Evaluation of physical constants in engineering formulas (semiconductor engineering)

$$\Theta = \exp\left(\frac{-qBL}{E_g}\right) \qquad with \qquad B = \frac{4\sqrt{2m^*}E_g^{3/2}}{3q(h/2\pi)}$$

$$\Theta = \exp\left(\frac{-L}{L_o}\right) \qquad with$$

$$L_o = \frac{E_G}{qB} = \frac{E_g 3q(h/2\pi)}{q4\sqrt{2m^*}E_g^{3/2}} = \frac{3}{4}\frac{(h/2\pi)}{\sqrt{2m^*}E_g^{1/2}} = \frac{3}{4}\frac{(hc/2\pi)}{\sqrt{2c^2m^*}E_g^{1/2}}$$

$$we\ use\ m^*c^2 = 0.51\ MeV\ and\ hc = 12430\ eV\ A = 12430\,eV\cdot 10^{-10}\,m$$

$$L_O = \frac{3}{4}\frac{(hc/2\pi)}{\sqrt{2c^2m^*}E_g^{1/2}} == \frac{3}{4}\frac{(hc/2\pi)}{\sqrt{2c^2m^*}E_g^{1/2}} = 0.75\frac{(12430/2\pi)}{\sqrt{1.02\times 10^6}\cdot 1.1^{1/2}} = 1.4A = 1.4\cdot 10^{-10}m$$

$$\Theta = \exp(-L/L_o) = 6.25\times 10^{-8} \qquad \rightarrow \qquad L = 16.58\times 1.4 = 23A = 2.3nm$$

$$if\ we\ correct\ for\ effective\ mass \quad m^* = 0.2m \quad L = 5\ nm$$

$$\alpha = \sqrt{\frac{2m(V_o - E)}{(h/2\pi)^2}}$$

$$T_o = \frac{16E(V_o - E)}{V_o^2}$$

$$\alpha = \sqrt{\frac{2m(V_o - E)}{(h/2\pi)^2}} = \left[\frac{2(9.1\times10^{-31}kg)(10eV - 7eV)(1.6\times10^{-19}J/eV)}{(1.05\times10^{-34}J/s)^2}\right]^{1/2} = 8.9\times10^{9}m^{-1}$$

$$\alpha a = (8.9\times10^{9}m^{-1})(5\times10^{-9}m) = 44.50 \quad for \quad a = 5nm$$

$$1eV = 1.6\times10^{-19}J \quad conversion\ Joule\ to\ eV$$

$$\alpha = \sqrt{\frac{2m(V_o - E)}{(h/2\pi)^2}} = \left[\frac{2(9.1\times10^{-31}kg)(10eV - 7eV)(1.6\times10^{-19}J/eV)}{(1.05\times10^{-34}J/s)^2}\right]^{1/2} = 8.9\times10^{9}m^{-1}$$

$1eV = 1.6\times10^{-19}J$ *conversion*

Alternative evaluation

$$\alpha = \sqrt{\frac{2m(V_o - E)}{(h/2\pi)^2}} = \frac{\sqrt{2m(V_o - E)}}{h/2\pi)} = \frac{\sqrt{2mc^2(V_o - E)}}{hc/(2\pi)}$$

we use $m_e c^2 = 0.51\ MeV$ *and* $hc = 12430\ eV\cdot10^{-10}m$

$$\alpha = \frac{\sqrt{2mc^2(V_o - E)}}{hc/(2\pi)} = \frac{\sqrt{1.02\times10^{6}\times3}}{12430/(6.28)\times10^{-10}} = 8.84\times10^{9}\ m^{-1}$$

Solution:

$$T = T_o \exp(-2\alpha a) = 3.36\exp(-2\times 44.50) = 3.36\exp(-89) \approx 7.4\times 10^{-39} \quad for \quad a = 5\,nm$$

$$with \quad a = 1\,nm$$

$$T = T_o \exp(-2\alpha a) = 3.36\exp(-2\times 8.9) = 3.36\exp(-17.8) \approx 6.2\times 10^{-8} \quad for \quad a = 1\,nm$$

$$R = 1 - T \approx 1$$

$$T = T_o \exp(-2\alpha a) = 30.24\exp(-2\times 13.6) = 30.24\times \exp(-27.2) \approx 4.65\times 10^{-11}$$

$$for\ a = 1nm\ and\ E = 3eV$$