PROBLEM SET 1

Issued: Tuesday, January 23, 2007

Due (at the beginning of class): Tuesday, January 30, 2007

1. An IC manufacturing plant produces 2000 wafers per week. Assume that each wafer contains 100 dice, each of which can be sold for $80 if functional. The yield on these devices is currently 50%. If the yield can be increased, the incremental income is almost pure profit because all 100 chips on each wafer are manufactured whether they work or not.

   (a) How many additional die per wafer need to function properly in order to produce an annual profit increase of $50,000,000?

   (b) Now assume that the design is being re-targeted to a different and denser process technology. What density improvement would be needed to reach the same $50,000,000 annual profit increase? Use the negative binomial yield model described in class with the product of defect density (D_0) and original chip area (A_{chip}) = 1 (assume A_{crit} = A_{chip}). Also, assume the clustering factor α and D_0 remain the same when moving to the new process.

2. A <100> silicon wafer is oxidized for 1.3 hours at 1150^oC in dry O_2. It is then photomasked and has the oxide removed over half the wafer. The whole wafer is then oxidized again in steam at 900^oC for 37 minutes.

   (a) Determine the oxide thickness in the two regions using the oxidation equations. (**DO NOT** use the graphs in the text to determine the oxide thickness or the rate constants B/A and B)

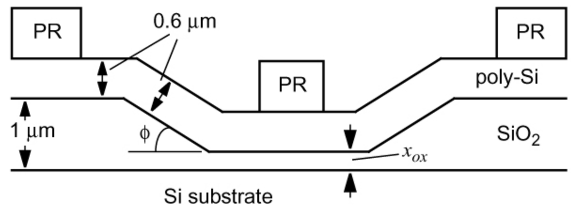
   (b) Using this link below (www.lelandstanfordjunior.com/thermaloxide.html) repeat part (a). Compare with the results of part (a) and comment on any possible sources of difference.

   (c) Draw an accurate cross-sectional sketch of the transition region between the two oxide thicknesses. Be sure to calculate and indicate the oxide surface step height and the step height in the silicon substrate.

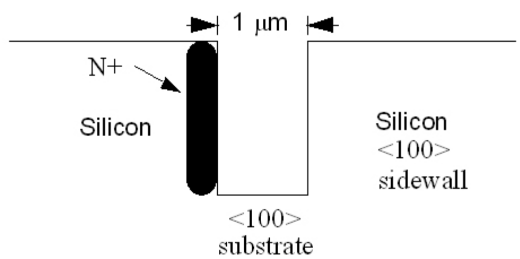
3. 0.6μm of poly-Si is conformally deposited on a wafer with topography as shown on the next page. In etching the poly-Si, it is required that all unmasked poly-Si be cleared without etching into the substrate. Assume that the poly-Si etching process has the following selectivities: poly-Si /SiO_2=8/1, poly-Si/photoresist=2/1. Determine the maximum allowable step angle in ϕ (the thin to thick oxide transition) if the thin oxide thickness x_{ox} is:

   (a) 40nm
   (b) 20nm
   (c) 10nm

   Assume a completely directional etch.



4. A 1µm wide trench is etched in a <100> silicon wafer, so that the sides of the trench are <110> planes. An angled implant is performed, doping one sidewall N^+ and thereby enhancing the appropriate rate constant by a factor of 4. The structure is then oxidized in steam at 1100^{o}C. At what time during the oxidation will the trench be filled with SiO_2? Assume the appropriate oxidation coefficients scale as follows (111:110:100) = (1.68:1.2:1).



5. Boron is to be implanted into a Si wafer to form the source and drain of a MOSFET. The dose is 3E12/cm^2 and the energy is 80keV. A drive-in step is performed for 10 minutes at 900^{o}C. Assume the background concentration to be 10^{14}cm^{-3}

   (a) Find the resulting junction depth, x_j. Ignore the Dt product of ion implantation.

   (b) Now assume there is a ramp-up and ramp-down time for the furnace from 0^{o}C to 900^{o}C of 900C/10s. Recalculate the new junction depth, x_j.