Marwari college Darbhanga

Subject---physics (Hons)

Class--- B. Sc. Part 2

Paper---04 ; Group—B

Topic--- Basic Electronics (semiconductors)

Lecture series---30

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SEMICONDUCTOR

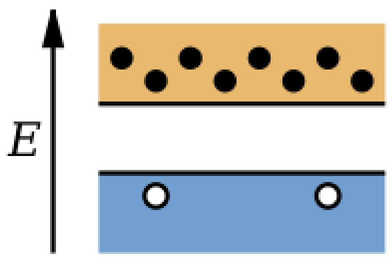
A semiconductor material has an electrical conductivity value falling between that of a conductor*, such as metallic copper, and an* insulator*, such as glass. Its resistance falls as its temperature rises; metals are the opposite. Its conducting properties may be altered in useful ways by introducing impurities ("doping") into the crystal structure. When two differently-doped regions exist in the same crystal, a semiconductor junction is created. The behavior of charge carriers which include electrons, ions and electron holes at these junctions is the basis of diodes,* transistors and *all modern* *electronics. Some examples of semiconductors are silicon, germanium, gallium arsenide, and elements near the so-called "metalloid staircase" on the periodic table. After silicon, gallium arsenide is the second most common semiconductor[citation needed] and is used in laser diodes, solar cells, microwave-frequency integrated circuits and others. Silicon is a critical element for fabricating most electronic circuits.*

The modern understanding of the properties of a semiconductor relies on quantum physics to explain the movement of charge carriers in a crystal lattice.[1] Doping greatly increases the number of charge carriers within the crystal. When a doped semiconductor contains mostly free holes it is called "p-type", and when it contains mostly free electrons it is known as "n-type". The semiconductor materials used in electronic devices are doped under precise conditions to control the concentration and regions of p- and n-type dopants. A single semiconductor crystal can have many p- and n-type regions; the p–n junctions between these regions are responsible for the useful electronic behavior.

. Dopping

The conductivity of semiconductors may easily be modified by introducing impurities into their crystal lattice. The process of adding controlled impurities to a semiconductor is known as *doping*. The amount of impurity, or dopant, added to an *intrinsic* (pure) semiconductor varies its level of conductivity. Doped semiconductors are referred to as *extrinsic*. By adding impurity to the pure semiconductors, the electrical conductivity may be varied by factors of thousands or millions.

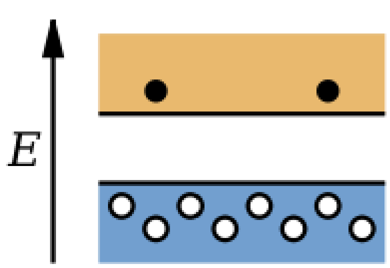
N-type semiconductors



Band structure of an n-type semiconductor. Dark circles in the conduction band are electrons and light circles in the valence band are holes. The image shows that the electrons are the majority charge carrier.

N-type semiconductors are created by doping an intrinsic semiconductor with an electron donor element during manufacture. The term *n-type* comes from the negative charge of the electron. In *n-type* semiconductors, electrons are the majority carriers and holes are the minority carriers. A common dopant for *n-type* silicon is phosphorus or arsenic. In an *n type* semiconductor, the Fermi level is greater than that of the intrinsic semiconductor and lies closer to the conduction band than the valence band.

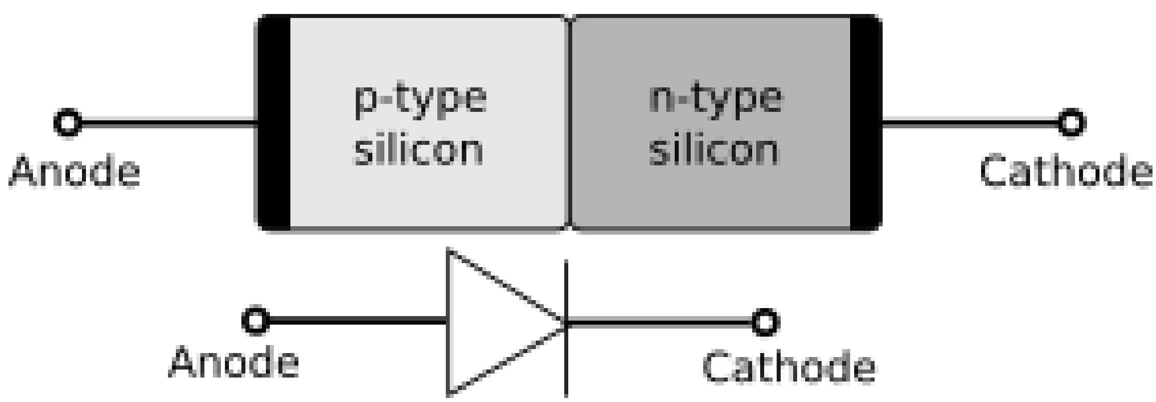
P-type semiconductors



Band structure of a p-type semiconductor. Dark circles in the conduction band are electrons and light circles in the valence band are holes. The image shows that the holes are the majority charge carrier

P-type semiconductors are created by doping an intrinsic semiconductor with an electron acceptor element during manufacture. The term *p type* refers to the positive charge of a hole. As opposed to *n type* semiconductors, *p-type* semiconductors have a larger hole concentration than electron concentration. In *p-type* semiconductors, holes are the majority carriers and electrons are the minority carriers. A common *p-type* dopant for silicon is boron or gallium. For *p type s*emiconductors the Fermi level is below the intrinsic Fermi level and lies closer to the valence band than the conduction band.

p–n junction



A p–n junction. The circuit symbol is shown: the triangle corresponds to the p side.

A **p–n junction** is a boundary or interface between two types of semiconductor materials, p-type and n-type, inside a single crystal of semiconductor. The "p" (positive) side contains an excess of holes, while the "n" (negative) side contains an excess of electrons in the outer shells of the electrically neutral atoms there. This allows electrical current to pass through the junction only in one direction. The p-n junction is created by doping, for example by ion implantation, diffusion of dopants, or by epitaxy (growing a layer of crystal doped with one type of dopant on top of a layer of crystal doped with another type of dopant). If two separate pieces of material were used, this would introduce a grain boundary between the semiconductors that would severely inhibit its utility by scattering the electrons and holes.

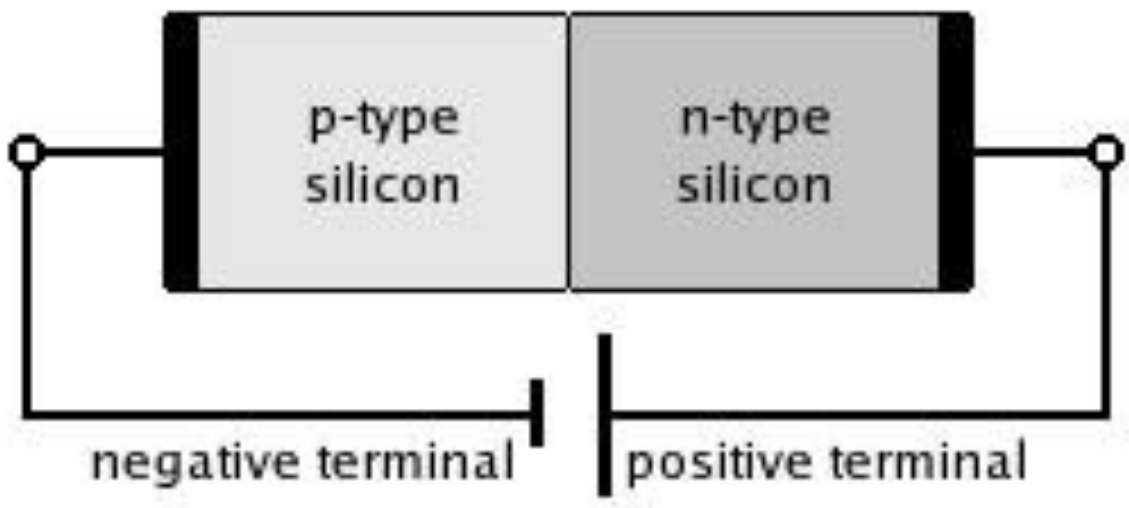
p–n junctions are elementary "building blocks" of semiconductor electronic devices such as diodes, transistors, solar cells, LEDs, and integrated circuits; they are the active sites where the electronic action of the device takes place. For example, a common type of transistor, the bipolar junction transistor, consists of two p–n junctions in series, in the form n–p–n or p–n–p; while a diode can be made from a single p-n junction. A Schottky junction is a special case of a p–n junction, where metal serves the role of the p-type semiconductor.

Forward Bias

In forward bias, the p-type is connected with the positive terminal and the n-type is connected with the negative terminal

With a battery connected this way, the holes in the p-type region and the electrons in the n type region are pushed toward the junction and start to neutralize the depletion zone, reducing its width. The positive potential applied to the p-type material repels the holes, while the negative potential applied to the n-type material repels the electrons. The change in potential between the p side and the n side decreases or switches sign. With increasing forward-bias voltage, the depletion zone eventually becomes thin enough that the zone's electric field cannot counteract charge carrier motion across the p–n junction, which as a consequence reduces electrical resistance. Electrons that cross the p–n junction into the p-type material (or holes that cross into the n-type material) diffuse into the nearby neutral region. The amount of minority diffusion in the near-neutral zones determines the amount of current that can flow through the diode.

Reverse bias



A silicon p–n junction in reverse bias.

Connecting the *p-type* region to the negative terminal of the battery and the *n-type* region to the *positive* terminal corresponds to reverse bias. If a diode is reverse-biased, the voltage at the cathode is comparatively higher than at the anode. Therefore, very little current flows until the diode breaks down. The connections are illustrated in the adjacent diagram.

Because the p-type material is now connected to the negative terminal of the power supply, the 'holes' in the p-type material are pulled away from the junction, leaving behind charged ions and causing the width of the depletion region to increase. Likewise, because the n-type region is connected to the positive terminal, the electrons are pulled away from the junction, with similar effect. This increases the voltage barrier causing a high resistance to the flow of charge carriers, thus allowing minimal electric current to cross the p–n junction. The increase in resistance of the p–n junction results in the junction behaving as an insulator. t

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