Crystalline Material that Falls Between an Insulator and A Conductor

Lawkesh Tripathi
Asst. Professor
Department of Electronics and Communication Engg.
Shri Krishna University, Chhatarpur (M.P.)

ABSTRACT
Any crystalline material that falls between an insulator and a conductor in terms of electrical conductivity is referred to as a semiconductor. Semiconductors are used in the production of integrated circuits, diodes, and transistors among other types of electronic devices. These gadgets' affordability, portability, dependability, and power efficiency have led to their widespread adoption. They have been used as separate components in solid-state lasers, power devices, and optical sensors and light emitters. They can handle a wide range of current and voltage, and more importantl, they can be easily integrated into intricate yet easily manufactured microelectronic circuits. They serve as the essential components of most electronic systems, supporting applications related to computing, communications, signal processing, and control in both consumer and Industries.

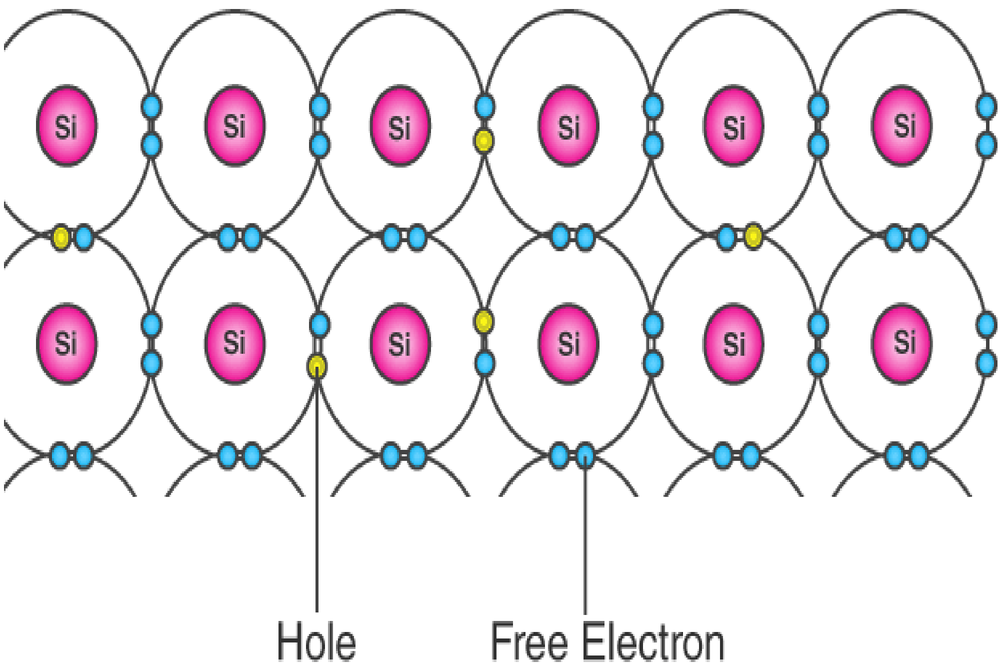
KEY WORDS
Semiconductor, Holes, Electron, Valence Band, P-n Junction, Electric Field, circuit.

INTRODUCTION
Materials with conductivity between non-conductors or insulators (like ceramics) and conductors (usually metals) are known as semiconductors. pure elements like silicon or germanium, or semiconductors like gallium arsenide. The properties and theories around semiconductors are better understood in terms of physics.
In semiconductors, gallium arsenide, germanium, and silicon are among the most often utilized materials. Gallium arsenide is utilized in solar cells, laser diodes, and other devices, whereas silicon is employed in the construction of electrical circuits.

HOLES AND ELECTRONS IN SEMICONDUCTORS
The charge carriers responsible for the current flow in semiconductors are holes and electrons. The positively charged electric charge carriers are called holes (valence electrons), and the negatively charged particles are called electrons. The polarity of electrons and holes is opposing, yet their magnitudes are equal.

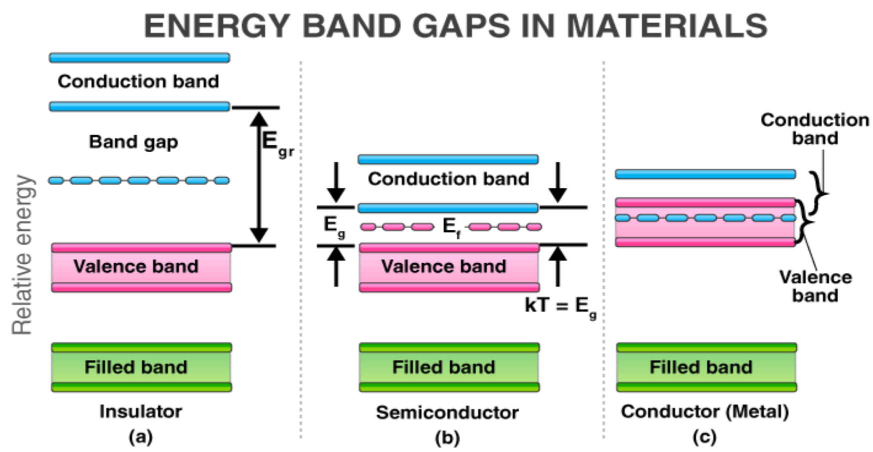
MOBILITY OF ELECTRONS AND HOLES
The electrons' mobility in a semiconductor is greater than the holes'. Their disparate band structures and scattering mechanisms are the primary causes of this.

Whereas holes move in the valence band, electrons move in the conduction band. Because of their limited mobility, holes are not able to travel as easily as electrons when an electric field is applied. In semiconductors, holes are created when electrons are elevated from their inner shells to higher shells. Holes have less mobility than electrons because the nucleus exerts a greater atomic force on them. In a semiconductor, a particle's mobility increases when its effective mass decreases. There is more time between scattering events.
At 300 K, the electron mobility in intrinsic silicon is 1500 cm2 (V·s)-1, while the hole mobility is 475 cm2 (V·s)-1.Below is a picture of the silicon bond model for electrons with valency 4. Here, a hole (grey dots) is created when a free electron (blue dots) departs from the lattice position. As a result, a hole is formed in the lattice that accepts the electron's opposite charge and moves as positive charge carriers.



BAND THEORY OF SEMICONDUCTORS

Band theory was first introduced in the scientific realm during the quantum revolution. The energy bands were discovered by Fritz London and Walter Heitler. We are aware that an atom's electrons exist at various energies. Each level of an atom must split into N levels in the solid when we attempt to create a lattice of N atoms. Energy Bands are created when sharp, closely spaced energy levels split apart. A band gap is the space between adjacent bands that indicate an electron-free range of energies.



CONDUCTION BAND AND VALENCE BAND IN SEMICONDUCTORS

VALENCE BAND

The energy band containing the energy levels of the valence electrons is called the valence band. This is the highest occupied energy range. Compared to insulators, the bandgap of semiconductors is smaller. This allows electrons in the valence band to jump to the conduction band when external energy is applied.

CONDUCTION BAND

It is the lowest unoccupied band containing positive (holes) or negative (free electrons) energy levels. It has conduction electrons that cause a current to flow. The conduction band has a high energy level and is usually empty. The conduction band of semiconductors accepts electrons from the valence band.

WHAT IS THE FERMI LEVEL IN SEMICONDUCTORS?

Fermi level (EF) is found between the valence band and conduction band. It's the highest occupied molecular orbit at absolute zero. In this state, the charge carriers have their quantum states and do not interact with one another. When the temperature goes above absolute zero, the charge carriers start to occupy states above Fermi. In a p type semiconductor, the number of unfilled states increases. This means that more electrons are able to be accommodated at lower energy levels. In an n type semiconductor, however, the number of states increases, so more electrons can be accommodated at higher energy levels.

WHY DOES THE RESISTIVITY OF SEMICONDUCTORS GO DOWN WITH TEMPERATURE?

Semiconductors have a different charge carrier density than conductors, which explains why their resistivity decreases with temperature. Semiconductors' resistivity decreases as the number of carriers increases with temperature, resulting in a fractional change in the temperature coefficient.

SOME IMPORTANT PROPERTIES OF SEMICONDUCTORS

● Semiconductors act like insulators at zero Kelvin. On increasing the temperature, they work as conductors.

● Due to their exceptional electrical properties, semiconductors can be modified by doping to make semiconductor devices suitable for energy conversion, switches and amplifiers.

● Lesser power losses.

● Semiconductors are smaller in size and possess less weight. Their resistivity is higher than conductors but lesser than insulators.

APPLICATION OF SEMICONDUCTOR

● Semiconductors are used in almost all electronic devices.

● 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.

● 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, diodes, photosensors, microcontrollers, integrated chips and much more are made up of semiconductors.

CONCLUSION

Semiconductor Diodes: P-n junction Diodes are diodes that are connected to external electrical current sources. Forward Bias Semiconductor Diode: The positive terminal of the battery is connected to one of the p-type regions (semiconductor diode) and the negative terminal of the diode (n-type region).

REFERENCES

1. Ordinary Level Physics, A.F. Abbott, Arnold-Heinemann (1984).
2. Advanced Level Physics, M. Nelkon and P. Parker,6th Edition, Arnold-Heinemann (1987).
3. Advanced Physics, Tom Duncan, John Murray (2000).
4. Fundamentals of Physics, David Halliday, Robert Resnick and Jearl Walker,7th Edition John Wily (2004).
5. University Physics (Sears and Zemansky's), H.D. Young and R.A. Freedman,11th Edition, Addison—Wesley (2004).
6. Semiconductor Devices 2nd Edition by S. M.Sze,Wiley Student Edition.