SEMICONDUCTOR PHYSICS-RELATED EQUATIONS

$$x_{sc} = \sqrt{\frac{2\epsilon_{si}(N_a + N_d)}{q(N_a N_d)}(\phi_{bi} - V_a)} \tag{1}$$

$$\phi_{bi} = \frac{kT}{q} Ln \frac{N_a N_d}{n_i^2} \tag{2}$$

$$np = n_i^2 \tag{3}$$

$$\frac{D}{\mu} = \frac{kT}{q} \tag{4}$$

$$v = \mu E \tag{5}$$

$$n = n_i \exp(\frac{q(\phi_f - \phi_i)}{kT}) \tag{6}$$

$$p = p_i \exp(\frac{q(\phi_i - \phi_f)}{kT}) \tag{7}$$

$$J_n = -q\mu n \nabla \phi_{fn} \tag{8}$$

$$J_p = -q\mu p \nabla \phi_{fp} \tag{9}$$

$$J_n = q[n\mu_n E_x + D_n \frac{dn}{dx}] \tag{10}$$

$$J = env \tag{11}$$

$$\rho = \frac{1}{en\mu} \tag{12}$$

$$\sigma = \frac{1}{\rho} \tag{13}$$

$$R = \rho G \tag{14}$$

$$G = \frac{L}{A} \tag{15}$$

$$\rho^{sheet} = \frac{\rho}{t} \tag{16}$$

$$E_x = -\frac{\partial \phi}{\partial x} \tag{17}$$

$$E_{sheet} = \frac{1}{2} \frac{\sigma}{\epsilon_{si}} \tag{18}$$

$$f(E) = \frac{1}{1 + \exp\left[(E - E_f)/kT\right]} \tag{19}$$

For trap occupancy including spin degeneracy:

$$f(E) = \frac{1}{1 + g\exp\left[(E - E_f)/kT\right]} \tag{20}$$

DIODE RELATED EQUATIONS

$$I_D = I_s(\exp(\frac{qV_d}{kT}) - 1) \tag{21}$$

$$C_{sc} = \frac{\partial Q_{sc}}{\partial V_a} = \frac{A\epsilon_{si}}{x_{sc}} \tag{22}$$

$$C_{diff} = \frac{\tau I_D}{V_{thermal}} \tag{23}$$

$$J_s = \frac{qD_p p_{no}}{L_p} + \frac{qD_n n_{po}}{L_n} \tag{24}$$

MOSCAPS

$$C_{ox} = A\frac{\epsilon_{ox}}{d_{ox}} \tag{25}$$

Semiconductor space-charge capacitance:

$$C_{sc} = A\frac{\epsilon_{si}}{x_{sc}} \tag{26}$$

Flat-band capacitance:

$$C_{FB} = A\frac{\epsilon_{si}}{L_d} \tag{27}$$

$$L_d = \sqrt{\frac{2\epsilon_{si}}{qN_{doping}}\frac{kT}{q}} \tag{28}$$

MOS-RELATED EQUATIONS

$$\phi_b = \frac{kT}{q} Ln\left[\frac{N_{a,d}}{n_i}\right] \tag{29}$$

$$V_{th}^0 = 2\phi_b + \frac{1}{C_{ox}}\sqrt{2qN_a\epsilon_{si}2\phi_b} \tag{30}$$

$$V_{th} = V_{FB} + V_{th}^0 \tag{31}$$

$$I_{ds}^{L/T} = \mu C_{ox}\frac{W}{L}((V_{gs} - V_{th})V_{ds} - \frac{V_{ds}^2}{2}) \tag{32}$$

$$I_{ds}^{sat} = \frac{\mu C_{ox}}{2}\frac{W}{L}((V_{gs} - V_{th})^2)(1 + \lambda V_{ds}) \tag{33}$$

$$\Delta V_{th} = \gamma[\sqrt{2\phi_b - V_{sx}} - \sqrt{2\phi_b}] \tag{34}$$

$$r_o = \frac{V_a}{I_c} \tag{35}$$

$$g_m = \frac{2I_{ds}}{V_{gs} - V_{th}} \tag{36}$$

$$V_{gs} - V_{th} = V_{ds}^{po} \tag{37}$$

PROCESS RELATED EQUATIONS

$$d_{min} = 1.25\sqrt{g\lambda} \tag{38}$$

$$x_{min} = k_1 \frac{\lambda}{NA} \tag{39}$$

$$DOF = k_2 \frac{\lambda}{NA^2} \tag{40}$$

For Oxidation:

$$x = \frac{B}{A}(t + \tau) \tag{41}$$

$$x = \sqrt{Bt} \tag{42}$$

For Implant:

$$C(x) = C_p \exp[-\frac{(x - R_p)^2}{2\Delta R_p^2}] \tag{43}$$

For Diffusions;

$$C_{dep}(x,t) = C_s erfc(-\frac{x}{2\sqrt{Dt}}) \tag{44}$$

$$C_{drive}(x,t) = \frac{N'}{\sqrt{\pi Dt}} \exp(\frac{x^2}{4Dt}) \tag{45}$$

An estimate of the diffused junction depth;

$$x_d = \sqrt{Dt} \tag{46}$$

CONSTANTS

$$\epsilon_{si} = 10^{-12} Fd - cm^{-1} \tag{47}$$

$$\epsilon_{ox} = 3.5 \times 10^{-13} Fd - cm^{-1} \tag{48}$$

$$\mu_n = 1500 cm^2/V - s \tag{49}$$

$$\mu_p = 500 cm^2/V - s \tag{50}$$

$$V_{thermal} = 0.0259V \tag{51}$$

$$q = 1.6 \times 10^{-19} Coulombs \tag{52}$$

Typically, you may take: $\tau = 10^{-4} sec$, $L_n = L_p = 10^{-3} cm$