Basics OF sEMICONDUCTOR

Lecture – 2

TDC PART – I

Paper - I (Group - B)

Chapter - 4

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Semiconductor Basics

Semiconductors are made up of individual atoms bonded together in a regular, periodic structure to form an arrangement whereby each atom is surrounded by 8 electrons. An individual atom consists of a nucleus made up of a core of protons (positively charged particles) and neutrons (particles having no charge) surrounded by electrons. The number of electrons and protons is equal, such that the atom is overall electrically neutral. The electrons occupy certain energy levels, based on the number of electrons in the atom, which is different for each element in the periodic table.

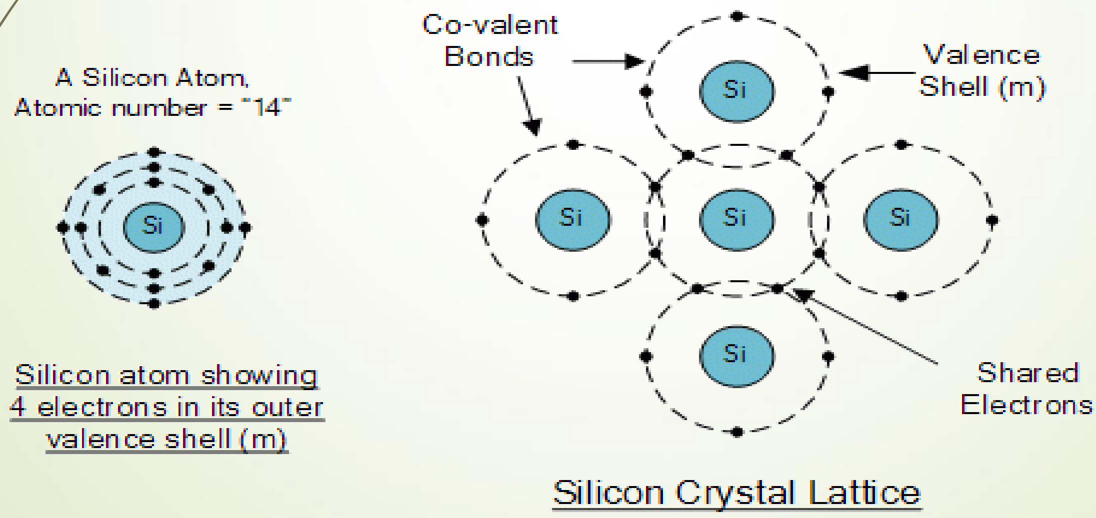

Fig.1 Lecture-2, silicon crystal lattice

COVALENT BONDS IN A SILICON CRYSTAL LATTICE

The atoms in a semiconductor are materials from either group IV of the periodic table, or from a combination of group III and group V (called III-V semiconductors), or of combinations from group II and group VI (called II-VI semiconductors). Silicon is the most commonly used semiconductor material as it forms the basis for integrated circuit (IC) chips. Most solar cells are also silicon based. Several properties of silicon are described at the silicon page

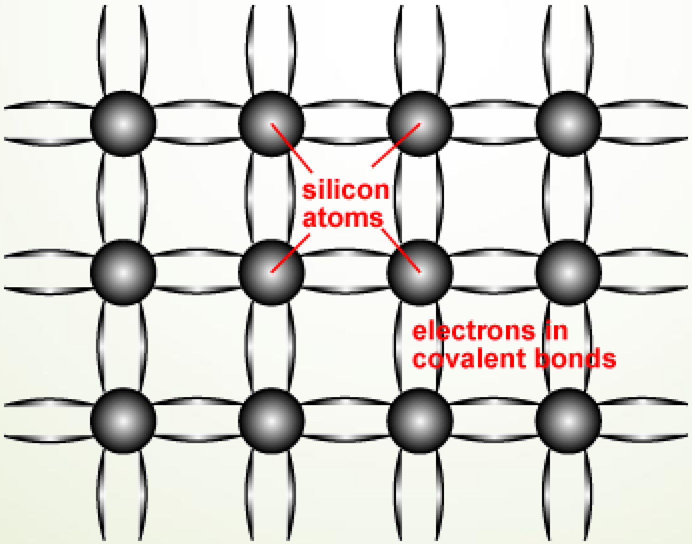

Fig-2, Lecture-2

Bond Structure in Semiconductor

The bond structure of a semiconductor determines the material properties of a semiconductor. One key effect is limit the energy levels which the electrons can occupy and how they move about the crystal lattice. The electrons surrounding each atom in a semiconductor are part of a covalent bond. A covalent bond consists of two atoms "sharing" a single electron, such that each atom is surrounded by 8 electrons. The electrons in the covalent bond are held in place by this bond and hence they are localised to region surrounding the atom. Since they cannot move or change their energy, electrons in a bond are not considered "free" and cannot participate in current flow, absorption or other physical processes which require presence of free electrons

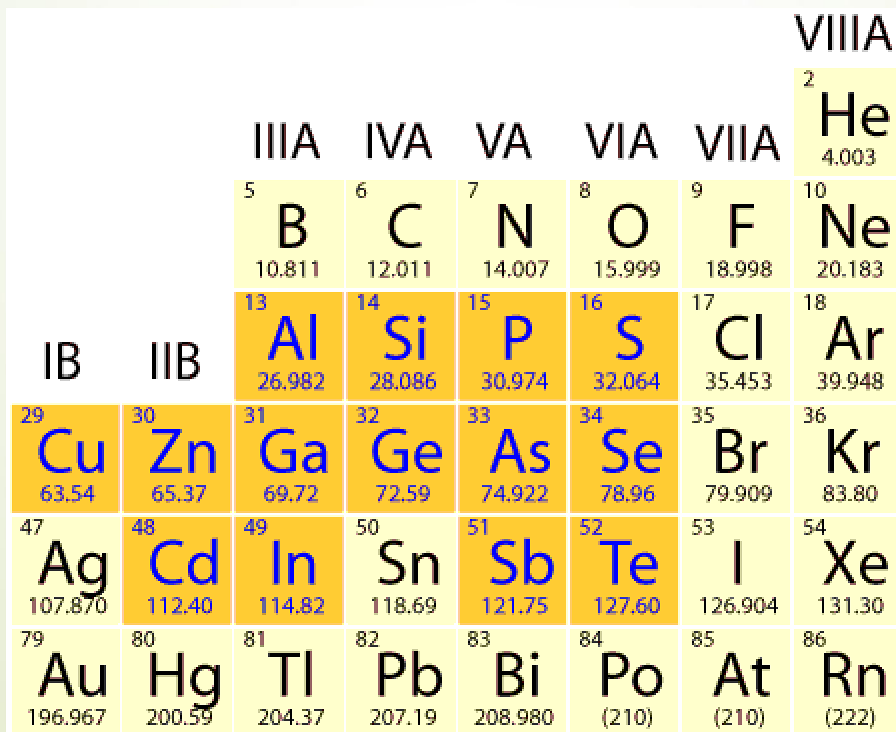

Fig-3, Lecture-2, Bond structure

BandGap

The band gap of a semiconductor is the minimum energy required to move an electron from its bound state to a free state where it can participate in conduction. The band structure of a semiconductor gives the energy of the electrons on the y-axis and is called a "band diagram". The lower energy level of a semiconductor is called the "valence band" (E_V) and the energy level at which an electron can be considered free is called the "conduction band" (E_C). The band gap (E_G) is the distance between the conduction band and valence band. Once the electron is in the conduction band, it is free to move about the semiconductor and participate in conduction. However, the movement of an electron to the conduction band will also allow an additional conduction process to take place. The movement of an electron to the conduction band leaves behind an empty space for an electron. An electron from a neighboring atom can move into this empty space. When this electron moves, it leaves behind another space. The continual movement of the space for an electron, called a "hole",

1. The resistivity is usually high.
2. The temperature co-efficient of resistance is always neg
3. The contact between semiconductor and a metal forms
4. When some suitable metallic impurity (e.g. Arsenic Galli
5. They exhibit a rise in conductivity in the increasing temp
and at low temperatures semiconductors becomes dielectr

Some Important Questions

Q1. What is the basis for classifying a material as a conductor, semiconductor, or a dielectric? What is the conductivity of perfect dielectric?

Conductors possess high conductivity whereas the characteristic property of insulating materials (or dielectrics) is poor conductivity. Semiconductors occupy an intermediate position between conductors and insulators. Though there is no rigid line separating the conductors from semiconductors and semiconductors from insulators, but still according to resistivity the materials of resistivity of the order from 10^{-8} to 10^{-3} , 10^{-13} to 10^{6} and 10^{6} to 10^{18} ohm-meters may be classified as conductors, semiconductors and dielectrics respectively. Another classification is based on temperature coefficient of resistivity. Metals have positive temperature coefficient of resistivity. Semiconductors have small negative temperature coefficient of resistivity and insulators have large negative temperature coefficient of resistivity.

Important Questions

Q2. Differentiate semiconductors, conductors and insulators on the basis of band gap.

The distinction between conductors, insulators and semiconductors is largely concerned with the relative width of the forbidden energy gaps in their energy band structures. There is a wide forbidden gap (more than 5eV) for insulators, narrow forbidden gap (about 1eV) in case of semiconductors and no forbidden gap in case of conductors.

Q3. What is the importance of valence shell and valence electrons?

The outermost shell of an atom is called valence shell and the electrons in this shell are called valence electrons. Formation of energy bands occur owing to overlapping of energy levels of these valence electrons in valence shells. With the decrease in interatomic distance between the atoms in a crystal, the energy levels of electrons in outermost shells of atoms overlap to form energy bands.

Define a hole in a semiconductor.

When an energy is supplied to a semiconductor a valence electron is lifted to a higher energy level. The departing electron leaves a vacancy in the valence band. The vacancy is called a hole. Thus, a vacancy left in the valence band because of lifting of an electron from the valence band to conduction band is known as a hole.

Thank you