NOC: Fundamentals of electronic materials and devices

Exam information sheet

Useful constants

$1\ eV = 1.6 \times 10^{-19}\ J$
$h = 6.626 \times 10^{-34}\ Js$
$c = 3 \times 10^{8}\ ms^{-1}$
$k_B = 1.38 \times 10^{-23}\ JK^{-1}$

$e\ =\ 1.6 \times 10^{-19}\ C$
$\epsilon_0 = 8.854 \times 10^{-12}\ Fm^{-1}$
$k_B = 1.38 \times 10^{-23}\ JK^{-1}$
$N_A = 6.023 \times 10^{23}$

Useful relations

$$f(E)\ =\ \frac{1}{1\ +\ \exp[\frac{E-E_F}{k_BT}]} \qquad g(E)\ =\ 8\pi\sqrt{2}(\frac{m_e}{h^2})^{3/2}\sqrt{E} \qquad n(E)\ =\ f(E)g(E)$$

$$n_i\ =\ \sqrt{N_cN_v}\ \exp(-\frac{E_g}{2k_BT}) \qquad np\ =\ n_i^2$$

$$N_c\ =\ 2(\frac{2\pi m_e^* k_BT}{h^2})^{3/2} \qquad N_v\ =\ 2(\frac{2\pi m_h^* k_BT}{h^2})^{3/2}$$

$$E_{Fi}\ =\ \frac{E_g}{2}\ -\ \frac{1}{2}k_BT\,ln(\frac{N_c}{N_v})$$

$$E_{Fn}\ -\ F_{Fi}\ =\ k_BT\,ln(\frac{n}{n_i}) \qquad E_{Fp}\ -\ F_{Fi}\ =\ -k_BT\,ln(\frac{p}{n_i})$$

$$\sigma\ =\ ne\mu_e\ +\ pe\mu_h$$

$$\text{Schottky junction}:\ J\ =\ J_0\ \exp(\frac{eV}{k_BT}) \text{ where } J_0\ =\ AT^2\ \exp(\frac{-\phi_B}{k_BT})$$

$$pn \text{ junction contact potential}:\ V_0\ =\ \frac{k_BT}{e}\ \ln(\frac{n_np_p}{n_i^2})$$

$$pn \text{ junction depletion width}:\ w_0\ =\ \sqrt{\frac{2\epsilon_0\epsilon_r(N_A\ +\ N_D)V_0}{eN_AN_D}}\ ;\ w_nN_D\ =\ w_pN_A$$

$$pn \text{ junction forward bias}:\ J\ =\ J_0\ \exp(\frac{eV}{k_BT}) \text{ where } J_0\ =\ n_i^2e\left[\frac{D_h}{L_hN_D}\ +\ \frac{D_e}{L_eN_A}\right]$$

$$D_e\ =\ \frac{k_BT\mu_e}{e};\ D_h\ =\ \frac{k_BT\mu_h}{e};\ L_e\ =\ \sqrt{D_e\tau_e};\ L_h\ =\ \sqrt{D_h\tau_h}$$

$$\text{MOS junction}:\ \phi_s\ =\ \frac{e^2N_Aw_D^2}{2\epsilon_0\epsilon_r} \qquad \text{channel width}:\ x_m\ =\ w_D\ (\frac{\sqrt{2}-1}{\sqrt{2}})$$

$$\text{Energy and wavelength}:\ E\ =\ \frac{hc}{\lambda} \qquad \text{Beer-Lambert's law}:\ I\ =\ I_0\ \exp(-\alpha x)$$

$$\text{Excess carrier concentration under illumination:}\ \frac{d\Delta p}{dt}\ =\ G_{ph}\ -\ \frac{\Delta p}{\tau_h}$$

$$\text{Solar cell open circuit voltage}: V_{oc}\ =\ \frac{k_BT}{e}\ ln(\frac{J_{ph}}{J_0})$$

where J_0 is defined above for a pn junction and J_{sc} is the short circuit current