Chapter 3: Metal-Semiconductor Junctions

3.2. Structure and principle of operation

$$f_B = \Phi_M - c \quad \text{, for an n-type semiconductor} \tag{3.2.1}$$

$$f_B = \frac{E_g}{q} + c - \Phi_M \quad \text{, for a p-type semiconductor} \tag{3.2.2}$$

$$f_i = \Phi_M - c - \frac{E_c - E_{F,n}}{q} \quad , \quad \text{n-type} \tag{3.2.3}$$

$$f_i = \frac{E_g}{q} + c - \frac{E_v - E_{F,p}}{q} - \Phi_M \quad , \quad \text{p-type} \tag{3.2.4}$$

$$f(x=\infty) - f(x=0) = f_i - V_a \tag{3.2.5}$$

3.3. Electrostatic analysis

$$\frac{d^2 f}{dx^2} = -\frac{r}{e_s} = -\frac{q}{e_s}(p - n + N_d^+ - N_a^-) \tag{3.3.1}$$

$$\frac{d^2 f}{dx^2} = \frac{2qn_i}{e_s}(\sinh\frac{f - f_F}{V_t} + \sinh\frac{f_F}{V_t}) \tag{3.3.2}$$

$$\sinh\frac{f_F}{V_t} = \frac{N_a^- - N_d^+}{2n_i} \tag{3.3.3}$$

$$\begin{aligned} r(x) &= qN_d \qquad 0 < x < x_d \\ r(x) &= 0 \qquad\quad x_d < x \end{aligned} \tag{3.3.4}$$

$$\begin{aligned} E(x) &= -\frac{qN_d}{e_s}(x_d - x) \qquad 0 < x < x_d \\ E(x) &= 0 \qquad\qquad\qquad\quad x_d \le x \end{aligned} \tag{3.3.5}$$

$$E(x=0) = -\frac{qN_d x_d}{e_s} = -\frac{Q_d}{e_s} \tag{3.3.6}$$

$$\begin{aligned} f(x) &= 0 \qquad\qquad\qquad\quad x \le 0 \\ f(x) &= \frac{qN_d}{2e_s}[x_d^2 - (x_d - x)^2] \qquad 0 < x < x_d \\ f(x) &= \frac{qN_d x_d^2}{2e_s} \qquad\qquad\quad x_d \le x \end{aligned} \tag{3.3.7}$$

$$f_i - V_a = f(x=\infty) - f(x=0) = \frac{qN_d x_d^2}{2e_s} \tag{3.3.8}$$

$$x_d = \sqrt{\frac{2e_s(f_i - V_a)}{qN_d}} \tag{3.3.9}$$

$$C_j = \left|\frac{dQ_d}{dV_a}\right| = \sqrt{\frac{qe_s N_d}{2(f_i - V_a)}} = \frac{e_s}{x_d} \tag{3.3.10}$$

$$\Delta f_B = \sqrt{\frac{qE_{\max}}{4pe_s}} \tag{3.3.11}$$

3.4. Schottky diode current

$$J_n = qvN_c \exp(-\frac{f_B}{V_t})\left(\exp(\frac{V_a}{V_t}) - 1\right) \tag{3.4.1}$$

$$J_n = q v_R n \Theta \tag{3.4.2}$$

$$J_n = \frac{qD_n N_c}{V_t}\sqrt{\frac{2q(f_i - V_a)N_d}{e_s}}\exp(-\frac{f_B}{V_t})[\exp(\frac{V_a}{V_t}) - 1] \tag{3.4.3}$$

$$E_{\max} = \sqrt{\frac{2q(f_i - V_a)N_d}{e_s}} \tag{3.4.4}$$

$$J_n = qm_n E_{\max} N_C \exp(-\frac{f_B}{V_t})[\exp(\frac{V_a}{V_t}) - 1] \tag{3.4.5}$$