Fundamentals of Electronics Devices

Unit-1

Lecture-8

Effective Mass

- The electrons in a crystal are not completely free, but instead interact with the periodic potential of the lattice.
- As a result, their “wave-particle” motion cannot be expected to be the same as for electrons in free space.

- Although electrons in solids are not free, most energy bands are close to parabolic at their minima (for conduction bands) or maxima (for valence bands).
- We can also approximate effective mass near those band extrema from the curvature of the band.

- There is nothing mysterious about the concept of an “effective” mass, m_n, and the fact that it is different in different semiconductors.
- Indeed, the “true” mass of electron, m, is the same in Si, Ge or GaAs – it is the same as for a free electron in vacuum.

Equation

- To understand why the effective mass is different from the true mass, consider Newton's second law which states that the time rate of change of momentum is the force.

$$dp/dt = d(mv)/dt = \text{Force}$$

- An electron in a crystal experiences a total force $F_{int} + F_{ext}$, where F_{int} is the collection of internal periodic crystal forces, and F_{ext} is the externally applied force.
- It is inefficient to solve this complicated problem involving the periodic crystal potential (which is obviously different in different semiconductors) every time we try to solve a problem.

Drift of carriers in electric and magnetic fields

- Knowledge of carrier concentrations in a solid is necessary for calculating current flow in the presence of electric and magnetic fields.
- In addition to the values of n and p, we must be able to take into account the collisions of the charge carriers with the lattice and with the impurities.
- These process will affect the ease with which electrons and holes can flow through the crystal, that is, their *mobility* within the solid.