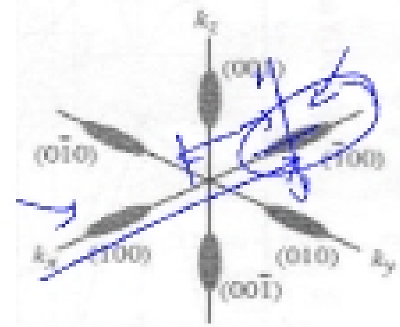
Dispersion Relation in Silicon near Conduction Band Minimum

- The two minima along the x-axis are represented by

$$E(k) = E_C + \frac{\hbar^2}{2}\left[\frac{(k_x \pm 0.85\frac{2\pi}{a})^2}{m_l^*} + \frac{k_y^2 + k_z^2}{m_t^*}\right]$$

- The two minima along the y-axis are represented by

$$E(k) = E_C + \frac{\hbar^2}{2}\left[\frac{(k_y \pm 0.85\frac{2\pi}{a})^2}{m_l^*} + \frac{k_x^2 + k_z^2}{m_t^*}\right]$$

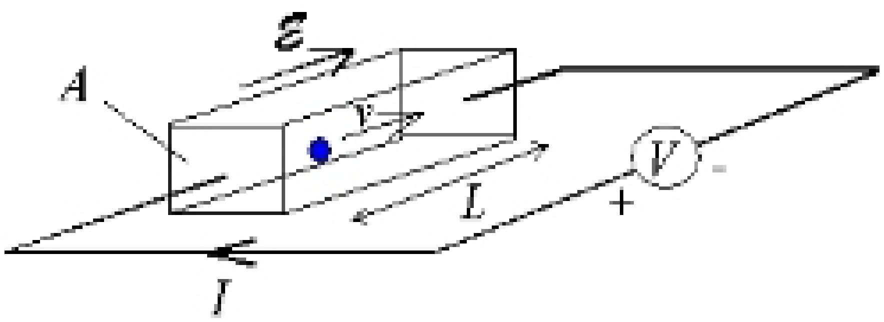


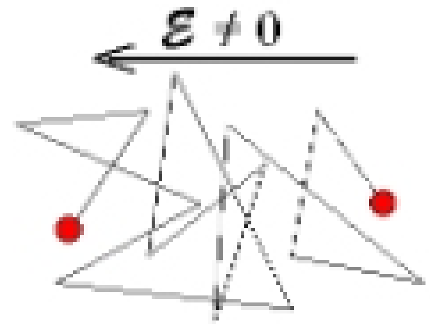
- The two minima along the z-axis are represented by

$$E(k) = E_C + \frac{\hbar^2}{2}\left[\frac{(k_z \pm 0.85\frac{2\pi}{a})^2}{m_l^*} + \frac{k_y^2 + k_x^2}{m_t^*}\right]$$

where the effective mass m_l^* and m_t^* are called longitudinal mass and transverse mass, respectively. For Si, $m_l^*=0.98$ m, $m_t^*=0.19$ m, where m=9.1×10^{-31} kg, mass of electron in free space.

Carrier Drift





Assume all carriers are moving with the same velocity *v* due to an applied field *E*, then the current is given by the total charge divided by the time t_r to traverse the distance *L* between one electrode to the other

$$I = \frac{Q}{t_r} = \frac{Q}{L/v} = \frac{Qv}{L}$$

ρ → charge density → Q/Volume

Current density *J* is $J = \frac{I}{A} = \left(\frac{Q}{AL}\right)v = \rho v = qnv$

q → 1.6×10^{-19} C, n → # of electrons/cm^3

Applying Newton's Law, $F = ma = m\frac{dv}{dt}$

This force is the difference between the electrostatic force and the scattering force due to the momentum change during collision

$F = qE - \frac{mv}{\tau_c}$ ← Collision time