Physics of Semiconductor Devices

Physics Department, Tehran University, Tehran, Iran

Fall semester 1395

Exercises Series 2: EXCESS CARRIERS IN SEMICONDUCTORS

Due time: Aban 10th, 1395

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1. Problem 2,3,7,11,12,14,17of Chapter 4 from Streetman (6th Ed.). (20pt)

2. Explain 3 types of Recombination mechanism in semiconductors with example. (5pt)

3. Shockley-Read-Hall Theory of Recombination : Show that the recombination rate of electrons and holes due to the recombination center at $E = E_t$ is given by (10pt)

$$R = \frac{C_n C_p N_t \,(np - n_i^2)}{C_n(n + n') + C_p(p + p')}$$

Where

$R_{cn} = C_n N_t \left(1 - f_F(E_t)\right) n$

R_{en} = capture rate (#/cm^3-s)

C_n= constant proportional to electron-capture cross section

N_t= total concentration of trapping centers

n = electron concentration in the conduction band

$f_F(E_t)$ = Fermi function at the trap energy

$R_{en} = E_n N_t f_F(E_t)$

R_{en}= emission rate (#/cm^3-s)

C_p= constant proportional to the hole capture rate

E_n = constant

$f_F(E_t)$ = probability that the trap is occupied

4. Consider Shockley-Read-Hall equation and the definitions τ_{p0} and τ_{n0} given by $\tau_{p0} = \frac{1}{C_p N_t}$ and $\tau_{n0} = \frac{1}{C_n N_t}$. Let $\tau_{p0} = 10^{-7}$ s and $\tau_{n0} = 5 \times 10^{-7}$ s. Also let $n' = p' = n = 10^{10} cm^{-3}$. Assume very low injection so that $\delta n \ll n_i$. Calculate $\delta n/R$ for a semiconductor which is (a) n-type (b) intrinsic and (c) P-type. (5pt)