Effective Mass *

The electrons in a crystal are not completely free. Hence they move in a Periodic Potential of the lattice. Thus their wave motion is diff for free space. The holes and electrons are treated as imaginary classical Particles with effective Positive masses mp and mn under the approximation that the applied fields are much weaker than internal Periodic fields

For a free electron the momentum

$$p = mv = \hbar k \qquad \left[mv = p = \frac{h}{\lambda} = \frac{h}{2\pi} \times \frac{2\pi}{\lambda} = \hbar k \right]$$

where $k =$ ~~Propagation const~~ wave N° $= 2\pi/\lambda$

$$E = \frac{1}{2} mv^2 = \frac{p^2}{2M} = \frac{\hbar^2 k^2}{2M}$$

$$\frac{dE}{dk} = \frac{\hbar^2}{m}k \quad \text{and} \quad \frac{d^2E}{dk^2} = \frac{\hbar^2}{m}$$

The effective mass of an electron in a band (with E, k) is given by

$$m^* = \hbar^2 / (d^2E/dk^2)$$

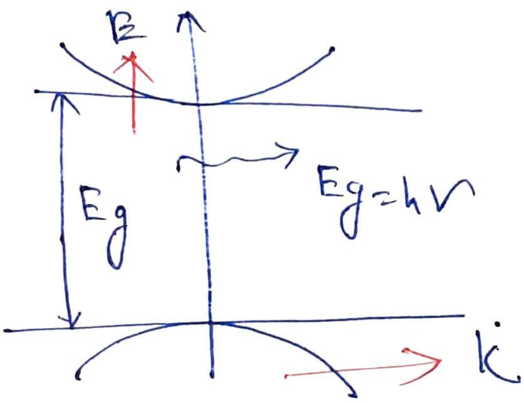
m^* = Effective mass of electron

For a band centred at $k=0$ the relation is given by

$$E = \frac{\hbar^2}{2m^*}k^2 + E_g$$

E_g = band gap

If we plot a graph in between E and k then nature is given as



The curvature d^2E/dk^2 is Positive at the conduction band (minima) but negative at valence band (maxima). Thus the electrons near the top of valence band have negative effective mass and at the bottom of conduction band has the effective mass.

Effective mass for Ge and Si, GaAs

	Ge	Si	GaAs
m_n^*	0.55 mo	1.1 mo	0.067 mo
m_p^*	0.37 mo	0.56 mo	0.48 mo

mo = Rest mass of electron.

m_n^* = Effective mass of electron
m_p^* = " " hole