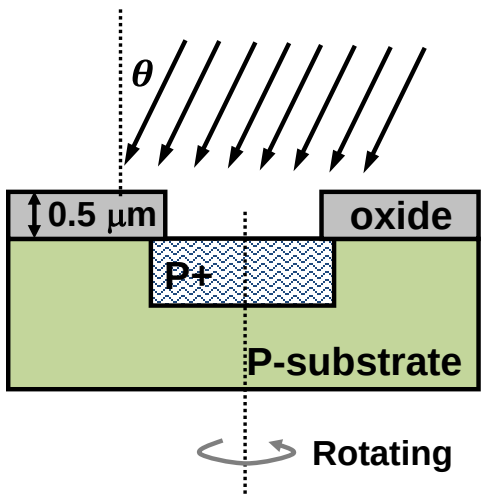
PROBLEM SET #6

Issued: Tuesday, Oct. 8, 2014

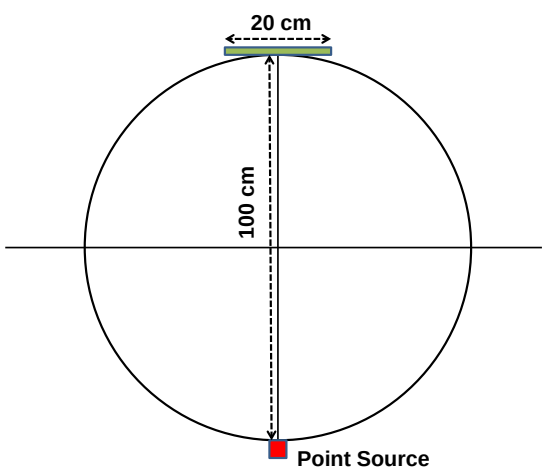
Due: Wednesday, Oct. 15, 2014, 8:00 a.m. in the EE 143 homework box near 140 Cory

• Film Deposition

1. Suppose you plan to evaporate aluminum over a substrate with a layer of patterned oxide to form an ohmic contact as illustrated below. Assume that the evaporation source is very far from the wafer such that the evaporation flux can be considered as uniform and parallel, that the contact opening has straight vertical sidewalls, and that the substrate is mounted on a chuck that rotates about the normal axis of the wafer surface to avoid the shadowing effect. The evaporation flux has an angle of θ with respect to the normal axis. Find the range of θ that yields the thickness of Al on the oxide sidewall within a percentage variation of 5% relative to that on the flat surface.

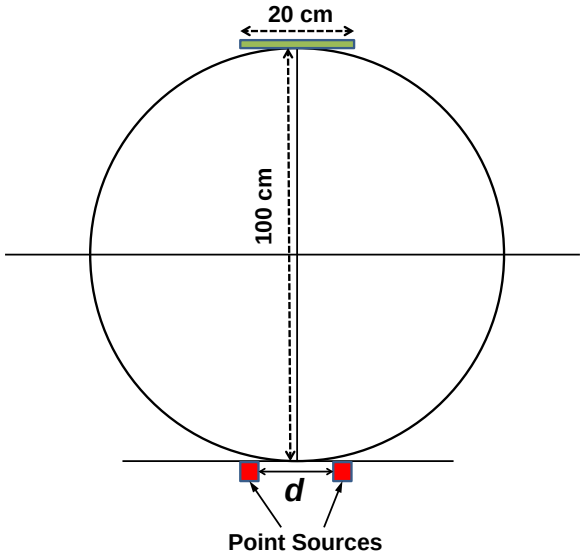


2. A wafer with a diameter of 200 mm is mounted in an evaporation system in which the spherical diameter is 100 cm as shown below.

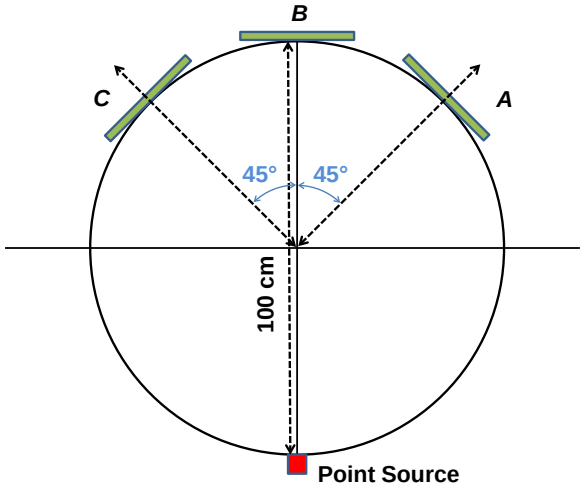


(a) Use Eq. (6.7) in Jaeger to estimate the worst-case percent variation (relative to the thickness in the center of the wafer) in the film thickness across the wafer diameter.

(b) Repeat (a) with a two-source configuration, where each of the sources is placed 5 cm away from the center (i.e., d = 10 cm).



(c) Now, suppose the wafer is mounted with an angle above a single point source. Estimate the percentage variation of film thickness (again, relative to the thickness in the center) across the wafer for location A.



(d) To alleviate the shadowing effect, the wafer is mounted on a movable chuck and deposited with the material at the locations A, B and C. Estimate the percentage variation of film thickness on the wafer after being deposited for the same amount of time at each of the locations (e.g., deposit for t mins at A, then t mins at B, and finally t mins at C).

3. Suppose a $SiCl_4$ source is used to deposit polysilicon via chemical vapor deposition (CVD). Assume the $SiCl_4$ concentration in the gas stream N_g is 5×10^{16} molecules/cm^3, the mass-transfer coefficient h_g is 0.63 cm/sec, the surface-reaction rate constant k_s is $2 \times 10^6 \exp(-1.9/kT)$ cm/sec, and the polysilicon atom density is 5×10^{22} atoms/cm^3.

   (a) Estimate the polysilicon film growth rate, assuming the CVD process is mass-transfer limited.

   (b) At what temperature does the mass-transfer coefficient h_g equal the surface-reaction rate constant k_s? What is the growth rate at this temperature?

   (c) The following figure (i.e., Fig. 6.10 in the textbook) shows the deposition rates of polysilicon for four different gas sources. From the SiH_4 curve, estimate the activation energy E_A (in eV) for the surface-reaction rate constant.