Semiconductor fundamentals:

1.1 Energy band

Formation of Energy Band

The electrons in each orbit of an isolated atom have a certain amount of energy. The energy level of the outermost orbit electrons is influenced by the atoms nearby. The electrons in the outermost orbit feel an attractive attraction from the closest or adjacent atomic nucleus when two isolated charges are brought close together.

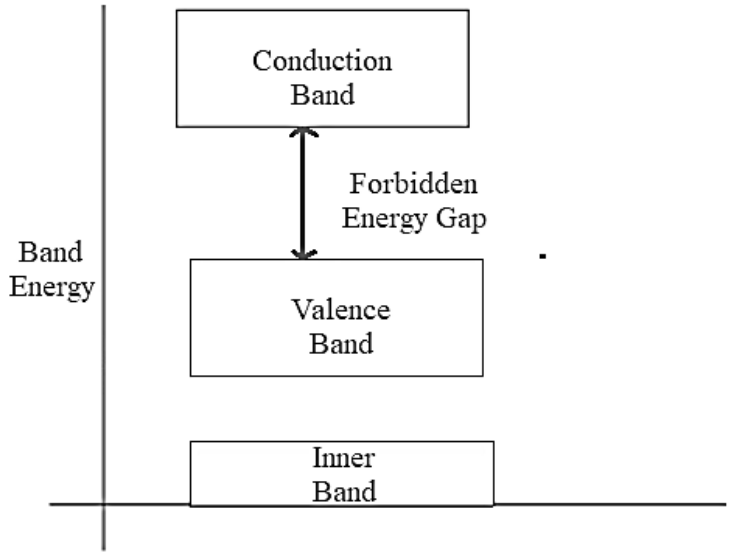
Because of this, electron energies will not be at the same level, and electron energy levels will be modified to a value that is greater or lower than the initial energy level of the electron. The energy of inner orbit electrons, on the other hand, is unaffected by the existence of nearby atoms.

The energy levels of electrons in the same orbit differ. The term "energy band" refers to the grouping of these various energy levels.

Energy Band Theory

According to Bohr's hypothesis, each atom's shell has a different amount of energy at different levels. The major focus of this theory is on electron communication between the interior and outer shells. The energy bands are categorised into three categories according to the theory of energy bands, which include the following.

- Conduction Band
- Valence Band
- Forbidden Gap



Energy Band Theory

Conduction Band

At normal temperature, the valence electrons are loosely connected to the nucleus. Some valence electron electrons will be able to depart the band freely. Because they flow towards neighbouring atoms, these are called free electrons. These free electrons, also known as conduction electrons, will conduct current flow within a conductor. The band that includes conduction electrons is known as the conduction band, and its occupied energy is lower.

Valence Band

Although electrons travel at fixed energy levels within atoms, the energy of an electron in the inner shell is greater than that of an electron in the outer shell. Valance electrons are the electrons that are found within the outer shell. These electrons are made up of a series of energy levels that make up the valence band. This band has the highest level of occupied energy.

Forbidden Gap

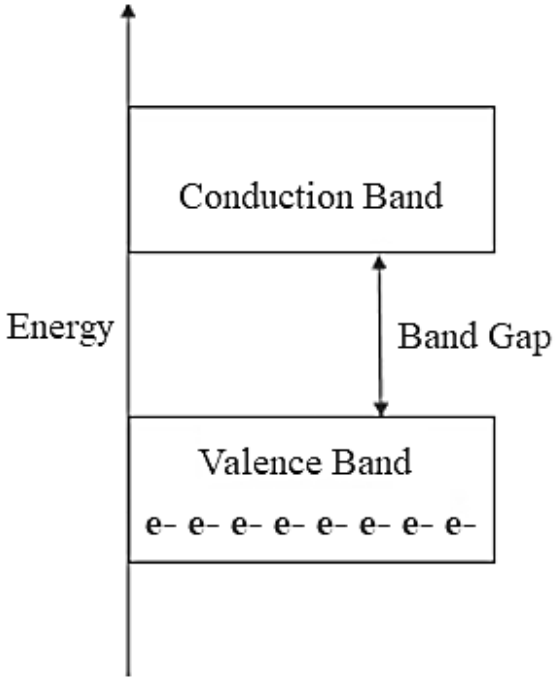
The prohibited gap is defined as the space between the conduction and valence bands. This is a band that is not allowed to exist because it lacks energy. As a result, no electrons flow in this band. This gap will allow electrons to move from the valence to the conduction state.

Semiconductors, conductors, and insulators are created based on the gap size.

- Insulators
- Conductors
- Semiconductors

Insulators

Insulators are substances or materials that do not conduct electricity and do not allow it to pass through them. The prohibited energy gap in the insulators is wide enough to prevent electricity from passing through. Insulators include materials such as rubber and wood. The structure of energy bands in insulators is seen in the diagram below.



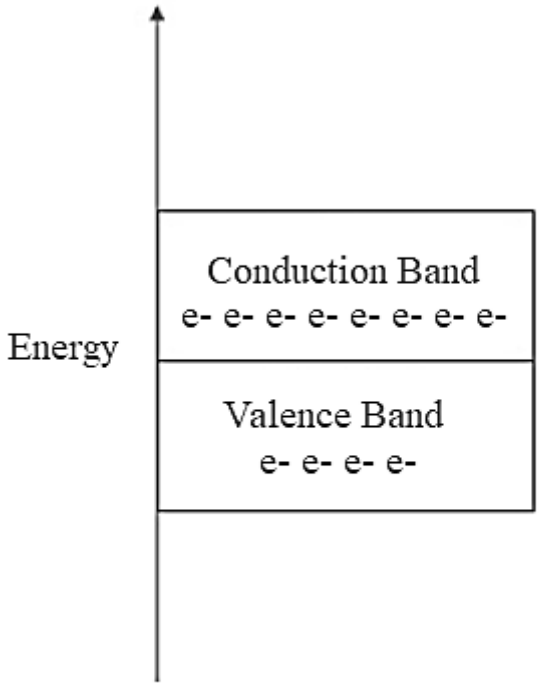
Energy Band in Insulators

Insulators have the following characteristics:

- ✓ In the valence band, electrons are strongly bonded or firmly connected to atoms.
- ✓ In insulators with a value of 10 eV, the prohibited energy gap is big enough.
- ✓ Conduction may occur in some insulators when the temperature rises.

Conductors

Conductors are the substances or materials that conduct electricity as they allow electricity to flow through them. The forbidden energy gap disappears in the conductors, as the conduction band and the valence band come close to each other and overlap. Copper, gold, and silver are a few examples of conductors. The figure given below shows the structure of energy bands in conductors. At normal temperature, the amount of free electrons available is enormous. The conductor's energy band diagram is given below.



Energy Band in Conductors

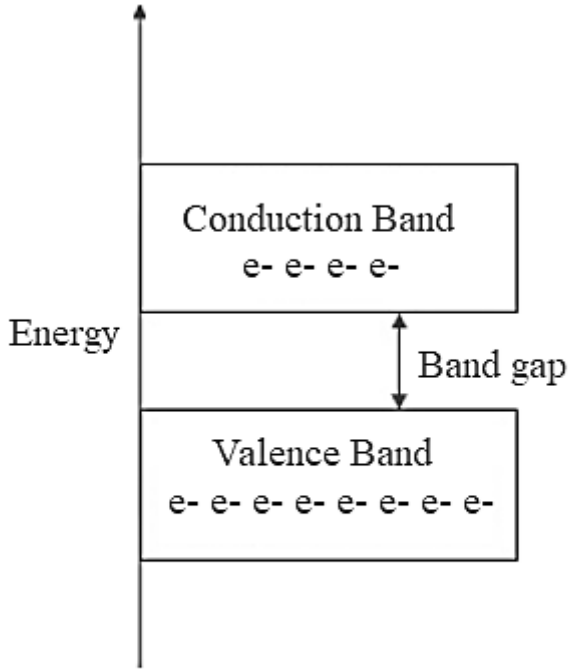
The energy gap, which is banned, is one of the most important properties of conductors. The energy bands of valence and conduction will get entangled. There are plenty of free electrons available for conduction. Once the limited number of voltages rises, the conduction will grow.

Conductors have the following characteristics:

- ✓ In a conductor, there is no such thing as a prohibited energy gap.
- ✓ In conductors, the valence band and the conduction band overlap.
- ✓ There are a large number of free electrons accessible for power transmission.
- ✓ When the voltage is increased slightly, the conduction increases as well.
- ✓ Because the constant flow of electrons adds to the current produced, there is no idea of hole creation.

Semiconductors

Semiconductors are materials or substances that have conductivity between conductors and insulators. The prohibited energy gap in semiconductors is tiny, and electricity can only be conducted if external energy is applied. Semiconductors examples are germanium and silicon. The structure of energy bands in semiconductors is seen in the diagram below.



Energy Band in Semiconductors

Semiconductors have the following characteristics:

- ✓ In a semiconductor, the prohibited energy gap is minimal.
- ✓ The prohibited energy gap for Germanium (Ge) is 0.7eV, whereas it is 1.1eV for Silicon (Si).
- ✓ The conductivity of semiconductors rises as the temperature rises.
- ✓ Semiconductors have neither strong conductivity nor good insulating properties.