ECE 340 **Fall 2015**

Homework Assignment #8

DUE: FRIDAY, OCTOBER 30, 2015

Print your **name** and **NetID** legibly. Follow the guidelines and format given in the syllabus. Staple multiple pages. Show all units. Homework must be turned in at the **beginning** of class and any late homework assignments will not be accepted. Please contact the course director, Professor Dallesasse, should any issues with late homework arise.

1. BREAKDOWN OF P-N JUNCTION

For a symmetric Si p-n junction ($N_A = N_D = 10^{17}$ cm^{-3}):

(A). Determine the reverse breakdown voltage if the peak electric field in the junction at breakdown is 6×10^5 V/cm.

(B). Calculate the depletion region thickness just prior to avalanche breakdown.

2. JUNCTION CAPACITANCE OF A SI P$^+$-N JUNCTION

A Si p$^+$-n junction has $N_D = 5\times10^{15}$ cm^{-3} and a cross-sectional area of 100 μm^2.

(A). Calculate the capacitance of the junction under reverse bias V_R of 1, 5, and 10V.

(B). Plot $1/C^2$ vs. V_R for the three cases.

(C). Demonstrate that the slope of the plot in (B) yields the donor concentration N_D.

3. EFFECT OF DOPING IN A P-N$^+$ JUNCTION

The p-doping N_A of a p-n$^+$ junction is quadrupled. How do the following change if everything else remains unchanged? Indicate only increase, decrease, or unchanged. Justify your answers.

(A). Junction capacitance

(B). Built-in potential

(C). Breakdown voltage

(D). Depletion width

(E). Ohmic losses

4. Solar Cells

A Si solar cell has the following parameters:

$N_A = 6\times10^{16}$ cm^{-3}
$N_D = 2\times10^{15}$ cm^{-3}
$D_n = 20$ cm^2/s
$D_p = 10$ cm^2/s
$\tau_n = 0.2\ \mu$s
$\tau_p = 0.1\ \mu$s
Area = 1 cm^2

The solar cell is under constant illumination which gives $g_{op} = 4\times10^{16}$ cm^{-3}s^{-1}.

(A). Calculate the short circuit current.

(B). Is the drift or diffusion photocurrent dominant? What fraction of the total current is due to the dominant mechanism?

(C). What are the maximum concentration of the minority electrons and holes?

5. Photodiodes and Light Emitting Diodes

NOTE: Some of the topics in this problem will not be covered in lecture until Friday 10/30/2015. Please read ahead on sections 8.1, 8.2, and 8.4 from the Streetman textbook to find the information required.

(A). The active area of a photodiode is governed by its depletion width. Describe the effect of depletion width on the sensitivity and response time of a photodiode.

(B). Describe the trade-offs for high and low doping in a photodiode. How does one design a photodiode with large depletion width?

(C). Explain why ternary and quarternary III-V alloys are more widely used as the active component in optoelectronic devices than group-IV or III-V semiconductors.

(D). Determine the required composition x of $Al_xGa_{1-x}As$ to construct an LED operating at 650nm. Repeat for $GaAs_{1-x}P_x$. Refer to Fig. 3-6 and 8-11.