ECE 340 # Homework Assignment #4 **Fall 2015**

DUE: FRIDAY, SEPTEMBER 25, 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. CONDUCTIVITY

For a piece of N-type piece of silcon at 300K, its conductivity distribution is given as $\sigma(x) = 3e^{-x^2/2}$ $(\Omega\cdot\text{cm})^{-1}$. x is in the unit of μm, denoting the depth into the semiconductor from the surface.

(A). Find the average conductivity of this piece of silicon with an effective depth of 2 μm. HINT: evaluate the integral from 0 to ∞ and normalize over the depth.

(B). If the mobilities are given as $\mu_n = 1450\text{cm}^2/\text{V}\cdot\text{s}$ and $\mu_p = 500$ $\text{cm}^2/\text{V}\cdot\text{s}$, calculate the electron and hole concentration using your answer from part A.

2. RESISTANCE UNDER DOPING

A Si bar is 0.25 cm long with a cross-sectional area of $5\times10^4\mu m^2$. It is grounded at x = 0 and biased to +12 V at x=0.25 cm. Find the resistance and the current at T=300K:

(A). when the Si bar is doped with $2.5\times10^{17}\text{cm}^{-3}$ Arsenic

(B). when the Si bar is doped with $2\times10^{14}\text{cm}^{-3}$ Gallium and $1.99\times10^{14}\text{cm}^{-3}$ Arsenic

(C). Find the average drift velocity of an electron for each case.

(D). Explain how and why resistance varies with doping.

3. INVARIANCE

(A). Consider a doped GaAs material where E_f-E_i =0.4 eV. Draw its band structure, label E_c, E_v, E_f, and E_i and the relative energy separations.

(B). Consider the case when the above GaAs material has grown atop it a separately doped GaAs material; the second material has E_f-E_i =0.2 eV. At equilibrium, what can we say for certain about the band diagrams across the wafers?

4. Excitation and Band Gaps

You have three samples, one of pure GaN (E_g = 3.4 eV), one of $Al_{0.49}Ga_{0.51}As$ (E_g = 2.03 eV) and one of Si (E_g = 1.12 eV), and each have parallel faces and a thickness of 2 cm.

(A). When excited with a 10mW orange light LED centered at λ=612nm, which sample(s) transmit light?

(B). When excited with a 10mW white light LED (assume uniform visible spectrum energy distribution), state the order from lowest to highest in which the semiconductors transmit the light. Why is this? Note the spectrum for the white LED you used in your answer.

5. Excess Carriers and Optical Absorption

A 0.5-μm Si wafer is doped with 4×10^{16} cm^{-3} donors and has an excess carrier concentration of 4×10^{14} cm^{-3}.

(A). Calculate the recombination coefficient, α_r, if $\tau_p = \tau_n = 10$ μs.

(B). If the wafer is excited with an $h\nu$=1.9 eV monochromatic beam of light incident at 20mW and the absorption coefficient is 2×10^4 cm^{-1}, what is the rate of the absorbed energy given up thermally before recombination?