ELEC 321/4-H	INTRODUCTION TO SEMICONDUCTOR MATERIALS AND DEVICES	Winter 2018

Homework due on March 29th 2018

No late homework will be accepted

Homework #5

1. A particular intrinsic semiconductor has a resistivity of 50 Ω-cm at T=300 K and 5 Ω-cm at T=330 K. Neglecting the change in mobility and effective density of states with temperature, determine the bandgap energy of the semiconductor.

2. Three scattering mechanisms are present in a particular semiconductor material. If only the first scattering mechanism were present, the mobility would be 2000 cm^2/V-s, if only the second mechanism were present, the mobility would be 1500 cm^2/V-s, if only the third mechanism were present, the mobility would be 15 cm^2/V-s. What is the net mobility?

3. A semiconductor material has electron and hole mobilities μ_n and μ_p, respectively. When the conductivity is considered as a function of the hole concentration p_0, (a) show that the minimum value of conductivity, σ_{min} can be written as

$$\sigma_{\min} = \frac{2\sigma_i(\mu_n\mu_p)^{1/2}}{(\mu_n+\mu_p)}$$

Where σ_i is the intrinsic conductivity, and (b) show that the corresponding hole concentration is $p_0 = n_i(\mu_n/\mu_p)^{1/2}$.

4. A constant electric field, E=12 V/cm, exists in the +x direction of an n-type gallium arsenide semiconductor for $0 \le x \le 50\mu m$. The total current density is constant and is equal to 100 A/cm^2. At x=0, the drift and diffusion current densities are equal. Let T=300 K and μ_n=8000 cm^2/V-s. (a) Determine the expression for electron concentration n(x). (b) Calculate the electron concentration at x=0 and at x=50 μm. (c) Calculate the drift and diffusion current densities at x= 50 μm.

5. In a GaAs sample the donor impurity concentration varies as $N_{d0}\exp(-x/L)$ for $0 \le x \le L$, where L=0.1 μm and $N_{d0}=5\times10^{16}$ cm^{-3}. Assume μ_n=6000 cm^2/V-s and T=300 K. (a) Derive the expression for the electron diffusion current density versus distance over the given range of x. (b) Determine the induced electric field that generate the drift current density that compensates the diffusion current density.

6. Germanium is n-type doped at 5×10^{15} cm^{-3} at T=300 K. The dimensions of the Hall device are $d=5\times10^{-3}$ cm, $W=2\times10^{-2}$ cm, and $L=10^{-1}$ cm. The current is I_x=250 μA, the applied voltage is V_x=100 mV, and the magnetic flux density is B_z= 500 gauss=5×10^{-2} T. Calculate: (a) the Hall voltage, (b) the Hall field, and (c) carrier mobility.

7. A perfectly compensated semiconductor is one in which the donor and acceptor impurity concentrations are exactly equal. Assuming complete ionization, determine the conductivity of silicon at T=300 K in which the impurity concentrations are (a) $N_a=N_d=10^{14}$ cm^{-3} and (b) $N_a=N_d=10^{18}$ cm^{-3}. Use the appropriate graphs from the text with reference to the graph, if necessary.