UCD Solid-State Electronics (1) Vers. G

LIST OF PHYSICAL CONSTANTS, SEMICONDUCTOR DATA & USEFUL FORMULAE

Physical Constants:

Planck's Constant	h	6.63 x 10^{-34} Joule.sec
Charge on Electron	q	1.60 x 10^{-19} Coulomb
Electron Rest Mass	m	9.11 x 10^{-31} kg
kT at Room Temperature	kT	0.0259 eV
Permittivity of free-space	ε_o	8.85 x 10^{-12} Farads/m

Pure Semiconductor Data at 300K:

		Silicon	*GaAs*
Dielectric constant	ε_r	11.8	12.7
Intrinsic concentration	n_i	1.50 x 10^{10} /cm^3	2.0 x 10^6 /cm^3
Electron Mobility	μ_n	1300 cm^2/(V.sec)	8500 cm^2/(V.sec)
Hole Mobility	μ_p	450 cm^2/(V.sec)	450 cm^2/(V.sec)

Dielectric constant of SiO_2 = 3.82

1-D Schrödinger Wave Equation:

$$\frac{\hbar^2}{2m}\cdot\frac{d^2\psi(x)}{dx^2}+[\mathcal{E}-U(x)]\cdot\psi(x)=0$$

Fermi-Dirac Distribution:

$$f(\mathcal{E})=\frac{1}{1+e^{\left(\varepsilon-\varepsilon_f/kT\right)}}$$

Conductivity and Current Flow in a Metallic Conductor:

$$J=q\cdot n\cdot v_e \qquad v_e=\mu_e\cdot E \qquad \mu_e=\frac{q\cdot\bar{\tau}_e}{m} \qquad \sigma=q\cdot n\cdot\mu_e$$

Boltzmann Approximation for Carrier Concentrations in Thermal Equilibrium:

$$n_o=n_i\cdot\exp\left[\left(\varepsilon_f-\varepsilon_i\right)/kT\right] \qquad p_o=n_i\cdot\exp\left[\left(\varepsilon_i-\varepsilon_f\right)/kT\right] \qquad n_o\cdot p_o=n_i^2$$

Einstein Relationships:

$$D_n=(kT/q)\cdot\mu_n \qquad D_p=(kT/q)\cdot\mu_p$$

Semiconductor Conductivity:

$$\sigma=q\cdot\left(\mu_n\cdot n+\mu_p\cdot p\right)$$

Total (a) Hole and (b) Electron Current Density:

(a) $$J_p(x)=q\mu_p p(x)E(x)-qD_p\frac{dp(x)}{dx}$$ ***(b)*** $$J_n(x)=q\mu_n n(x)E(x)+qD_n\frac{dn(x)}{dx}$$

Continuity Equation for Excess Minority (a) Holes and (b) Electrons:

(a) $$\frac{\partial\Delta p}{\partial t}=-\frac{1}{q}\cdot\frac{\partial J_p}{\partial x}-\frac{\Delta p}{\tau_p}$$ ***(b)*** $$\frac{\partial\Delta n}{\partial t}=\frac{1}{q}\cdot\frac{\partial J_n}{\partial x}-\frac{\Delta n}{\tau_n}$$

Poisson Equation: $$\frac{dE(x)}{dx}=\frac{\rho(x)}{\varepsilon}=\frac{q}{\varepsilon}\cdot\left[p(x)-n(x)+N_D^+-N_A^-\right]$$

Depletion Width in PN Junction:

$$W=\left[\frac{2\varepsilon(\varphi_i-V)}{q}\cdot\frac{N_A+N_D}{N_A\cdot N_D}\right]^{1/2}$$

Magn. of Fermi Level Displacement:

$$\left|\phi_f\right|=\frac{kT}{q}\cdot\ln\left|\frac{N_A(orN_D)}{n_i}\right|$$

PN Junction Boundary Conditions:

$$\Delta n_p\left(-x_p\right)=n_{po}\left[e^{qV/kT}-1\right] \qquad \Delta p_n(x_n)=p_{no}\left[e^{qV/kT}-1\right]$$

Mathematical Identities:

$$Sin^2(\theta) = \tfrac{1}{2}\left(1 - Cos(2\cdot\theta)\right) \qquad Cos^2(\theta) = \tfrac{1}{2}\left(1 + Cos(2\cdot\theta)\right)$$

$$\int x^n \cdot dx = \frac{x^{n+1}}{n+1} + C \qquad \frac{dx^n}{dx} = n \cdot x^{n-1} \qquad \frac{de^{k\cdot x}}{dx} = k \cdot e^{k\cdot x}$$