



CONDUCTOR AND INSULATORS

CONTENT

- Conductors
- Semi-conductors
- Band theory of Semi conductor
- Properties of Semi conductor
- Difference between of Intrinsic and Extrinsic conductors
- Insulators
- Difference between conductor and insulator



We differentiate the elements around us based on their physical properties, such as malleability, phase, texture, colour, polarity, solubility, etc. But as we know, another very important classification of elements is done on the basis of their conductivity of electric charge, i.e. conductors and insulators.



If we perform as imple experiment with a battery and a small LED bulb, we will notice that when the electric circuit between the battery and the bulb is completed using a plastic or a cotton thread, the bulb doesn't glow. Whereas if we perform the same experiment with the help of a metallic wire such as copper, the bulb starts to glow. This indicates that some of the elements enable the transfer of charge from the battery to the bulbs, while others do not. The basis of the classification of such elements is their electrical conductivity. Let us learn more about conductors and insulators today.



What Are Conductors?

In simple terms, an electrical conductor is defined as materials that allow electricity to flow through them easily. This property of conductors that allow them to conduct electricity is known as conductivity. The flow of electrons in a conductor is known as the electric current. The force required to make that current flow through the conductor is known as voltage.

- When a charge is transferred to such an element, it gets distributed across the entire surface of the object, which results in the movement of electrons in the object. The charges transferred to an electrical conductor distribute until the force of repulsion between electrons in areas of excess electrons is decreased to the minimum value. When such an object is brought in contact with another conductor, the charge gets transferred from the first conductor to the other until the overall repulsion due to charge is minimized.
 - Metals, humans, and earth are all conductors. This is the reason why we get electric shocks!
- 

Examples of conductor

- Graphite, the human body, and the earth are good conductors of electricity.
- Some of the common conductor examples include metals such as:
 - Copper
 - Gold
 - Iron

Semiconductors

Semiconductors are materials which have a conductivity between conductors (generally metals) and non-conductors or insulators (such as ceramics). Semiconductors can be compounds, such as gallium arsenide, or pure elements, such as germanium or silicon. Physics explains the theories, properties and mathematical approach related to semiconductors.

Examples of Semiconductors

Gallium arsenide, germanium and silicon are some of the most commonly used semiconductors. Silicon is used in electronic circuit fabrication, and gallium arsenide is used in solar cells, laser diodes, etc.

Holes and Electrons in Semiconductors

Holes and electrons are the types of charge carriers accountable for the flow of current in semiconductors. Holes (valence electrons) are the positively charged electric charge carrier, whereas electrons are the negatively charged particles. Both electrons and holes are equal in magnitude but opposite in polarity.

Mobility of Electrons and Holes

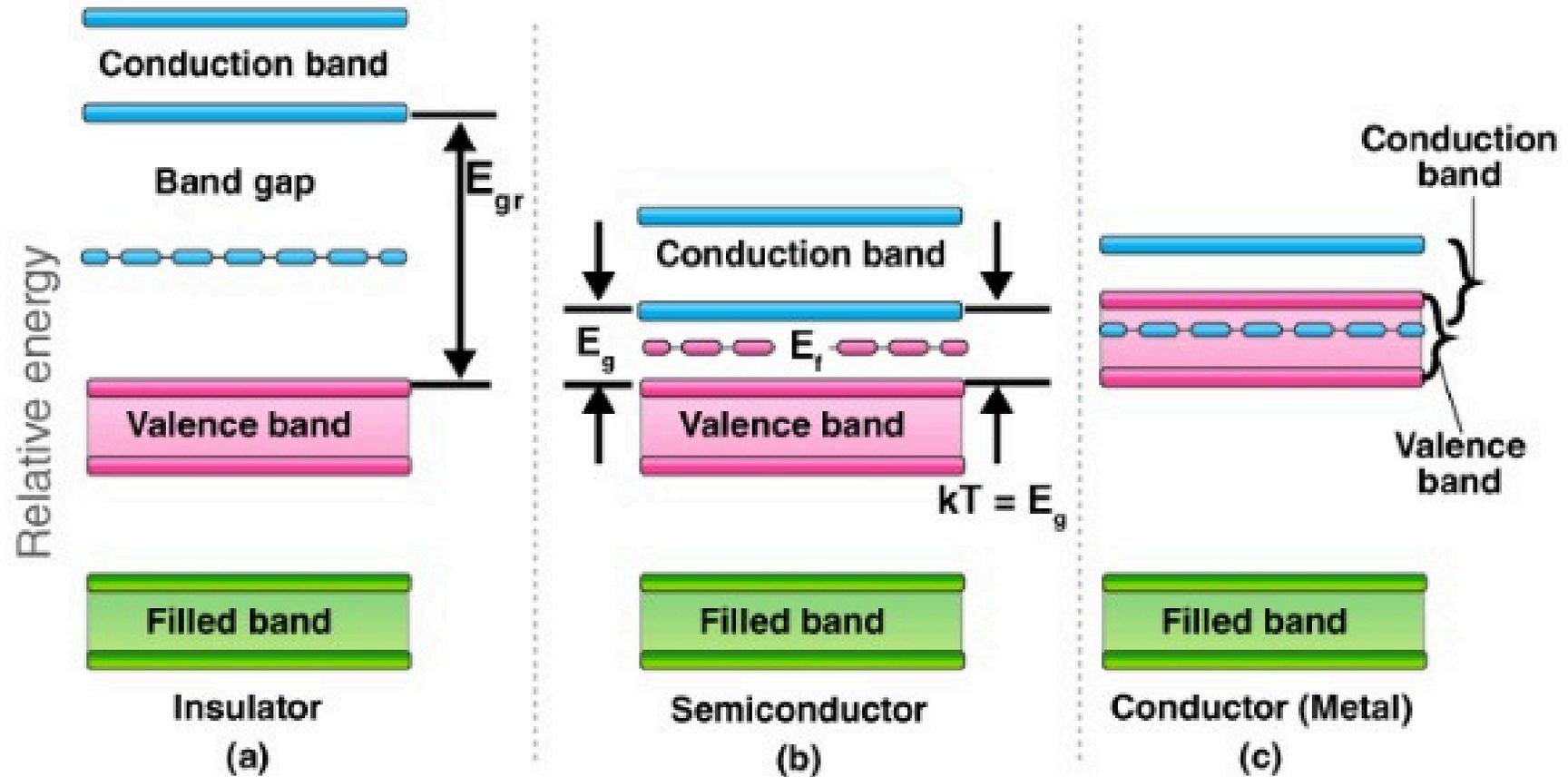
- In a semiconductor, the mobility of electrons is higher than that of the holes. It is mainly because of their different band structures and scattering mechanisms.
- Electrons travel in the conduction band, whereas holes travel in the valence band. When an electric field is applied, holes cannot move as freely as electrons due to their restricted movement. The elevation of electrons from their inner shells to higher shells results in the creation of holes in semiconductors. Since the holes experience stronger atomic force by the nucleus than electrons, holes mobility.
 - The mobility of a particle in a semiconductor is more, if
 - The effective mass of particles is lesser
 - The time between scattering events is more

Band Theory of Semiconductors



- The introduction of band theory happened during the quantum revolution in science. Walter Heitler and Fritz London discovered the energy bands.
- We know that the electrons in an atom are present at different energy levels. When we try to assemble a lattice of a solid with N atoms, each level of an atom must split into N levels in the solid. This splitting of sharp and tightly packed energy levels forms Energy Bands. The gap between adjacent bands representing a range of energies that possess no electron is called a Band Gap.

ENERGY BAND GAPS IN MATERIALS



Energy Band Diagram for Semiconductors, Conductors and Insulators

Properties of Semiconductors

- Semiconductors can conduct electricity under preferable conditions or circumstances. This unique property makes it an excellent material to conduct electricity in a controlled manner as required.
- Unlike conductors, the charge carriers in semiconductors arise only because of external energy (thermal agitation). It causes a certain number of valence electrons to cross the energy gap and jump into the conduction band, leaving an equal amount of unoccupied energy states, i.e., holes. The conduction due to electrons and holes is equally important.
- **Resistivity:** 10^{-5} to $10^6 \Omega\text{m}$
- **Conductivity:** 10^5 to 10^{-6}mho/m
- **Temperature coefficient of resistance:** Negative
- **Current flow:** Due to electrons and holes

Semiconductors Go Down with Temperature?

- The difference in resistivity between conductors and semiconductors is due to their difference in charge carrier density.
- The resistivity of semiconductors decreases with temperature because the number of charge carriers increases rapidly with an increase in temperature, making the fractional change, i.e., the temperature coefficient negative.

Some Important Properties of Semiconductors

1. Semiconductors act like insulators at zero Kelvin. On increasing the temperature, they work as conductors.
2. Due to their exceptional electrical properties, semiconductors can be modified by doping to make semiconductor devices suitable for energy conversion, switches and amplifiers.
3. Lesser power losses.
4. Semiconductors are smaller in size and possess less weight
5. Their resistivity is higher than conductors but lesser than insulators.
6. The resistance of semiconductor materials decreases with an increase in temperature and vice-versa.

Types of Semiconductors

Semiconductors can be classified as follows:

1. Intrinsic Semiconductor
2. Extrinsic Semiconductor

Extrinsic Semiconductor The conductivity of semiconductors can be greatly improved by introducing a small number of suitable replacement atoms called IMPURITIES. The process of adding impurity atoms to the pure semiconductor is called DOPING. Usually, only 1 atom in 10^7 is replaced by a dopant atom in the doped semiconductor.

An extrinsic semiconductor can be further classified into types:

- N-type Semiconductor
- P-type Semiconductor

- An **intrinsic type of semiconductor material** is made to be very pure chemically. It is made up of only a single type of element.
 - Germanium (Ge) and silicon (Si) are the most common types of intrinsic semiconductor elements. They have four valence electrons (tetravalent). They are bound to the atom by a covalent bond at absolute zero temperature.
 - When the temperature rises due to collisions, few electrons are unbounded and become free to move through the lattice, thus creating an absence in its original position (hole). These free electrons and holes contribute to the conduction of electricity in the semiconductor. The negative and positive charge carriers are equal in number.
 - The thermal energy is capable of ionizing a few atoms in the lattice, and hence, their conductivity is less.
- 

DIFFERENCE BETWEEN INTRINSIC AND EXTRINSIC CONDUCTOR

Factors	Intrinsic semiconductor	Extrinsic semiconductor
Purity of semiconductor	Pure semiconductor	Impure semiconductor
Density of electrons	Density of electrons is equal to the density of holes	Density of electrons is not equal to the density of holes
Electrical conductivity	Electrical conductivity is low	Electrical conductivity is high
Temperature effect	Dependence on temperature only	Dependence on temperature as well as on the amount of impurity only
Impurities	No impurities	Trivalent impurity, pentavalent impurity

Applications of Semiconductors

Let us now understand the uses of semiconductors in daily life. Semiconductors are used in almost all electronic devices. Without them, our life would be much different. Their reliability, compactness, low cost and controlled conduction of electricity make them ideal to be used for various purposes in a wide range of components and devices. Transistors, diodes, photosensors, microcontrollers, integrated chips and much more are made up of semiconductors

Uses of Semiconductors in Everyday Life

- Temperature sensors are made with semiconductor devices.
- They are used in 3D printing machines
- Used in microchips and self-driving cars
- Used in calculators, solar plates, computers and other electronic devices.
- Transistors and MOSFET used as a switch in electrical circuits are manufactured using semiconductors.

Industrial Uses of Semiconductors

- The physical and chemical properties of semiconductors make them capable of designing technological wonders like microchips, transistors, LEDs, solar cells, etc.
- The microprocessor used for controlling the operation of space vehicles, trains, robots, etc., is made up of transistors and other controlling devices, which are manufactured by semiconductor materials.

Importance of Semiconductors

- Here, we have discussed some advantages of semiconductors, which make them highly useful everywhere.
- They are highly portable due to their small size
- They require less input power
- Semiconductor devices are shockproof
- They have a longer lifespan
- They are noise-free while operating

What Are Insulators?

Insulators are materials that hinder the free flow of electrons from one particle of the element to another. If we transfer some amount of charge to such an element at any point, the charge remains at the initial location and does not get distributed across the surface. The most common process of charging of such elements is charging by rubbing (for some elements, with the help of suitable materials).

Examples of insulators

Some of the common insulator examples are given below:

- Plastic
- Wood
- Glass

CONDUCTOR	INSULATOR
Materials that permit electricity or heat to pass through it.	Materials that do not permit heat and electricity to pass through it.
A few examples of a conductor are silver, aluminum, and iron.	A few examples of an insulator are paper, wood, and rubber.
Electrons move freely within the conductor.	Electrons do not move freely within the insulator.
The electric field exists on the surface but remains zero on the inside.	The electric field doesn't exist.



Thank You

Shamna Subaida Khalid
shamnaplpy@gmail.com