COLLEGE OF ENGINEERING AND TECHNOLOGIES

ALMUSTAQBAL UNIVERSITY

AC Power Converter

EET 307

Lecture 2

- Material Classification -

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Introduction

- Electrical resistivity is a fundamental property of a material that measures how strongly it resists electric current.
- A low resistivity indicates a material that readily allows electric current.
- Resistivity is commonly represented by the Greek letter ρ (rho).
- The SI unit of electrical resistivity is the ohmmeter (Ω·m).

Resistivity

$$\rho = R\frac{A}{l}$$

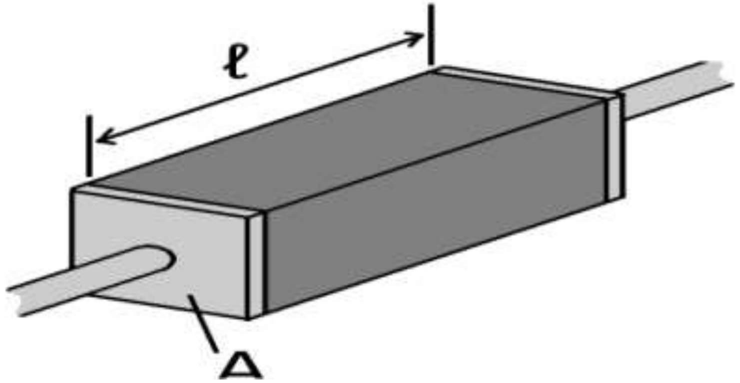

Figure 1: Resistive material with electrical contacts on both ends

Where:

- R is the electrical resistance of a uniform specimen of the material.
- l is the length of the specimen .
- A is the cross-sectional area of the specimen.

Resistivity

- Both resistance R and resistivity ρ describe how difficult it is to make electrical current flow through a material.

- But unlike resistance, resistivity is an intrinsic property.

- This means that all pure copper wires irrespective of their shape and size, have the same resistivity.

- But a long, thin copper wire has a much larger resistance than a thick, short copper wire.

- Every material has its own characteristic resistivity.

Resistivity

For example, rubber has a far larger resistivity than copper.

Figure 2: Resistivity of rubber and copper

Conductivity

- Electrical conductivity or specific conductance is the reciprocal of electrical resistivity.

- It represents a material's ability to conduct electric current.

- It is commonly signified by the Greek letter σ (sigma).

- The SI unit of electrical conductivity is siemens per meter (S/m).

$$\sigma = \frac{1}{\rho}$$

Where:

- σ is the electrical conductivity.
- ρ is the electrical resistivity.

Causes of conductivity

- In Metal: A metal consists of a lattice of atoms, each with an outer shell of electrons that freely dissociate from their parent atoms and travel through the lattice.

- This 'sea' of dissociable electrons allows the metal to conduct electric current.

- When an electrical potential difference (a voltage) is applied across the metal, the resulting electric field causes electrons to drift towards the positive terminal.

Electrical properties of Insulators, Semiconductors and Conductors

Based on the electrical conductivity all the materials in nature are classified as insulators, semiconductors, and conductors.

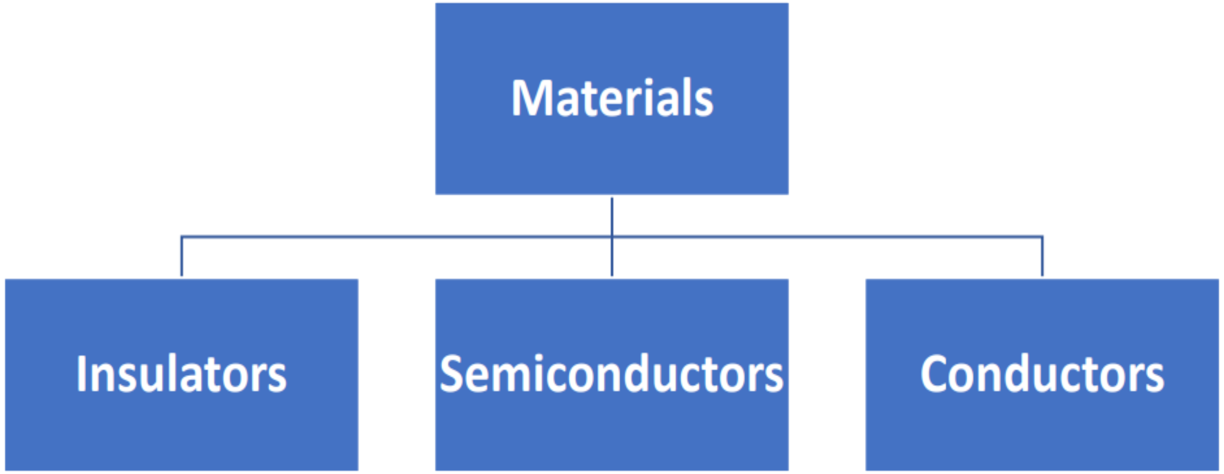

Figure 3: Material classification

Insulators

- An insulator is a material that offers a very low level (negligible) of conductivity when voltage is applied. Paper, Plastic, Rubber, ….

- Band structure of a material defines the band of energy levels that an electron can occupy.

- Valence band VB: is the range of electron energy where the electron remain bended to the atom and do not contribute to the electric current.

- Conduction bend CB: is the range of electron energies higher than valance band where electrons are free to accelerate under the influence of external voltage source resulting in the flow of charge.

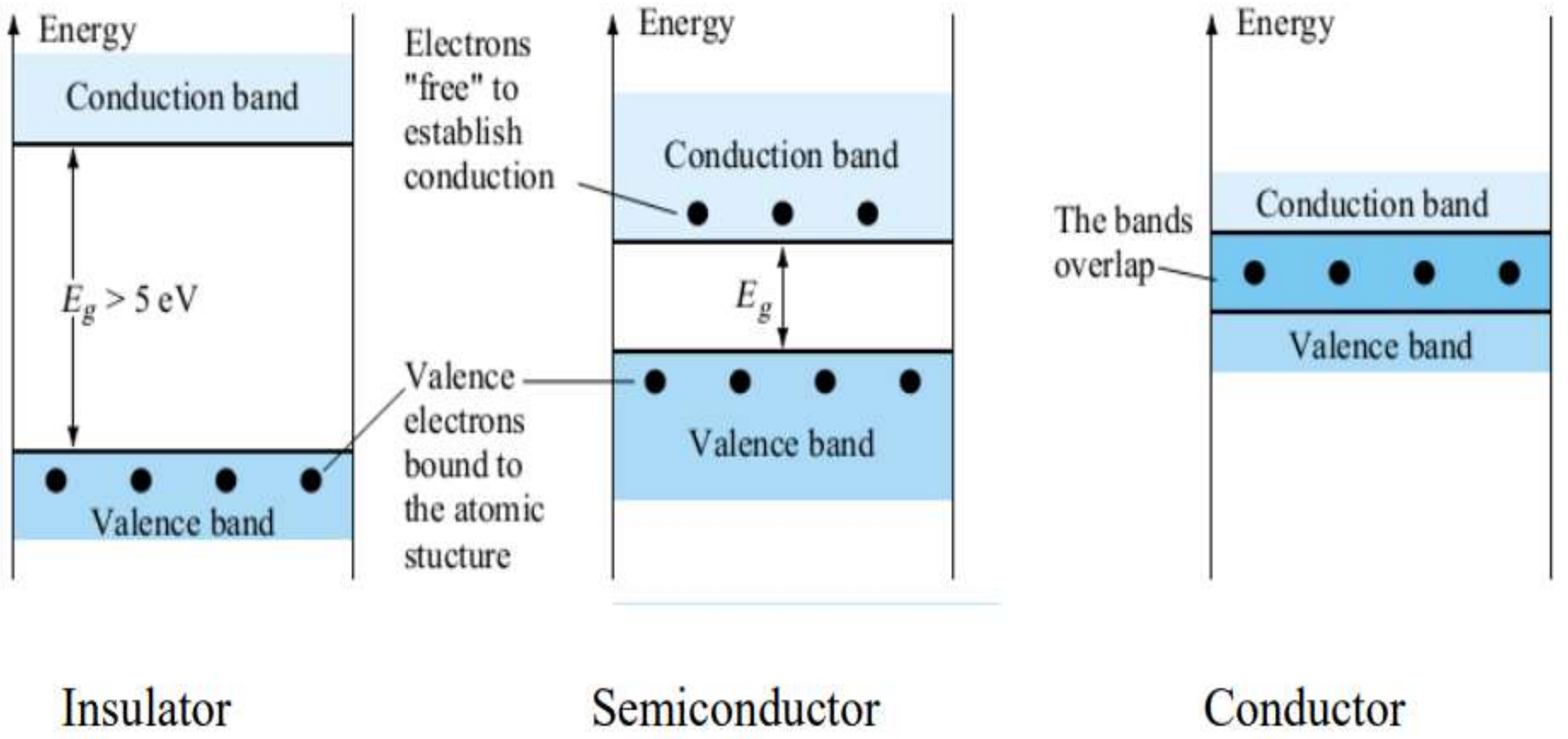

Figure 4: Energy band diagrams insulator, semiconductor and conductor

Conductors

- A conductor is a material which supports a generous flow of charge when a voltage is applied across its terminals, (it has very high conductivity).

- Eg: Copper, Aluminum, Silver, Gold….

- The Valance and conduction bands overlap and there is no energy gap for the electrons to move from valence band to conduction band.

- This implies that there are free electrons in CB even at absolute zero temperature.

Semiconductor

- A semiconductor is a material that has its conductivity somewhere between the insulator and conductor.

- Two of the most commonly used are Silicon (Si=14 atomic no.) and germanium (Ge=32 atomic no.).

- Both have 4 valance electrons.

Energy Levels

- The more distant the electron from the nucleus, the higher the energy state.
- Any electron that has left its parent atom has a higher energy state than any electron in the atomic structure.

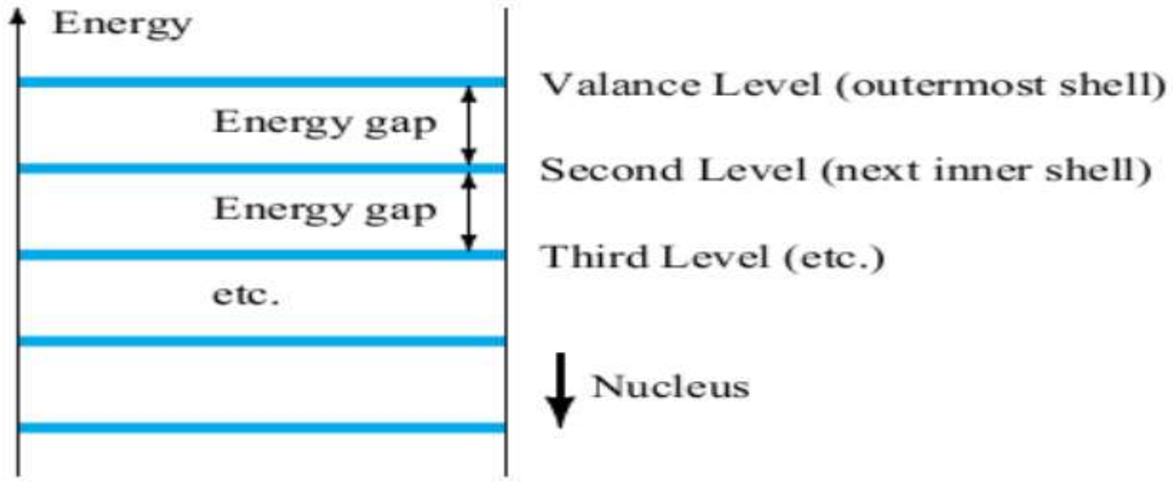

Figure 5: Energy level

Energy Levels

- Between the discrete energy levels are gaps in which no electrons in the isolated atomic structure can appear.

- Recall that ionization is the mechanism whereby an electron can absorb sufficient energy to break away from the atomic structure and enter the conduction band.

- You will note that the energy associated with each electron is measured in electron volts (eV).

$$1\ eV = 1.6 \times 10^{-19}\ J$$

- For an insulator, there is a large forbidden band gap of greater than 5Ev.