UNIT-IV

Fundamentals of semiconductor devices and digital circuits

Lecture 28

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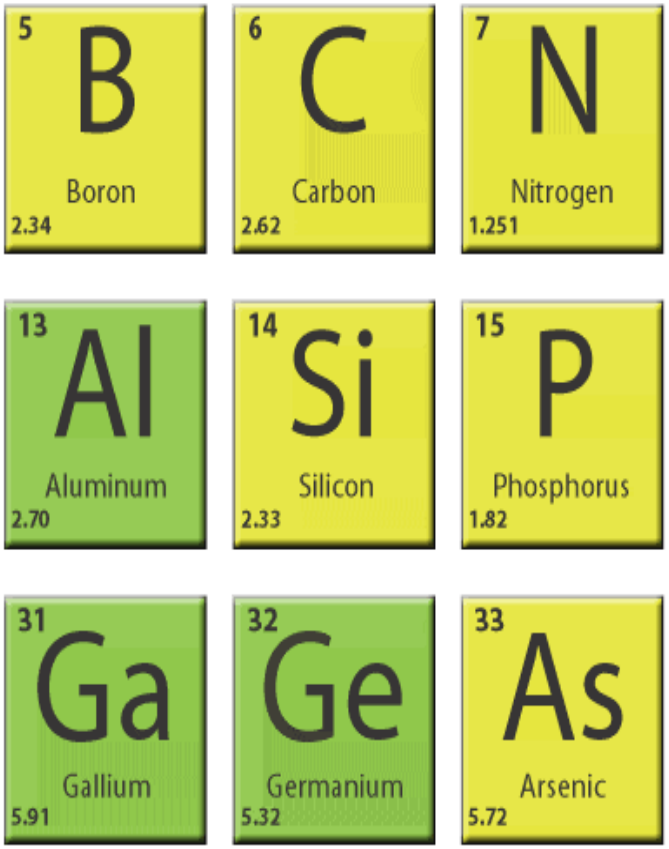
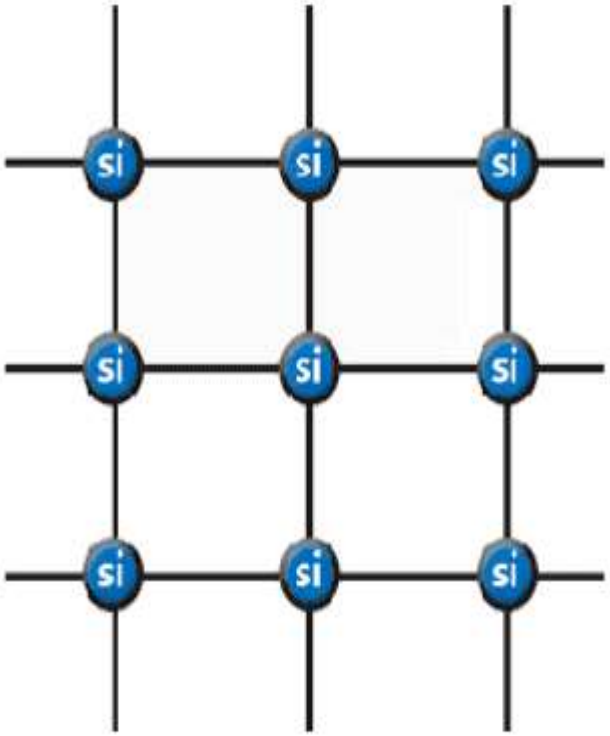
What are P-type and N-type ?

- Semiconductors are classified in to P-type and N-type semiconductor
- P-type: A P-type material is one in which holes are majority carriers i.e. they are positively charged materials (++++)
- N-type: A N-type material is one in which electrons are majority charge carriers i.e. they are negatively charged materials (-----)

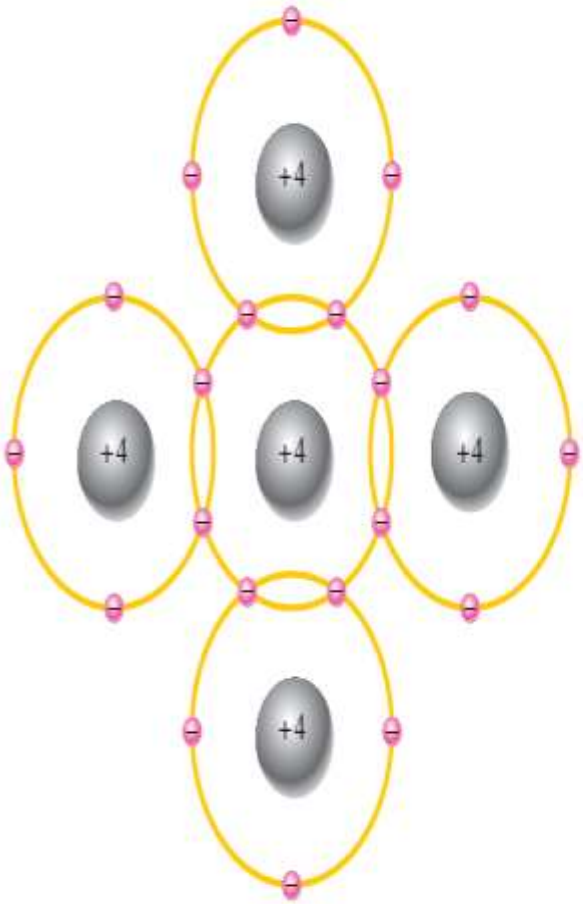
Silicon and Germanium

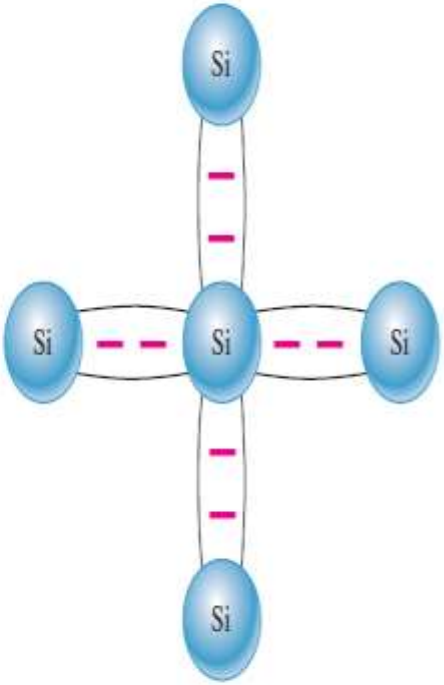


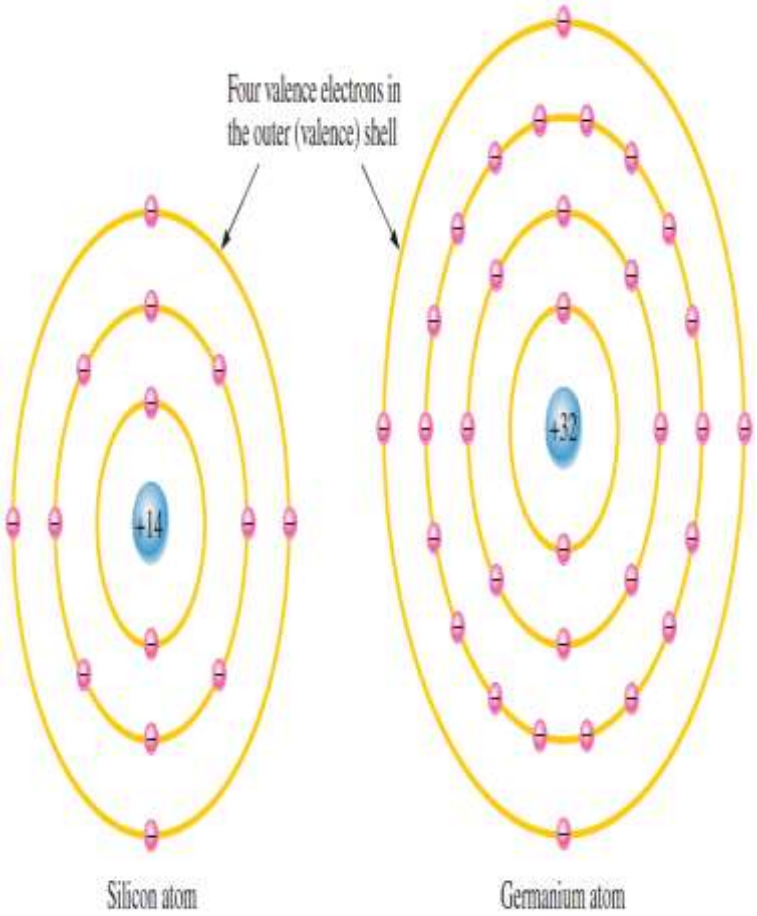


Silicon is a very common element, the main element in sand & quartz.

Silicon and Germanium







Intrinsic and Extrinsic semiconductor

The pure form of the semiconductor is known as the intrinsic semiconductor and the semiconductor in which intentionally impurities is added for making it conductive is known as the extrinsic semiconductor.

Conduction Electron and Holes.

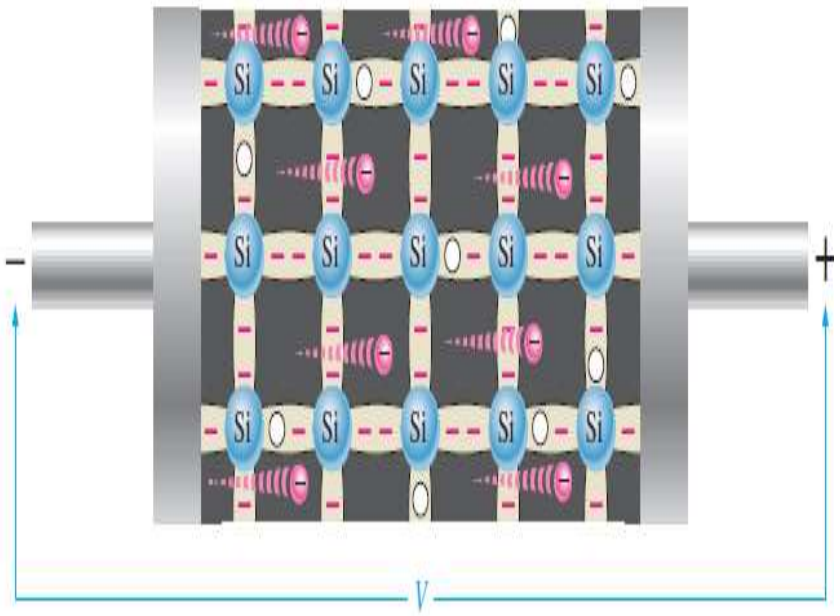
An intrinsic (pure) silicon crystal at room temperature has sufficient heat energy for some valence electrons to jump the gap from the valence band into the conduction band, becoming free electron called '**Conduction Electron**'

It leaves a vacancy in valance band, called **hole**.

Recombination occurs when a conduction-band electron loses energy and falls back into a hole in the valence band.

Electron Hole Current.

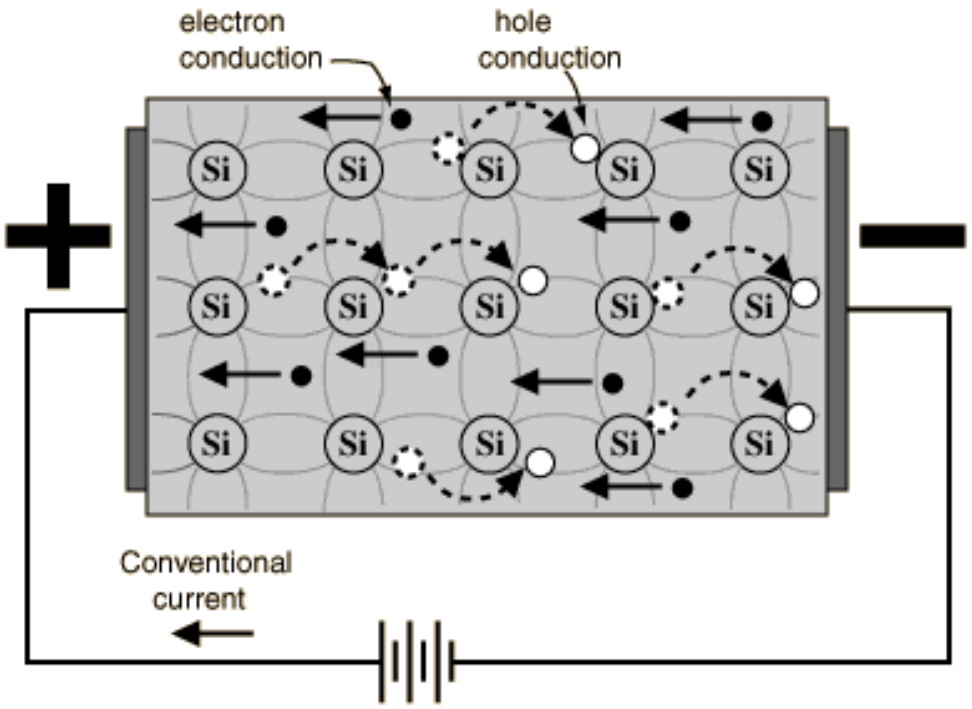
In conduction band : When a voltage is applied across a piece of intrinsic silicon, the thermally generated free electrons in the conduction band, are now easily attracted toward the positive end.



This movement of free electrons is one type of current in a semiconductive material and is called ***electron current.***

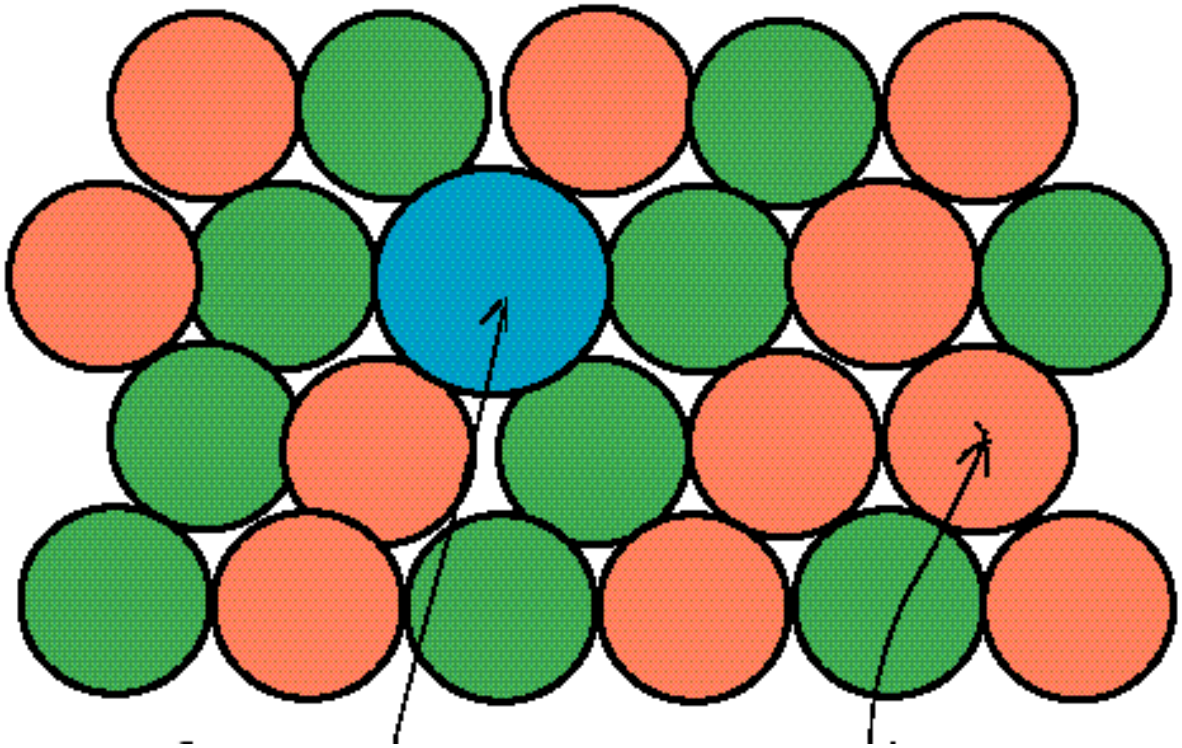
- **In valance band:** In valance band holes generated due to free electrons. Electrons in the valance band are although still attached with atom and not free to move, however they can move into nearby hole with a little change in energy, thus leaving another hole where it came from. Effectively the hole has moved from one place to another in the crystal structure. It is called ***hole current.***

Current Flow

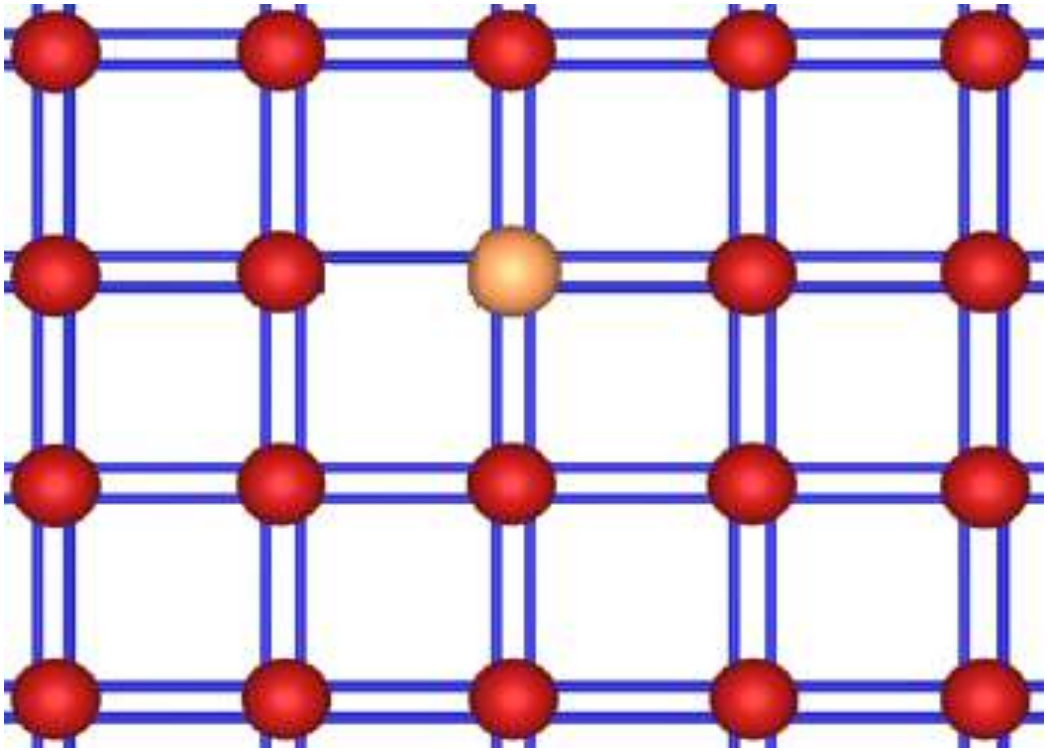


If a voltage is applied, then both the electron and the hole can contribute to a small current flow.

Impurity

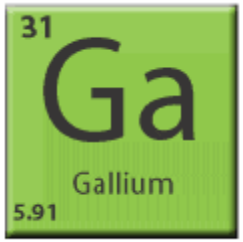


Doping



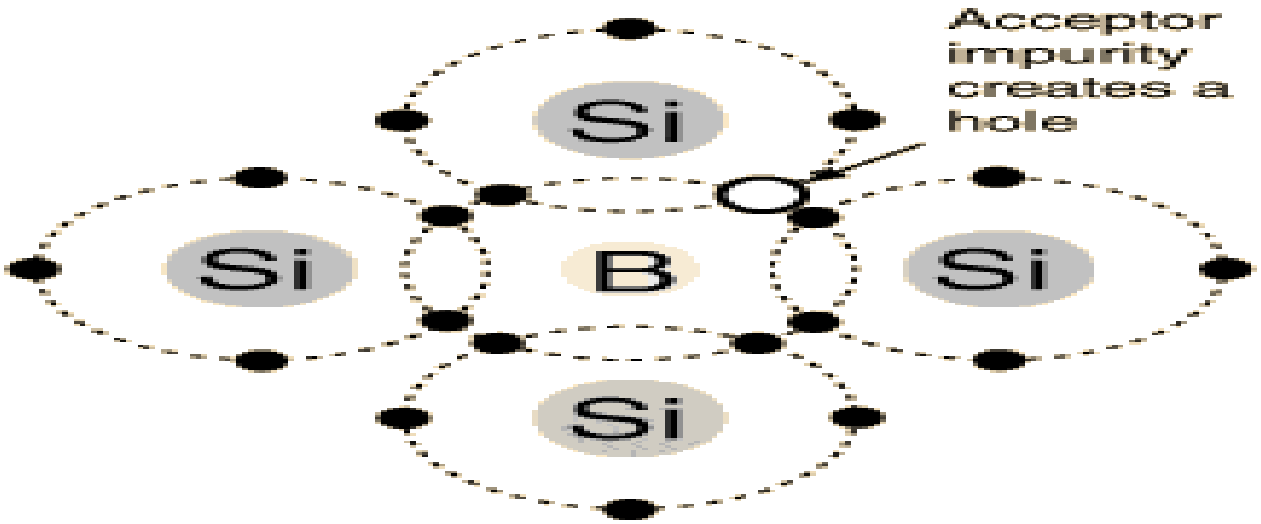
Doping (adding an impurity) can produce 2 types of semi-conductors depending upon the element added.

P-Type Doping



In P-type doping, boron or gallium is the dopant.

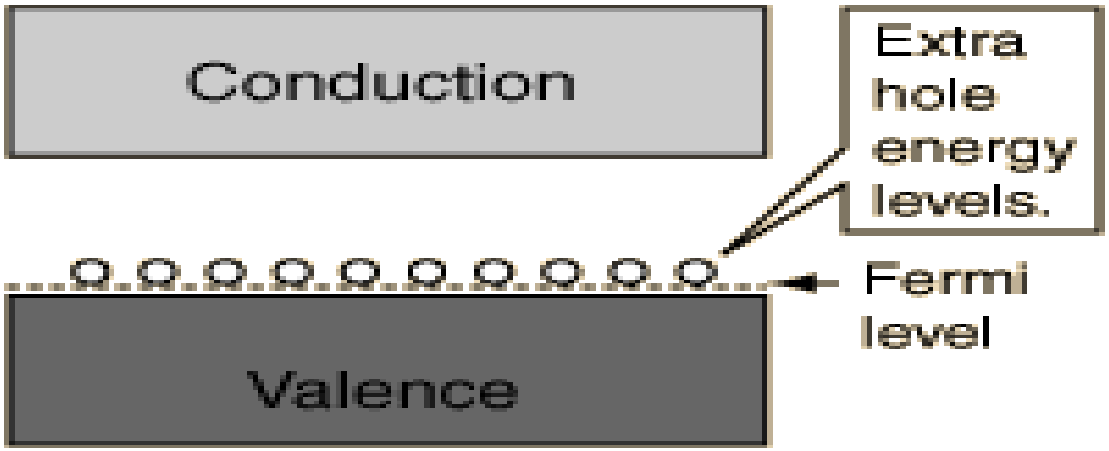
P-Type Doping



Boron and gallium each have only three outer electrons.

When mixed into the silicon lattice, they form "holes" in the lattice where a silicon electron has nothing to bond to.

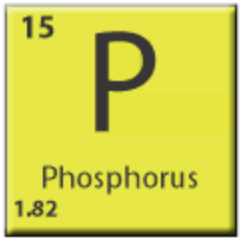
P-Type Doping



The absence of an electron creates the effect of a positive charge, hence the name P-type.

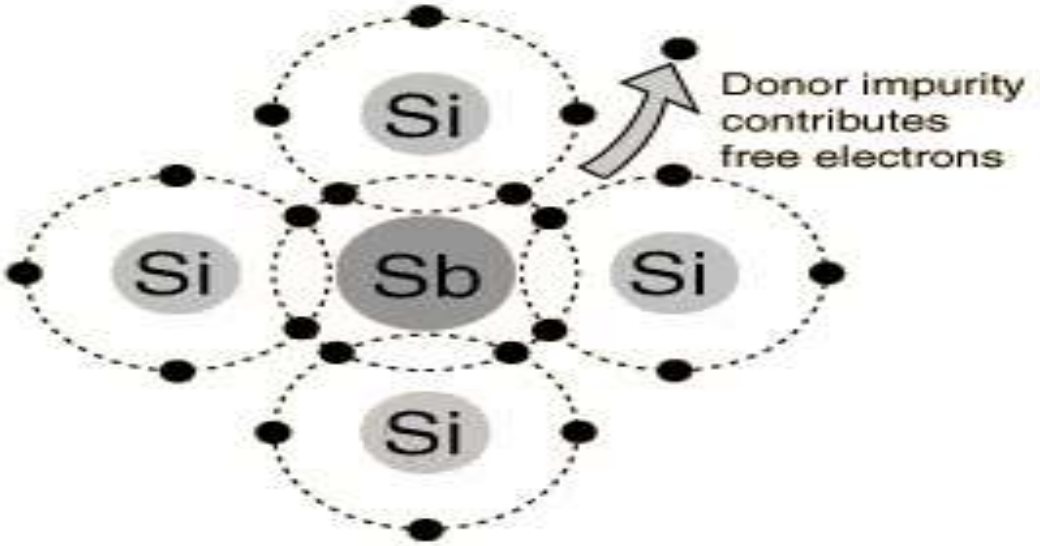
Holes can conduct current. A hole happily accepts an electron from a neighbor, moving the hole over a space. P-type silicon is a good conductor.

N-Type



In N-type doping, phosphorus or arsenic is added to the silicon in small quantities.

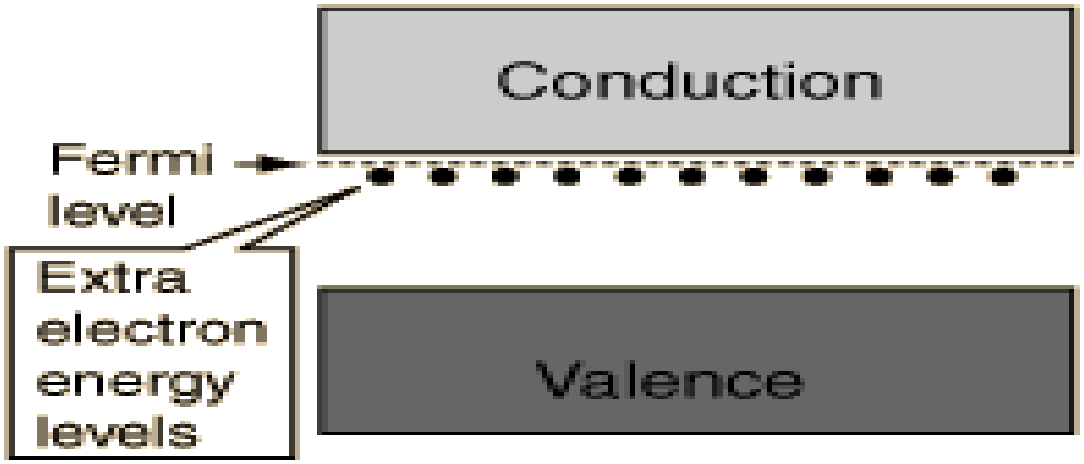
N-Type



Phosphorus and arsenic each have five outer electrons, so they're out of place when they get into the silicon lattice.

The fifth electron has nothing to bond to, so it's free to move around.

N-Type



It takes only a very small quantity of the impurity to create enough free electrons to allow an electric current to flow through the silicon. N-type silicon is a good conductor.

Electrons have a negative charge, hence the name N-type.

Quick Quiz (Poll 1)

When a pentavalent impurity is added to a pure semiconductor, it becomes ……

a) An insulator
b) An intrinsic semiconductor
c) p-type semiconductor
d) n-type semiconductor

Quick Quiz (Poll 2)

A semiconductor is formed by …… bonds.

a) Covalent
b) Electrovalent
c) Co-ordinate
d) None of the above

Quick Quiz (Poll 3)

The most commonly used semiconductor is …….

a) Germanium
b) Silicon
c) Carbon
d) Sulphur

Quick Quiz (Poll 4)

The temperature co-efficient of an intrinsic semiconductor is.....

A. Zero
B. Positive
C. Negative
D. None of them