ELECTRICAL PROPERTIES

Solids display a remarkable spectrum of electrical conductivities, spanning from 10^{-20} to 10^{7} $ohm^{-1}\ m^{-1}$. Based on their conductivities, solids can be categorized into three types.

(1) Conductors
(2) Insulators
(3) Semiconductors

Electrical Properties - Conductor

Conductors are materials that readily allow the flow of electric charge. They exhibit low resistivity, enabling them to conduct electricity efficiently.

High Conductivity:

Conductors are characterized by high electrical conductivity, meaning they offer minimal resistance to the passage of electric current. This property arises due to the presence of abundant free electrons, which are not tightly bound to their respective atoms and can move easily within the material when subjected to an electric field.

Free Electron Movement:

In conductors, the outermost electrons of atoms are loosely bound, allowing them to move freely throughout the material in response to an applied electric field. These mobile electrons facilitate the transfer of charge, resulting in the efficient conduction of electricity.

Low Resistivity:

The resistivity of conductors is significantly lower compared to insulators and semiconductors. This low resistivity enables conductors to transmit electric current with minimal loss of energy.

Applications:

Conductors find widespread applications in electrical wiring, circuits, and transmission lines due to their excellent conductivity. Common examples of conductors include metals such as copper, aluminum, silver, and gold.

Skin Effect:

At high frequencies, conductors may exhibit the skin effect, where the flow of current tends to concentrate near the surface of the conductor. This phenomenon is due to the self-inductance of the conductor and results in increased effective resistance at higher frequencies.

Temperature Dependence:

The conductivity of conductors typically decreases with increasing temperature. This is primarily because higher temperatures increase the lattice vibrations within the material, which can impede the movement of free electrons, leading to a rise in resistivity.

In summary, conductors possess high electrical conductivity, low resistivity, and abundant free electrons that facilitate the efficient flow of electric current. These materials play crucial roles in various electrical applications, including wiring, circuits, and transmission of electricity

Electrical Properties - Insulator and Semiconductor

Insulators and semiconductors are distinct categories of materials, each possessing unique electrical characteristics. Let's delve into the specifics of each:

Insulators

Insulators are materials that impede the flow of electricity. They exhibit exceptionally high resistivity, meaning they strongly resist the passage of electric current.

Within insulators, electrons remain firmly bound to their respective atoms, resulting in a scarcity of free electrons available for conducting electricity.

These materials are characterized by extremely low conductivities, typically ranging from 10^{-20} to 10^{-10} $(\Omega m)^{-1}$

Examples of insulators include compounds like MnO, CoO, NiO, CuO, Fe_2O_3, TiO_2.

Semiconductors

Semiconductors, on the other hand, occupy a middle ground between conductors (such as metals) and insulators in terms of electrical conductivity.

Unlike insulators, semiconductors exhibit a moderate resistivity, allowing them to conduct electricity under specific conditions.

Semiconductors house a greater number of free electrons compared to insulators, although still fewer than conductors.

The conductivity of semiconductors is notably influenced by variables such as temperature, impurities (known as doping), and applied voltage.

Falling within an intermediate conductivity range, typically spanning from 10^{-6} to 10^{4} $(\Omega m)^{-1}$, semiconductors play a pivotal role in electronic components.

Silicon (Si) and germanium (Ge) are prime examples of semiconductors, extensively utilized in the fabrication of transistors, diodes, and integrated circuits.

Furthermore, the energy band structure of semiconductors consists of both a valence band and a conduction band, with a narrower energy gap separating them compared to insulators. This diminished gap facilitates the movement of electrons from the valence band to the conduction band, particularly when influenced by external factors like temperature or doping.

To recap, insulators exhibit minimal conductivity due to tightly bound electrons and a significant energy gap between the valence and conduction bands, while semiconductors possess moderate conductivity owing to a narrower energy gap and a higher count of free electrons, whose conductivity can be enhanced by external factors.