ECE-305: Key Equations (for exam 2)

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Physical constants:

$\hbar = 1.055\times10^{-34}$ [J-s]

$m_0 = 9.109\times10^{-31}$ [kg]

$k_B = 1.380\times10^{-23}$ [J/K]

$q = 1.602\times10^{-19}$ [C]

$\varepsilon_0 = 8.854\times10^{-12}$ [F/m]

Silicon parameters (T = 300K)

$N_C = 3.23\times10^{19}$ cm^{-3}

$N_V = 1.83\times10^{19}$ cm^{-3}

$n_i = 1\times10^{10}$ cm^{-3}

$K_S = 11.8$

DOS: $g_C(E) = \dfrac{\left(m_n^*\right)^{3/2}\sqrt{2\left(E-E_C\right)}}{\pi^2\hbar^3}$ FF: $f(E) = \dfrac{1}{1+e^{(E-E_F)/k_BT}}$ $n_i = \sqrt{N_C N_V}\,e^{-E_G/2k_BT}$

Equilibrium Carrier densities:

$n_0 = N_C e^{\left(E_F-E_C\right)/k_BT}$ m^{-3} $N_C = \dfrac{1}{4}\left(\dfrac{2m_n^*k_BT}{\pi\hbar^2}\right)^{3/2}$ m^{-3} $n_0 = n_i\, e^{(E_F-E_i)/k_BT}$

$p_0 = N_V e^{\left(E_V-E_F\right)/k_BT}$ m^{-3} $N_V = \dfrac{1}{4}\left(\dfrac{2m_p^*k_BT}{\pi\hbar^2}\right)^{3/2}$ m^{-3} $p_0 = n_i e^{(E_i-E_F)/k_BT}$

Space charge neutrality: $p - n + N_D^+ - N_A^- = 0$ **Law of Mass Action:** $n_0 p_0 = n_i^2$

Conductivity and resistivity: $\sigma = \left(\sigma_n + \sigma_p\right) = q\left(n\mu_n + p\mu_p\right) = 1/\rho$

Current equations: $J_n = n\mu_n \dfrac{dF_n}{dx}$ $J_n = nq\mu_n\mathcal{E}_x + qD_n\dfrac{dn}{dx}$ $D_n/\mu_n = k_BT/q$

$J_p = p\mu_p\dfrac{dF_p}{dx}$ $J_p = pq\mu_p\mathcal{E}_x - qD_p\dfrac{dp}{dx}$ $D_p/\mu_p = k_BT/q$

Recombination: SRH: $R = \Delta n/\tau_n$ m^{-3}s^{-1} or $R = \Delta p/\tau_p$ m^{-3}s^{-1}

Semiconductor Equations:

$$\frac{\partial n}{\partial t} = -\nabla\bullet\left(\frac{\vec{J}_n}{-q}\right) + G_n - R_n$$

$$\frac{\partial p}{\partial t} = -\nabla\bullet\left(\frac{\vec{J}_p}{q}\right) + G_p - R_p$$

$$0 = -\nabla\bullet\left(\varepsilon\vec{\mathcal{E}}\right) + \rho$$

Minority Carrier Diffusion Equation:

$$\frac{\partial\Delta p}{\partial t} = D_p\frac{\partial^2\Delta p}{dx^2} - \frac{\Delta p}{\tau_p} + G_L$$

$$L_p = \sqrt{D_p\tau_p}$$

Carrier densities and QFL's:

$n = N_C e^{\left(F_n-E_C\right)/k_BT}$ $n = n_i\, e^{(F_n-E_i)/k_BT}$

$p = N_V e^{\left(E_V-F_p\right)/k_BT}$ $p = n_i e^{\left(E_i-F_p\right)/k_BT}$