SEMICONDUCTORS

Semiconductor are material that have conductivity between conductors (usually metals) and non- conductors or some insulators such as ceramics. Compound such as gallium arsenide or pure element such as germanium or silicon may be semiconductors.

Example: Many of the most widely used semiconductors includes gallium arsenide germanium and silicon. Silicon is used in the manufacture of electronic circuits and gallium arsenide is used in solar cells, laser diodes etc.

HOLES AND ELECTRONS

Holes and electrons are the type of charging carries which are responsible for current flow in semiconductors. Holes (valence electrons) are the electric charge carrier which is charged positively, whereas the electrons are the particles which are charged negatively. Both electrons and hole are of similar magnitude but polarity is opposite.

MOBILITY OF HOLES AND ELECTRONS

At low temperature in the crystal the electrons in a semiconductor are bound in their respective bands, they are not eligible for electric conduction. Thermal vibration at high temperatures may break some of the covalent bond to yield free electrons that will participate in current conduction. When an electron travels away from a covalent bond connected with that bond there is an electron vacancy. A neighboring electron will fill this vacancy position from one crystal site to another site. Fiction particle referred to as a hole which carries a positive charge and travels in the opposite direction to that of electron. As added to the semiconductor, both the free electrons located in the conduction band and the holes left behind in the valence band pas through the crystal, creating and electric current. The electric conductivity of a substance depends upon the number of free electrons and holes per unit volume and the rate these carries pass below. There are an equivalent number if free electrons and holes in an intrinsic semiconductor and both have different mobility. They travel through different speeds. For example, electron mobility is 1500 (cm2/V. S) for intrinsic silicon at room temperature.

The electron travels at a speed of 1500 centimeter par second under an electrical field of 1 volt per centimeter, while the mobility if the holes 500 cm2/V. in a specific semiconductor, the mobilities of the electron and hole usually decrease with increasing temperature.

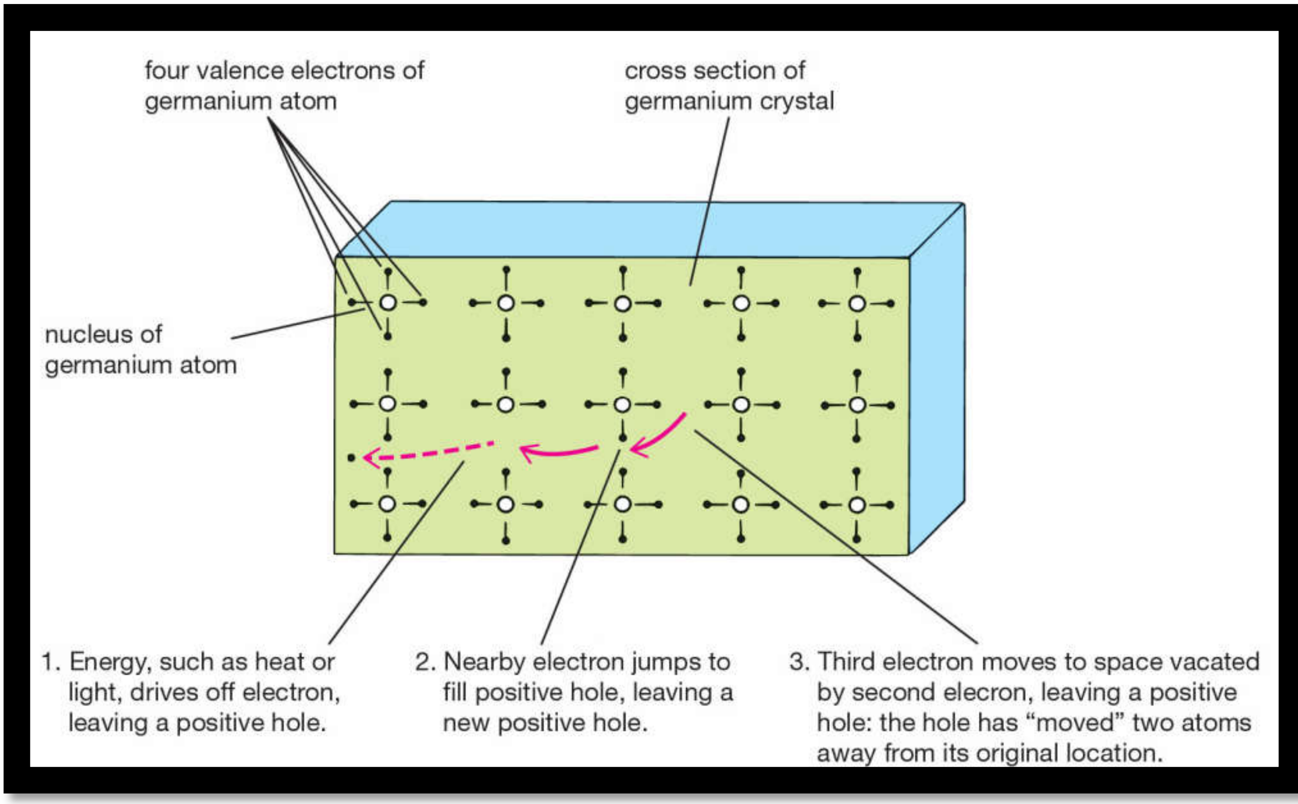


Figure 1: Electron and holes in semiconductors

BAND THEORY OF SEMICONDUCTORS

In Physics, the development of band theory occurred during the quantum revolution. The energy groups were discovered by Walter and Fritz London.

This fragmentation of sharp, tightly packed energy levels shapes Energy band. The difference between neighboring bands is called a BAND DISTANCE. Describing a spectrum of energies that do not contain an electron.

CONDUCTON BAND IN SEMICONDUCTORS

This is the lowest un occupied band that contains the energy levels of charging carries positive (holes) or negative (electrons). It has conducting electrons which result in current flow. The conductive band has high level of energy and is usually zero. For semiconductors the conductive band accepts electrons fro, the valence band.

VALANCE BAND IN SEMICONDUCTNCE

The energy band which includes the valence electrons levels is known as the valence band. This is the power category with the highest occupation. The band gap in semiconductors is smaller as compared to insulators. After receiving some external energy, it allows the electrons in the valence band to leap into the conduction band. Conduction and valence band along the energy axis.

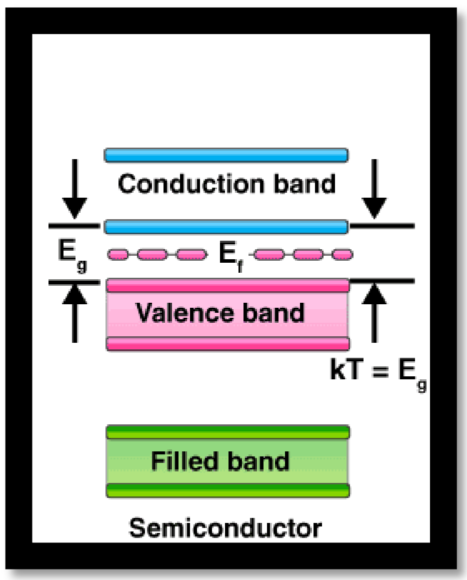
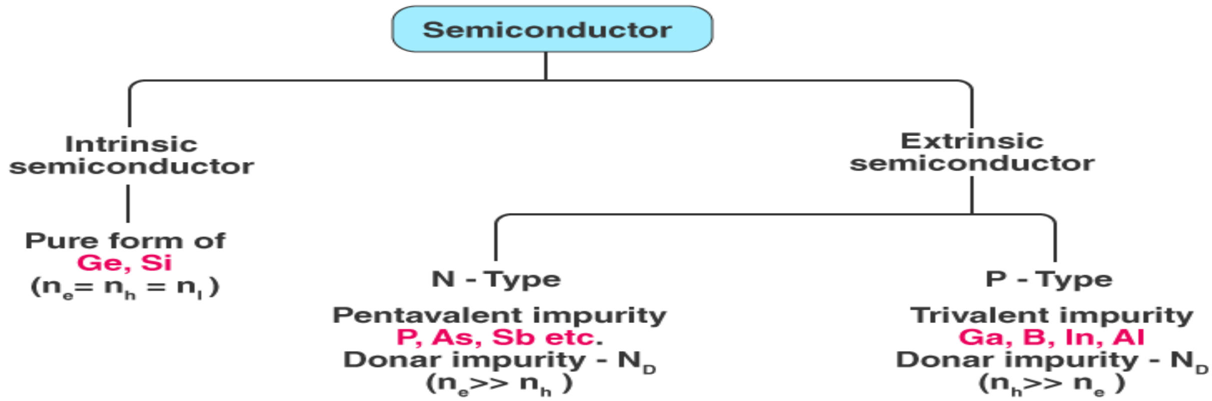


Figure 2: Energy band diagram in semiconductors

TYPES OF SEMICONDUCTORS

a) *Intrinsic*
b) *Extrinsic*



INTRINSIC SEMICONDUCTOR

Chemically very clean and poorly conductive. It carries equal numbers of negative (electrons) and carries positive (holes) impurities which do not affect its electrical behavior.

Example: the pure semiconductor material without impurities atoms. Such as silicon and germanium. Both have (4) four outer shell valence electrons.

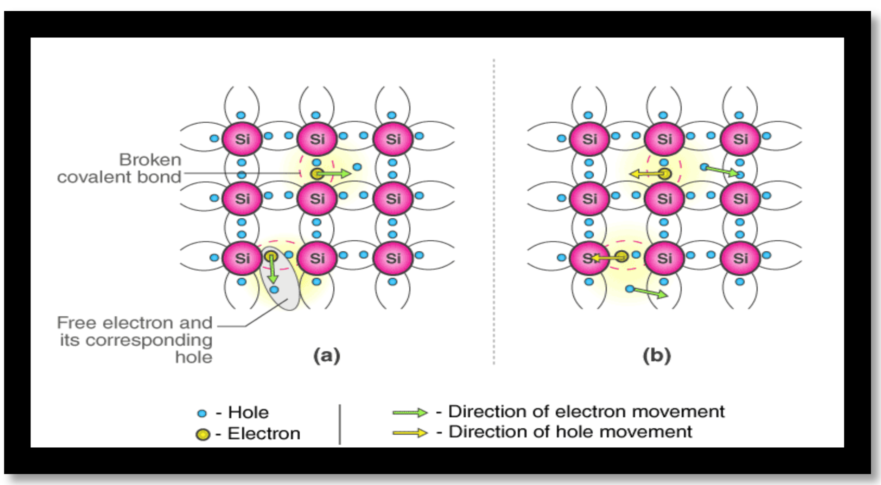


Figure 3: (a) In absence of electric field (b) In presence of electric field

At the temperature rises due to collision, few electrons are unbounded and free to pass through the lattice, thus producing an absence in its original (hole) location. These free electrons and holes in the semiconductor contribute to the conduction of electricity. The carries of negative and positive charges are equal in size. The thermal energy will ionize a few atoms in the lattice, and thus its conductivity is lower.

SEMICONDUCTORS AT DIFFERENT TEMPERATURE

At absolute zero kelvin temperature: The covalent bonds are very solid at this temperature and there are no free electrons, so the semiconductors functions as a natural insulator.

Above absolute temperature: Few valance electrons jump into the conduction band with the increase in temperature and therefore act as a poor conductor.

EXTRINSIC SEMICONDUCTOR

Improved intrinsic semiconductor with a small amount of impurities added through a process, known as a doping (dopant) process that alters the semiconductor’s electrical properties and improves its conductivity. Impurities can be introduced into the semiconductor material (doping process) to regulate its conductivity.

These extrinsic semiconductors are further divided into two types:

a) P-type Semiconductors
b) N-type Semiconductors

N-TYPE SEMICONDUCTORS

It is a type of extrinsic semiconductor in which the dopant atoms are capable of supplying the host material with extra conduction electrons. Example: (silicon phosphorous). This produce an excess of the negative electron charging carries (n- type). N-type semiconductor there is an extra electron present after the material has been dopant with phosphorous. Doping atom usually has one more valence electron than a host atom form. Example of this is atomic replacement by Group-V element in group-IV solids. If the host contains more than one type of atom the situation is more unpredictable. For example, silicon can be a donor in III-V semiconductors such as gallium arsenide when it substituents for gallium or an acceptor when adding arsenic. Many donors have less valence electron than the host, such as an alkali metals which in more solids are donor.

P-TYPE SEMICONDUCTORS

In this type after boron doping of the material, the electron is about from the structure, leaving a hole. It makes electron transfer faster. For the case of silicon, the crystal lattice is substituent by a trivalent atom. As a consequence, one electron is absent from one of the four covalent bonds that usually form part of the lattice of silicon. So the dopant atom will take an electron from the covalent bond of a neighboring atom to complete the fourth bond. For this function these dopants are called acceptors. This cause the loss of half of one bond from the neighboring atom when the dopant atom absorbs as an electron, which results in the creation of a hole. However, after each hole has a far away into the lattice, an electron will expose one proton in the atom at the position of the hole and will no longer cancel. This atom would have three electrons and one hole with four protons, surrounding a single nucleus. This reason, when a sufficient large number of acceptor atoms are instead a hole acts as a positive charge. Holes are thus the majority carries, while electrons in P-type materials are minority carries.

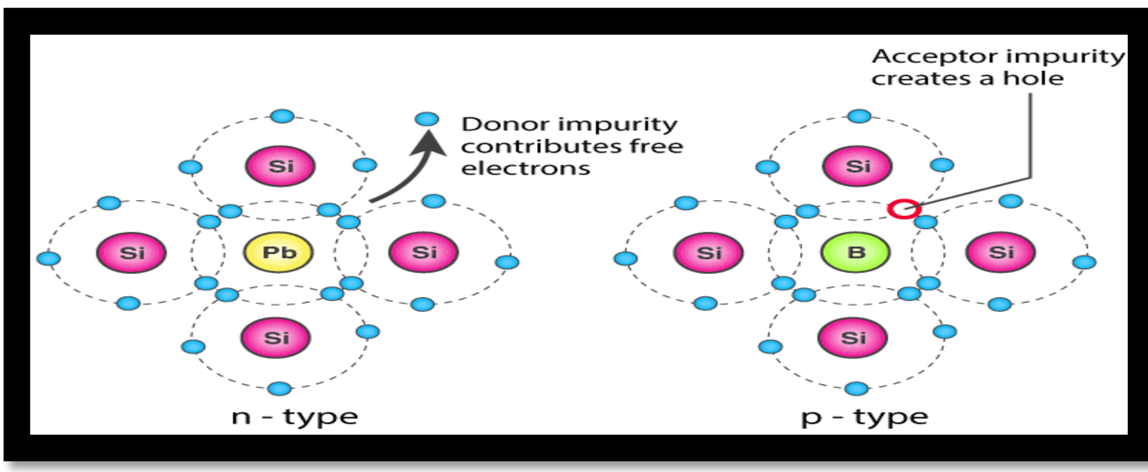


Figure 4: N-P Types semiconductors

Three types of Electronic Devices

a) FORWARD BIASED

If an unexpected shift in the amount of impurity occurs within a single crystal structure from acceptors (p-type) to donor (n-type) a p-n junction is formed. If a battery is attached to the p-n junction such that the battery's positive side is connected to the p-type side and the battery negative side is connected to the n-type.

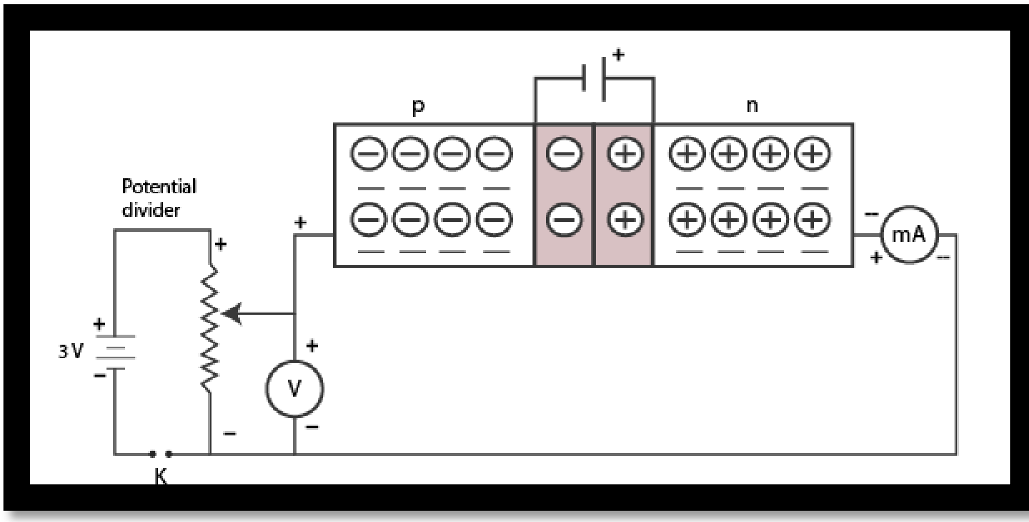


Figure 5: p-n junction of forward biased

The p-type material is positive when the battery voltage reaches the junction voltage (0.7V for silicon) and the n-type material is negative. Regardless its excessive number of holes the excessive electrons now in the n-type material are drawn through the depletion layer into the positive p-type material. Present flow resulting and the junction is said to be biased forward. The junction has poor resistance to current flow.

b) REVERSE BIASED

When a battery is placed at the p-n junction such that the battery positive side is connected to the n-type side and the battery's negative side is connected to the p-type.

The battery negative relation has the effect of attracting the holes in the p-type material away from the material and the battery positive side as the effect of attracting side electrons in the n-type material away from the material. The layer of depletion increase making the impact if insulators greater show in figure.

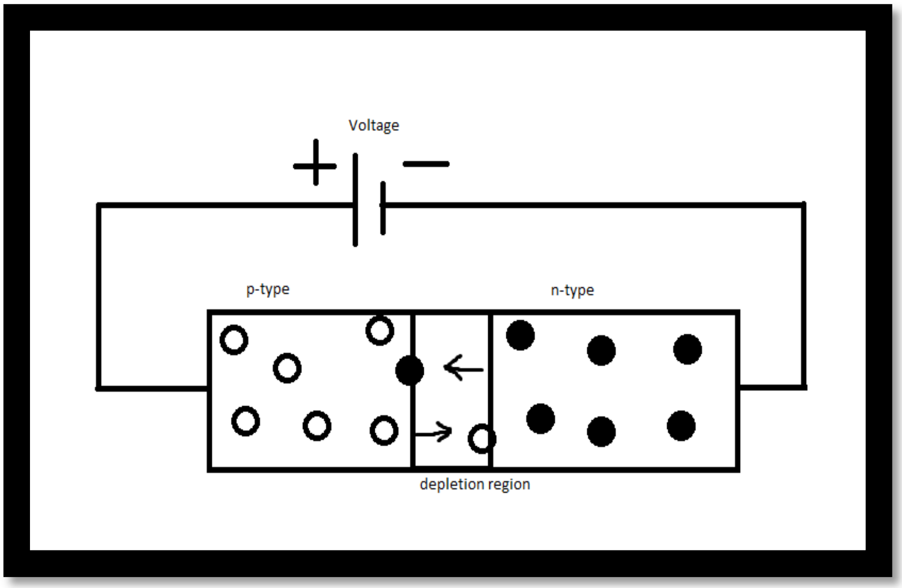
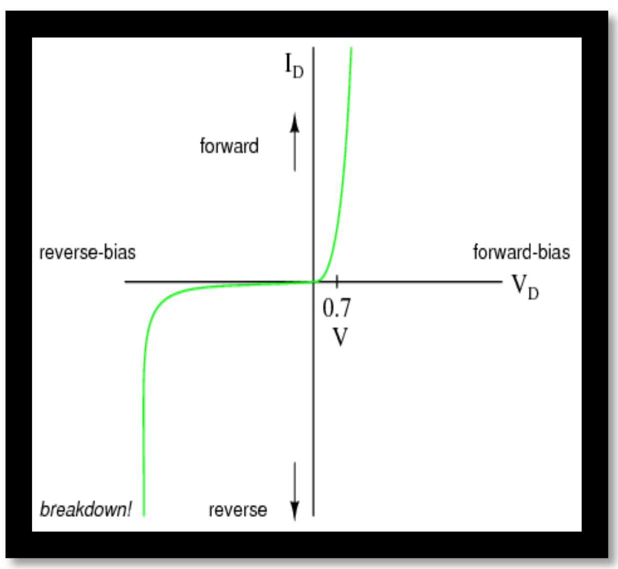


Figure 6: depletion layer between n-p type

The negative relation of the battery has the effect that the holes in the p-type material are drawn away from the material and the positive side of the battery has the effect of drawing the electrons in the n-type material away from the material. The graph below shows how the voltage for a diode will depend on the currents.



c) DIODES

The diodes are the simplest half conductor unit. It is a system that allows for faster passage of electric current in one direction than in the other. A diode consists of p-type and n-type semiconductor regions which are connected together. Because of combing two different place if doped silicon, a single sample of intrinsic silicon is treated with a p-dopant first, then an n-dopant. At each region metal contacts are coated to allow wires to be connected. The boundary between the region p-type and n-type is called junction. The junction influences the holes and the electrons in both the p and n regions. The two regions near the junction have force on the free charge carriers (electrons and holes). On the n-side free electrons are drawn to the positive holes on the p-side. The electrons pass rapidly through the p-side and recombine with the holes. P-side holes likewise pass into the n-side, where they recombine with electrons. The n-side has net positive charge as a result of this wave and the p-side has net negative charge.

Assumptions:

- We will say junction is step junction (abrupt junction) uniform p-side acceptor.
- straight and well define junction and uniform n-side donor doping.
- First we shall find a case of equilibrium in which there is no external excitation and no net current.
- Or current components (the electrons and holes drift and diffusion elements) will be extracted.
- We will then evaluate the case with positive (forward) and negative (reverse) discrimination.

IMPORTANCE

- These are highly portable due to their smaller size.
- They require fewer input power.
- These devices are shockproof.
- These have a longer service life and are a noise when running.
- Temperature sensors are made from semiconductor equipment.

APPLICATIONS

- We know understand the everyday uses of semiconductors. Virtually all electronic devices use semiconductors. Our life will be a lot different, without them. Its reliability, compactness, low cost and regulated electricity conduction make them suitable for use in a wide range of components and devices for different purpose. Semiconductors consists of transistors, diodes, photo sensors, microcontrollers, integrated chips and much more
- Remote control: most personal home entertainment uses IREDs to forward data to the main device. The laser light emitted from the CD or bar code must be identified by all CD players and store scanners.
- Diodes can detect and emit light.
- In general, a biased pn-junction diode is used as light detector.
- The light falling at the junction produces electrons and holes in pairs.
- They are pulled towards the diodes ends, resulting in a current which depends on the strength of the light.