$$E = h\nu$$

$$n_0 = N_c e^{-(E_c - E_f)/K_B T}$$

$$N_c = 2\left[\frac{2\pi m_n^\star K_B T}{h^2}\right]^{\frac{3}{2}}$$

$$n_i = \sqrt{N_c N_v} e^{-E_g/K_B T}$$

$$n_0 = n_i e^{(E_f - E_i)/K_B T}$$

$$\mu = \frac{v}{\varepsilon}$$

$$\mu = q\frac{\tau}{m}$$

$$\frac{D}{\mu} = \frac{K_B T}{q}$$

$$J_n = nq\mu_n\varepsilon + qD_n\frac{\partial n}{\partial x}$$

$$g_{th} = \alpha_r n_0 p_0$$

$$g = g_{th} + g_{opt}$$

$$\frac{dn}{dt} = \frac{\partial n}{\partial t} - \frac{1}{q}\frac{\partial}{\partial x}J_n$$

$$n = n_i e^{(F_n - E_i)/K_B T}$$

$$Si : E_g = 1.11eV, n_i = 1.5 \times 10^{10} cm^{-3}$$

$$GaAs : E_g = 1.43eV, n_i = 10^6 cm^{-3}, \epsilon_r = 13.2$$

$$m^* = \frac{\hbar^2}{\frac{\partial^2 E}{\partial k^2}}$$

$$p_0 = N_v e^{-(E_f - E_v)/K_B T}$$

$$N_v = 2\left[\frac{2\pi m_p^\star K_B T}{h^2}\right]^{\frac{3}{2}}$$

$$E_i = \frac{(E_c + E_v)}{2} + \frac{3}{4}K_B T ln(\frac{m_p^*}{m_n^*})$$

$$p_0 = n_i e^{(E_i - E_f)/K_B T}$$

$$\sigma = \frac{J}{\varepsilon}$$

$$D = \frac{L^2}{2\tau}$$

$$I = I_0 e^{-\alpha t}$$

$$J_p = pq\mu_p\varepsilon - qD_p\frac{\partial p}{\partial x}$$

$$r = n.p$$

$$\tau = \frac{1}{\alpha_r(n_0 + p_0)}$$

$$\frac{dp}{dt} = \frac{\partial p}{\partial t} + \frac{1}{q}\frac{\partial}{\partial x}J_p$$

$$p = n_i e^{(E_i - F_p)/K_B T}$$

$$Si : m_n^* = 1.08m_0, m_p^* = 0.56m_0, \epsilon_r = 11.8$$