EECS 523 Homework #3

1- Deal and Grove have modeled thermal oxidation of silicon by a linear and parabolic function of time for short and long time oxidation respectively. It is realized that there is not any specific oxide thickness that could be considered as the transition point between these two regions. But, one can mathematically define an approximate boundary for this transition point. Having this in mind answer the following questions:

a) Show that this boundary can be defined at Xo = B / 2(B/A).

b) Plot Xo for oxidation temperature ranging from 800 to 1200˚C on <111> surface (with H_2O and dry O_2).

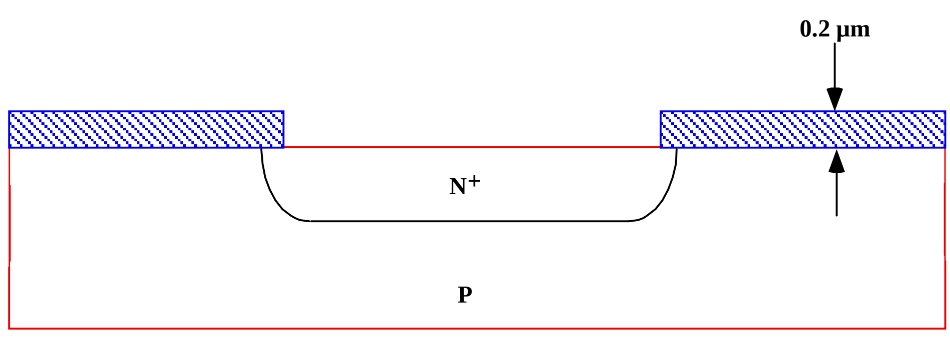
c) How does the plots change for <100> surface.

2- A silicon wafer is covered by an SiO_2 film 0.3 μm thick.

a) What is the time required to increase the thickness by 0.5 μm by oxidation in H_2O at 1200˚C?

b) Repeat for oxidation in dry O_2 at 1200˚C.

3- The structure shown below is formed by oxidizing a silicon wafer (x_0 = 200 nm), and then standard masking and etching techniques are used to remove the SiO_2 in the center region. An N^+ doping step is then used to produce the structure shown. The structure is next placed in an oxidation furnace and oxidized at 900˚C in H_2O. The oxide will grow faster over the N^+ region than it will over the lightly doped substrate. Assume that B/A is enhanced by 4X over the N^+ region. Will the growing oxide over the N^+ region ever catch up in thickness to the other oxide? If so, when and at what thickness? use the Deal Grove model for the oxidation kinetics.



4- A phosphorus doped poly silicon, 0.5 μm thick as shown below is used as an electrical resistor.

a) The doping concentration in the polysilicon is $1 \times 10^{16}\ \text{cm}^{-3}$. The carrier mobility $\mu = 100\ \text{cm}^2 \text{V}^{-1} \sec^{-1}$ is low because of scattering at grain boundaries. If the resistor has L=100μm, W=10μm, what is its resistance in Ohms? (In this problem we are disregarding the effect of metal contacts and the pads).

b) A thermal oxidation is performed on the polysilicon for 2 hours at 900˚C in H_2O. Assuming B/A for polysilicon is 2/3 that of <111> silicon, what is the polysilicon thickness that remains.

c) Considering phosphorous segregation during oxidation of the polysilicon (suppose still uniform doping concentration), what is the new value of the resistor in (a). Assume the mobility does not change.

5- 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 the sidewall N^+ and thereby enhancing the linear rate constant by a factor of 4. The structure is then oxidized in steam at 1100˚C. At what time during the oxidation will the groove be filled with SiO_2? Assume the appropriate oxidation coefficients scale as [(<111> : <110> : <100>) = (1.68 : 1.2 : 1.0)].