Definitions

Valence Band:

Thevalance band is the highest range of electron energies in a solid where electrons are typically present at absolute zero temperature.

- Electrons in the valence band are bound to atoms and are not free to move within the material.

Conduction Band

- The conduction band is the energy range above the valence band where electrons are free to move and conduct electricity.
- Electrons in the conduction band are no longer bound to individual atoms and are free to move across the material.

Energy Band Gap (Band Gap)

The band gap is the energy difference between the valence band and the conduction band

Insulators: Have a large band gap (typically > 3 eV

Semiconductors: Have a smaller band gap (typically 0.1 to 3 eV),

Conductors (Metals): Have no band gap (or a very small one), as the valence band and conduction band overlap

Energy Bandgap

Distinction among conductor, insulator and semiconductor.

Conductors

Substances having the property to transfer different types of energy. Definitely, the electric conductivity is the value of our interest.

Metals (Au, Ag, Al, Cu)

1. Their electric conductivity is dependent on free electrons (Fermi gas) due to the metal bonding.
2. With low energy, the electrons are sufficiently detached from the atoms and the conductivity is achieved.

Discuss:

Why does the conductivity of a metal decrease as temperature increases?

If the temperature rises, the thermal motion causes the electrons to collide, so that the electrons are constrained in their movements. Consequently, the resistance increases and

the conductivity decreases. With the decrease in temperature, the thermal effect is nullified and the electrons can flow smoothly without hindrance and thus conductivity increases.

Insulators

Substances with no free charge carriers, and therefore, they are non-conductive. The atomic bond is formed by shared electron pairs of nonmetals.

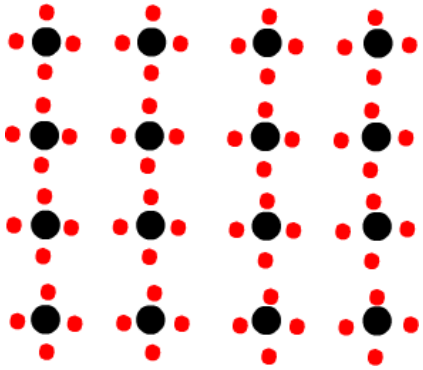

Fig.2.1. Insulator atoms arrangement in lattice.

Semiconductors

They are solids with conductivities lie between the conductors and insulators conductivities.

Si, Ge

1. Semiconductors atoms arrange as lattice structure.
2. Their conductivities increase with increasing temperature, why ?

Energy scheme is utilized to describe the conductivity of conductors, insulators, and semiconductors.

About 5E22 /cm^3 of Si, so number of energy levels are no longer distinguishable from each other and thus form broad energy ranges.

Fig.2.2. Silicon atoms arrangement in the lattice.

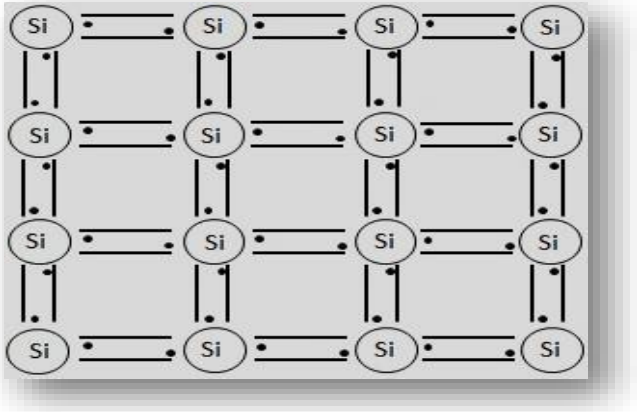

Fig.2.2. Silicon atoms arrangement in the lattice.

Electronic band structure

Conductors

- The valence band overlaps with the conduction band.
- The electrons can therefore move inside the partially filled valence band or inside both bands.
- No band gap between the valence and conduction band.

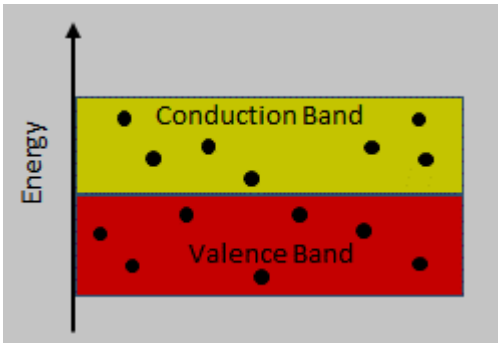

Fig. 2.3. Energy bandgaps of conductor

Insulators

- The valence band is completely occupied with electrons.
- The electrons can not transport due to the covalent bond between the atoms.
- Wide energy gap between valence and conduction band.

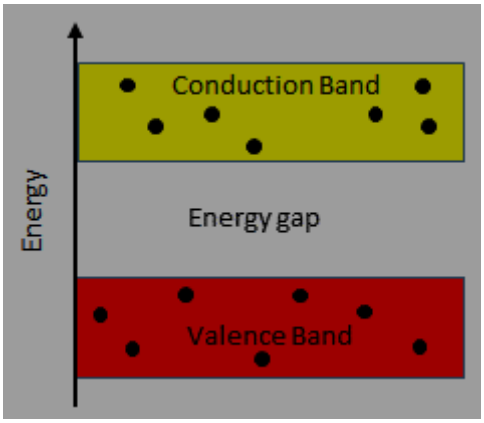

Fig.2.4. Energy bandgaps of insulator

Semiconductors

- The valence band is occupied with electrons at R.T.
- The energy band gap is so small compared to insulators
- Even at room temperature electrons can be lifted from the valence band into the conduction band.
- The transported electrons are free.
- Pairs of e-h are produced.

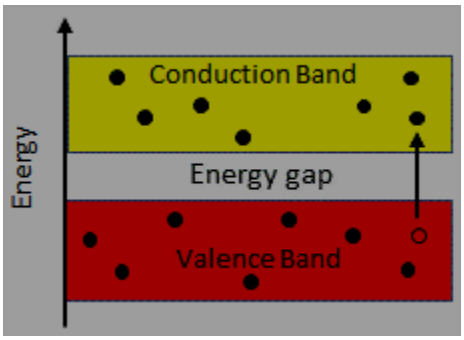

Fig. 2.5. Energy bandgaps of semiconductor

Semiconductors

- The valence band is occupied with electrons at R.T.
- The energy band gap is so small compared to insulators
- Even at room temperature electrons can be lifted from the valence band into the conduction band.
- The transported electrons are free.
- Pairs of e-h are produce

Questions:

Q1: Describe the difference between n-type and p-type semiconductor materials.

Q2: Describe the difference between donor and acceptor impurities.

Q5: Describe the difference between majority and minority carriers.

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