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Conduction in Semiconductors

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ABSTRACT

This paper will give us knowledge about conduction in semiconductor and energy bands and the process of conduction in conduction band in semiconductor. This will also tell about the how conduction takes place in the semiconductor and what is it useful for and how conduction in semiconductor takes place. We will know about the different type of band and the conduction take place in semiconductor material and how with the help of electron and holes it takes place.

INTRODUCTION

A **semiconductor** is a material, which has electrical conductivity between that of a conductor such as copper and that of an insulator such as glass. Semiconductors are the foundation of modern electronics, including transistors, solar cells, light-emitting diodes (LEDs), quantum dots and digital and analog integrated circuits. The modern understanding of the properties of a semiconductor relies on quantum physics to explain the movement of electrons and holes inside a lattice. An increased knowledge of semiconductor materials and fabrication processes has made possible continuing increases in the complexity and speed of integrated semiconductor devices.

The electrical conductivity of a semiconductor material increases with increasing temperature, which is behavior opposite to that of a metal. Semiconductor devices can display a range of useful properties such as passing current more easily in one direction than the other, showing variable resistance, and sensitivity to light or heat. Because the electrical properties of a semiconductor material can be modified by controlled addition of impurities or by the application of electrical fields or light, devices made from semiconductors can be used for amplification, switching, and energy conversion.

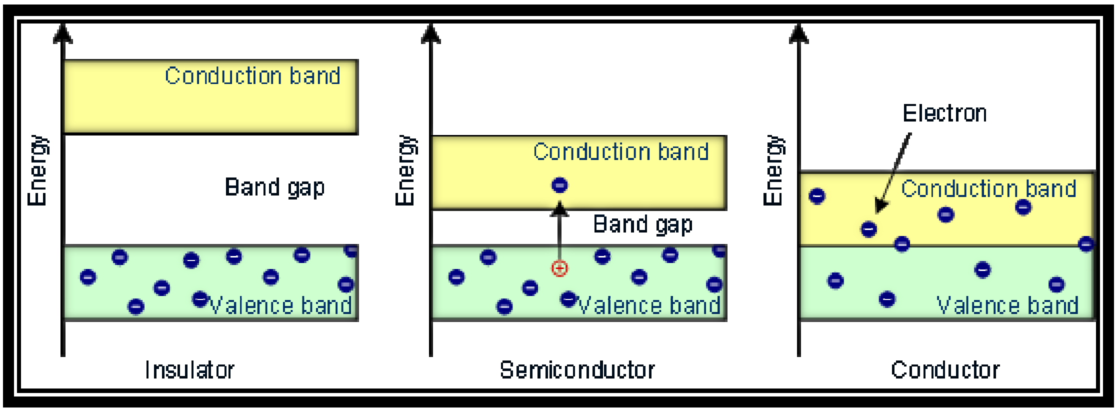
DISCUSSION

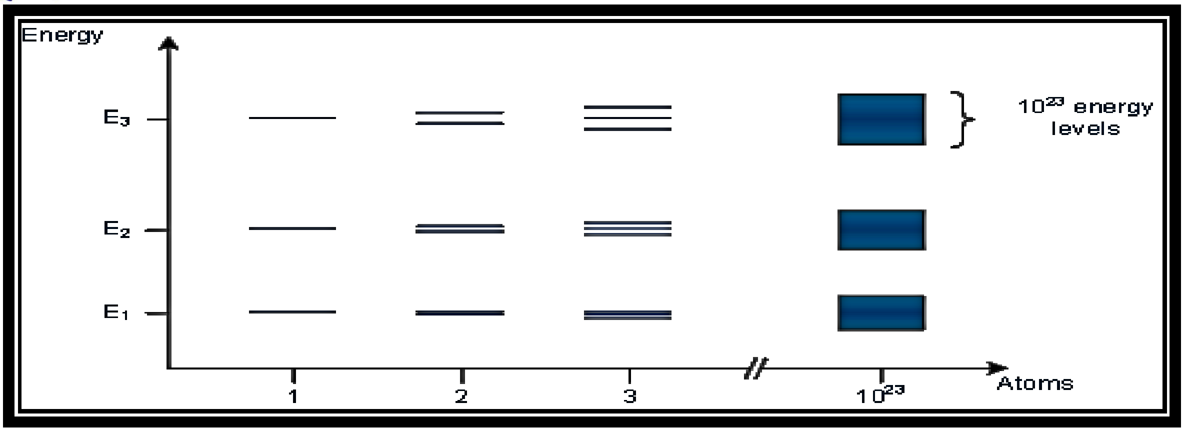
1. CONDUCTORS: They are substances which have the property to pass different type of energy.
2. INULATORS:They possess no free charyge carriers and thus are non conductive.

3. SEMICONDUCTORS:They are solid whose conductivity lies between the conductivity of conductors and insulators. Due to exchange of electrons they achieve nobel gas configuration. Semiconducctor arrange as lattice structure.unlike metals their conductivity increases with increse in temperature.

BAND MODEL OF SEMICONDUCTORS:

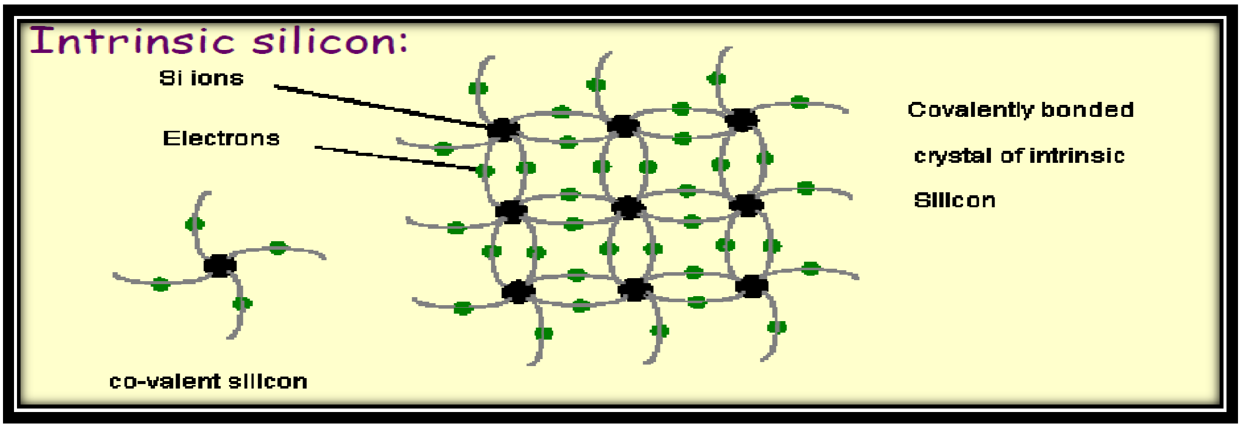
- Even in semiconductors, there is a band gap, but compared to insulators it is very small that even at room temperature electron can be lifted from the valence band to the conduction band.
- The electrons can move freely and act as charge carriers. Each electron also leaves a hole in the valence band that other electrons in the same valence band fill the gap. Thus, one gets wandering holes in the valence band, viewed as positive charge carriers.
- There are always pairs of electrons and holes, so that there are as many negative as positive charges, the semiconductor crystal as a whole is neutral. A pure undoped semiconductor is known as intrinsic semiconductor. Per cubic centimeter, there are about 10^{10} free electrons and holes (at room temperature).
- Since the electrons always assume the energetically lowest state, they fall back into the valence band and recombine with the holes if there is no energy supply.
- At a certain temperature, equilibrium is arranged between the electrons elevated to the conduction band and the electrons falling back.
- With increasing temperature the number of electrons that can leap the band gap is increased, and thus increasing the conductivity of semiconductors.





INTRINSIC SEMICONDUCTORS

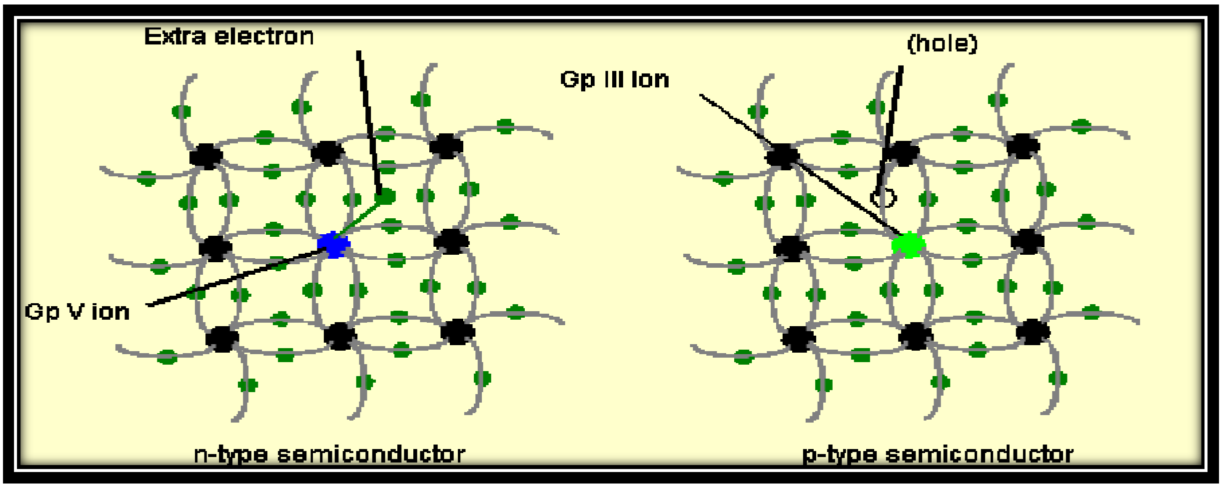
- Semiconductor = material for which gap between valence band and conduction band is small ;(gap width in Si is 1.1 eV, in Ge 0.7 eV).
- At T = 0, there are no electrons in the conduction band, and the semiconductor does not conduct (lack of free charge carriers);
- At T > 0, some electrons have sufficient thermal kinetic energy to overcome the gap and jump to the conduction band; fraction rises with temperature. e.g. at 20o C (293 K), Si has 0.9x1010 conduction electrons per cubic centimeter; at 50o C (323 K) there are 7.4x1010 .
- Electrons moving to conduction band leave "hole" (covalent bond with missing electron) behind; under influence of applied electric field, neighboring electrons can jump into the hole, thus creating a new hole, etc. ⇒ holes can move under the influence of an applied electric field, just like electrons; both contribute to conduction.
- in pure Si and Ge, there are equally many holes ("p type charge carriers") as there are conduction electrons ("n-type charge carriers");
- Pure semiconductors also called "intrinsic semiconductors".



EXTRINSIC (DOPED) SEMICONDUCTORS:

P-type: acceptor (p-type) impurities

- advantages of doped semiconductors:" can"tune" conductivity by choice of dopingfraction" can choose "majority carrier" (electron or hole)" can vary doping fraction and/or majority carrierwithin piece of semiconductor" can make "p-n junctions" (diodes) and"transistors"
- P-typesemiconductor remains electrically neutral as the number of mobile holes under all condition remains equal to the number of acceptors.
- In P-type conductivity the valance electron moves from one covalent bond to another covalent bond unlike N-type where conduction id by electrons.
- They are trivalent impurity. Example: Si and Ge



N-type: donor (n-type) impurities

- It donates one electron to conduction band of a pure semiconductor.
- They are pentavalent impurity.
- These donate electron called excess electron.
- When donor impurities are added to an intrinsic semiconductor, allowable energy levels are introduced at a very small distance below the conduction band.
- Example: arsenic, bismuth, antimony or phosphorus.

CONDUCTION IN SEMICONDUCTORS:

In semiconductors such as silicon, each constituent atom has four outer electrons, each of which pairs with an electron from one of four neighboring atoms to form the interatomic bonds. Completely pure silicon thus has essentially no electrons available at room temperature for electronic conduction, making it a very poor conductor. However, if an atom from column V of the periodic table, such as phosphorus, is substituted for an atom of silicon, four of its five outer electrons will be used for bonding, while the fifth will be free to move within the crystal. If the replacement atom comes from column III of the periodic table—say, boron—it will have only three outer electrons, one too few to complete the four interatomic bonds. The fact that the crystal would be electrically neutral was the bond complete means that, if an electron is missing, the vacancy will have a positive charge. A neighboring electron can move into the vacancy, leaving another vacancy in the electron's former place. This vacancy, with its positive charge, is thus mobile and is called a "hole." Holesin semiconductors move about as readily as electrons do, but, because they are positively charged, they move in directions opposite to the motion of electrons.

CONCLUSION: At last I will like to conclude that the method of conduction in semiconductor. That is due to electron and holes as they jump from valance band to conduction band or even in case of silicon and germanium how they pair up with electrons or holes.

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