

DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

Module-I, Lecture-13

**Classification of Electronic Materials
and Fermi level**



Classification of electronic materials

Conductors

Semiconductors

Insulators

Superconductor

Conductors

Conductors are substances which have free electrons, which can move under the action of an electric field. The electrons are free in the sense that they belong to the crystal as a whole and not tied down (bound) to a particular atom or a molecule. It having infinite conductivity.

Example : copper , silver etc.



Semiconductors

Semiconductors are materials which have the conductivity between conductors and insulators. Semiconductors are the elements of group-III, group-IV and group-V elements.

At normal temperature the conductivity of semiconductor is very low. With increase in temperature the conductivity of semiconductors increases exponentially.

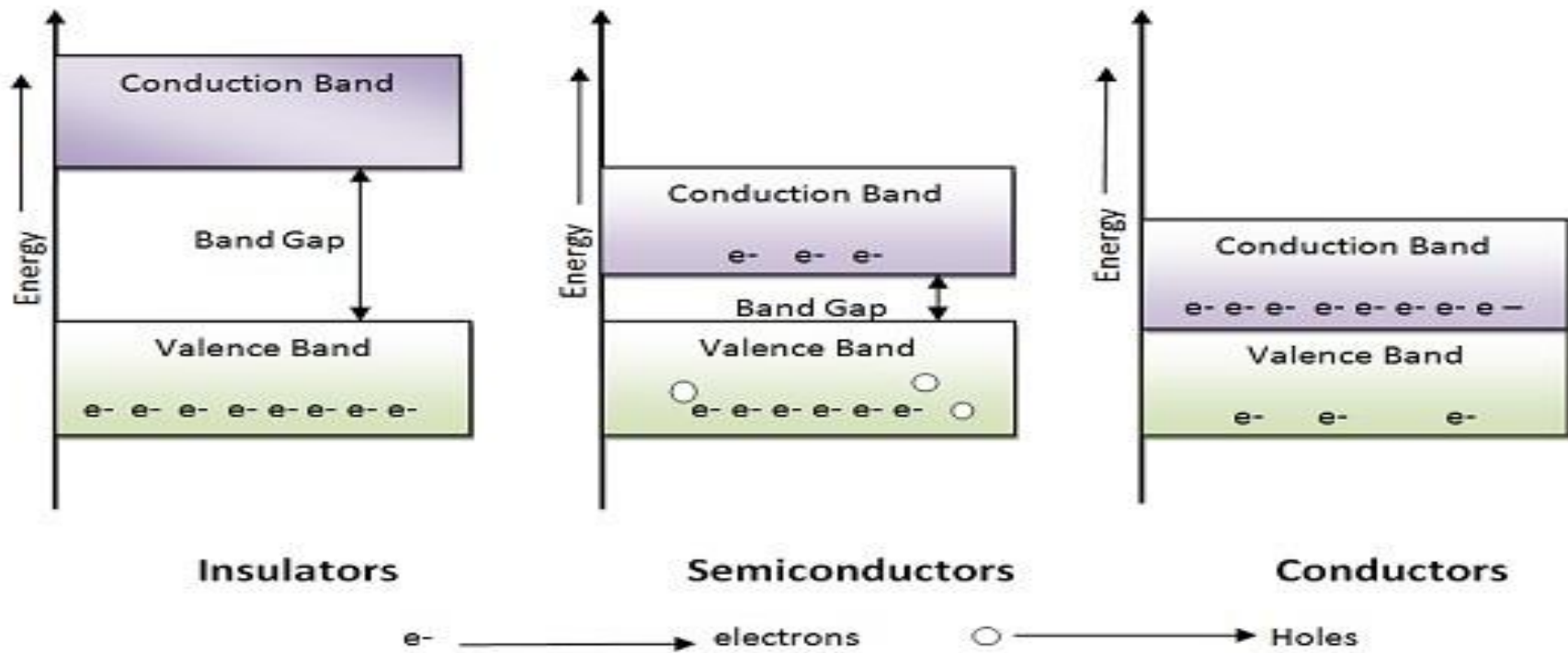
Example: Germanium, Silicon, Gallium Arsenic etc.

Insulators

Insulators are very poor conductor of electricity. The forbidden gap value is 3eV

Example: wood ,oil, mica.

Classification Of Electronic Materials





This statistics applicable to the identical, indistinguishable particles of half spin.

These particles obey Pauli's exclusion principle and are called fermions (e.g.) Electrons, protons, neutrons ...,

In such system of particles, not more than one particle can be in one quantum state.

Fermi Dirac Distribution Law is

$$n_i = \frac{g_i}{(e^{\alpha + \beta E_i}) + 1}$$

g_i - Distinct sublevels, E_i - Total energy level $\alpha = -\mu/K_B T$ $\beta = 1/K_B T$



Fermi Energy (E_F)

Fermi Energy is the energy of the state at which the probability of electron occupation is $\frac{1}{2}$ at any temperature above 0 K.

It is also the maximum kinetic energy that a free electron can have at 0 K.

The energy of the highest occupied level at absolute zero temperature is called the *Fermi Energy or Fermi Level*.

Fermi Energy



The Fermi energy at 0 K for metals is given by

$$E_F = \left[\frac{3N}{\pi} \right]^{2/3} \left(\frac{h^2}{8m} \right)$$

When temperature increases, the Fermi level or Fermi energy also slightly decreases.

The Fermi energy at non-zero temperatures,

$$E_F = E_{F_0} \left[1 - \frac{\pi^2}{12} \left(\frac{kT}{E_{F_0}} \right)^2 \right]$$

Here the subscript '0' refers to the quantities at zero kelvin