SRM
Institute of Science and Technology

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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PY103J – Physics: Semiconductor Physics
Module-I, Lecture-13

Classification of Electronic Materials and Fermi level

Classification Of Electronic Materials

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 belongto 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.

Classification Of Electronic Materials

Semiconductors

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

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

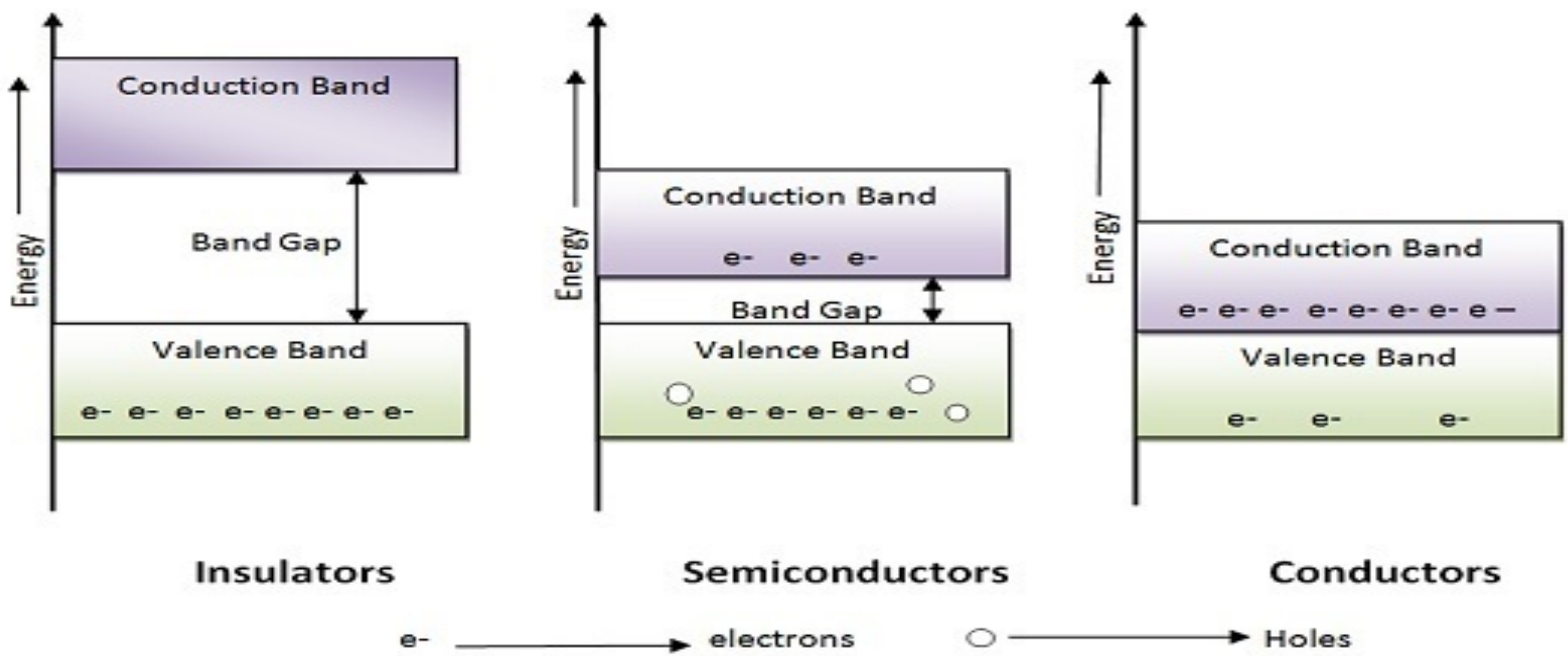
Example: Germanium, Silicon, Gallium Arsenic etc.

Insulators

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

Example: wood ,oil, mica.

Classification Of Electronic Materials



Fermi-Dirac Statistics (Quantum law)

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

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

Fermi Energy

Fermi Energy (E_F)

Fermi Energy is the energy of the state at which the probability of electron occupation is ½ 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

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

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