EE 203. HW3 Due 5/12

1. In Si
a. (5 pts) How many equivalent conduction band valleys are there?
b. (5 pts)Where are they?

2. In Ge,
a. (5 pts)How many equivalent conduction band valleys are there?
b. (5 pts)Where are they?

3. In GaAs,
a. (5 pts)How many equivalent conduction band valleys are there?
b. (5 pts)Where are they?

4. Describe the valence band structure of semiconductors.
a. (5 pts)Where does the maximum occur?
b. (5 pts)Sketch the bands.

5. (10 pts) Describe the process(es) by which an electron at the valence band maximum in Si could absorb a photon equal to the bandgap. Illustrate the process(es) on a sketch of the E-k diagrams.

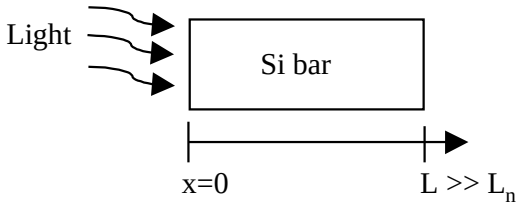
6. (10 pts)Derive the following expressions for **degenerate** statistics. You will need to use the

$$J_p = \mu_p p \vec{\nabla} F_p$$

$$J_n = \mu_n n \vec{\nabla} F_n$$

properties of the $\Im(\eta)$ function described in class.

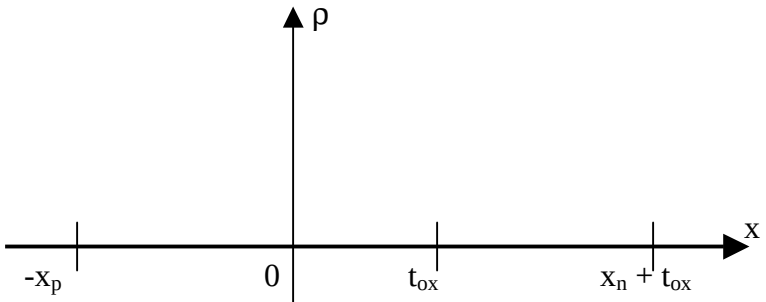
7. (10 pts) A Si bar has the following properties: $N_A = 10^{15}/cm^3$, $\mu_n = 1350\ cm^2/Vs$, $\mu_p = 500\ cm^2/Vs$, $\tau_n = \tau_p = 10^{-6}s$. The left end of the bar is illuminated so as to create $10^{10}/cm^3$ excess electron hole pairs at x=0. Assuming none of the light penetrates into the interior of the bar (x>0), Determine the excess minority carrier profile.



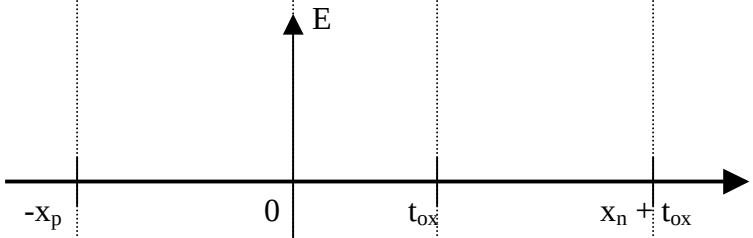
8. (10 pts) Assume that now, $L < L_n$, and, that at the right surface, the surface recombination rate is so large that $\Delta n = \Delta p = 0$. Determine the excess minority carrier profile.

9. Consider a p-type ($N_A = 10^{18}$ cm^{-3}) Si / 10 nm SiO_2 / n-type Si ($N_D = 10^{18}$ cm^{-3}) structure at 0 bias and T=300K, i.e. a pn junction with a 10 nm oxide between the n and p regions. Using the depletion approximation as we did for the pn diode.

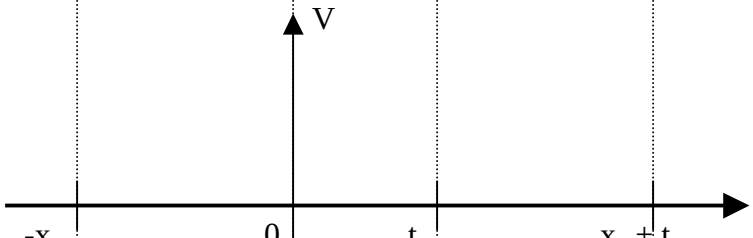
a. (10 pts) Sketch the charge distribution.
Label maximum and minimum points.



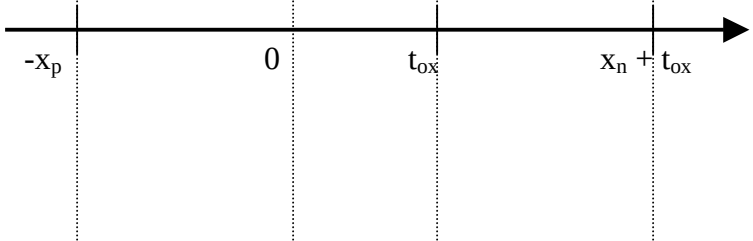
b. (10 pts) Sketch the electric field.
($\varepsilon_{Si} = 11.9$ & $\varepsilon_{SiO_2} = 3.9$)
Label max and min points.



c. (10 pts) Sketch the electrostatic potential.
Label max and min points.



d. (10 pts) Sketch the band diagram.
(E_G SiO_2 = 9 eV. $Ec(Si0_2) - Ec(Si)$ = 3eV)
(you will not be able to draw it to scale)



e. (10 pts) Calculate the built in voltage, V_{bi}.(A number in volts).

f. (50 pts) Calculate the total depletion width, $W = x_p + t_{ox} + x_n$. (a number in nm). You first have to derive the appropriate expression for W. No credit will be given for simply taking the W derived for a pn or pin junction. Pay attention to the 2 different dielectric constants.

(g) (30 pts) Calculate the capacitance in (F/cm^2).