ECE344 Fall08

HOMEWORK 4

P-N junctions

1 Problem 1

An abrupt Si P-N junction has $N_a = 10^{18} cm^{-3}$ on one side and $N_d = 5 * 10^{15} cm^{-3}$ on the other.

1. Calculate the Fermi-level positions at 300K in the P and N regions (relative to E_i levels).
2. Sketch to scale an equilibrium band diagram for the junction and determine the built-in potential qV_o from the diagram (in eV).
3. Compare the previous result with the one obtained by equation (5.10) in class (or textbook).
4. Using the full depletion approximation, calculate x_n, x_p, the electric field ε and Q the total charge density in the P or N side. We will suppose that the P-N junction has a circular cross section with a diameter of $10\mu m$. You will also sketch $\varepsilon(\mathrm{x})$ and the charge density $\rho(x)$ to scale.

2 Problem 2

An abrupt P-N junction (with cross section $A = 10^{-4} cm^2$) has the following properties at 300K.

P-side	N-side
$N_a = 10^{17} cm^{-3}$	$N_d = 10^{15} cm^{-3}$
$\tau_n = 0.1 \mu s$	$\tau_p = 10 \mu s$
$\mu_p = 200 cm^2/V.s$	$\mu_n = 1300 cm^2/V.s$
$\mu_n = 700 cm^2/V.s$	$\mu_p = 450 cm^2/V.s$

The junction is forward biased by $0.5V$. Using the "ideal diode" assumption, what is the forward current ? what is the current at a reverse bias of $-0.5V$? **You will report in a TABLE of the numerical values of all the physical quantities that are necessary to compute the current** I **(you will use** $n_i = 1.5 * 10^{10} cm^{-3}$**).**

3 Problem 3

1. Consider a GaAs P-N junction (ideal diode) with a reverse saturation current $\mathrm{I_o} = 10^{-18}\mathrm{A}$, calculate the applied bias potential required to obtain a current of $10\mathrm{mA}$.
2. An abrupt silicon ($n_i = 10^{10} cm^{-3}$) p-n junction consists of a p-type region containing $10^{16} cm^{-3}$ acceptors and a n-type region containing $5 * 10^{16} cm^{-3}$ donors. Calculate the built-in potential of this p-n junction. For an applied voltage equals 0, 0.5 and -2.5V, calculate the total width of the depletion region (in μm), calculate maximum electric field in the depletion region (in kV/cm), calculate the potential across the depletion region in the n-type semiconductor (in Volt). You will put these nine results into a summary table.

	$V_a = 0V$	$V_a = 0.5V$	$V_a = -2.5V$
$W \mu m$			
$E(kV/cm)$			
$V_n(V)$			