JAYPEE INSTITUTE OF INFORMATION TECHNOLOGY

Electronics and Communication Engineering

Electrical Science-2 (15B11EC211)

Tutorial Sheet: 8

Q.1 [CO3] Three scattering mechanisms are present in a particular semiconductor material. If only the first scattering mechanism were present, the mobility would be μ_1=2000 cm^2/V-s, , if only the second mechanism were present, the mobility would be μ_2=1500 cm^2/V-s, and if only the third mechanism were present, the mobility would be μ_3=500cm^2/V-s . what is net mobility μ?

Q.2 [CO3] Calculate the drift current density in a semiconductor for a given electric field. Consider a germanium sample at T = 300K with doping concentration of Nd = 0 and Na = 10^{16} cm^{-3}. Assume complete ionization and electron and hole mobilities are 3900 cm^2/V·sec and 1900 cm^2/V·sec. The applied electric field is E = 50 V/cm.

Q.3 [CO3] Calculate the free electron concentration, mobility and drift velocity of electrons in aluminium wire of length of 5 m and resistance of 0.06 Ω carrying a current of 15 A, assuming that each aluminium atom contributes 3 free electrons for conduction. [Given: Aluminium Parameters: Resistivity:- 2.7 x 10^{-8} Ω-m, Atomic Weight =26.98, Density = 2.7 x 10^3 Kg/m^3, Avagadro number =6.025 x 10^{23}.

Q.4 [CO3] At 300 K, find the diffusion coefficient of electrons in silicon. Given the mobility of electrons (μ_n) is 0.21m^2/V-s.

Q.5 [CO3] The Hall coefficient (R_H) of a semiconductor is 3.22 × 10^{-4} m^3 C^{-1}. Its resistivity is 8.50 × 10^{-3} Ω-m. Calculate the mobility and carrier concentration of the carriers.

Q.6 [CO3] Mobilities of electrons and holes in a sample of intrinsic germanium at 300 K are 0.36 m^2/V-s and 0.17 m^2/ V-s, respectively. If the resistivity of the specimen is 2.12 Ω-m, compute the intrinsic concentration.

Q.7 [CO3] A silicon wafer has a 2-inch diameter and contains 10^{14} cm^{-3} electrons with a mobility of 1400 cm^2 /V-sec. How thick should the wafer be so that the resistance between the front and back surface equals 0.1 Ohm?

Q.8 [CO3] The phosphorous (donor) concentration in a region of a silicon crystal varies linearly from a concentration of n_0 = $10^{14}cm^{-3}$ at x = 0mm to a concentration of n_1 = $10^{17}cm^{-3}$ at x = 1mm. The diffusion constant for electrons is Dn = 22.5cm^2/s, the diffusion constant for holes is D_p = 5.2cm^2/s, and the temperature is 300 K. What is the diffusion current density in the positive x-direction?

Q.9 [CO3] Consider n-type silicon with Nd = $10^{15}cm^{-3}$ at T = 300K. A light source is turned on at t = 0. The source illuminates the semiconductor uniformly, generating carriers at the rate of Gn = Gp = $10^{19}cm^{-3}s^{-1}$. There is no applied field.

(a) Write down the continuity equation and solve it to find the expression for the excess minority carrier concentration, $\boldsymbol{\delta p(t)}$, as a function of time for $t \geq 0$.
(b) As $t \to \infty$, the system will approach steady state. When the steady state excess carrier concentration is $5\times10^{13}cm^{-3}$, find the minority carrier lifetime, $\boldsymbol{\tau p}$.

Q.10 [CO3] A uniformly-doped n-type silicon sample has N_D = 10^{18} 1/cm^3. At room temperature, n_i = 1.45×10^{10} 1/cm^3. Use μ_n=1200 cm^2/V.s, μ_p=400 cm^2/V.s. The carrier lifetimes are $\tau_n = \tau_p = 10^{-7}$ sec.
Let a fixed excess hole concentration $\Delta p_n = \delta p_n$ (x = 0) be injected and maintained at one edge of the sample, at x = 0. Then the excess hole concentration profile throughout the sample will be given by

$$\delta p(x) = \Delta p_n \exp(-x/L_p)$$

Find the Δp_n level required to maintain a hole diffusion current density $J_{p,diff} = 10^{-5}$ A/cm^2=10 μA/cm^2 at the edge x = 0 at room temperature (T = 300 K, $kT/q \approx 0.026$ V).