PN JUNCTION DIODE

P type and N type semiconductors, taken separately are of very limited use.

If we join a piece of P type material to a piece of N type material such that the crystal structure remains continuous at the boundary,, ….. A **PN JUNCTION** is formed

- I t can function as …

Rectifier ,

Amplifier ,

Switching

And other operations in electronic circuits.

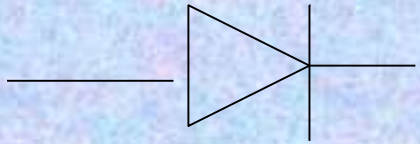
- A PN junction cannot be produced by simply pushing two pieces together or by welding etc…. Because it gives rise to discontinuities across the crystal structure.

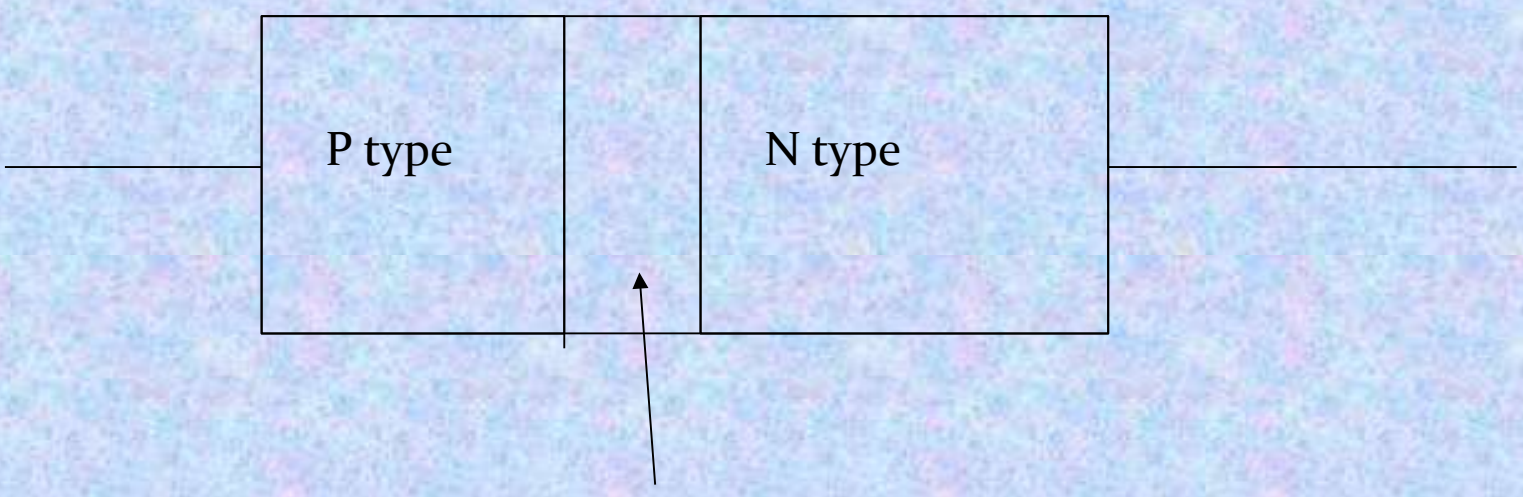
- Special fabrication techniques are adopted to form a P N junction

What is a PN Junction?

A PN junction is a device formed by joining p-type (doped with B, Al) with n-type (doped with P, As, Sb) semiconductors and separated by a thin junction is called PN Junction diode or junction diode.

- **E lectronic Symbol** .....the triangle shows indicated the direction of current





- In PN junction diode, N is at right and P is at left.
- Majority carriers

  N region -- electrons

  P region -- holes

Formation of depletion layer

<u>NO external connections</u>:

the excess electrons in the N region cross the junction and combine with the excess holes in the P region.

N region loses its electrons ……becomes + vly charged

P region accepts the electrons ……becomes -vly charged

At one point , the migratory action is stopped.

- A n additional electrons from the N region are repelled by the net negative charge of the p region.

Similarly,

- A n additional holes from the P region are repelled by the net positive charge of the n region.
- N e t result

a creation of a thin layer of each side of the junction .....which is depleted (emptied) of mobile charge carriers.... This is known as DEPLETION LAYER

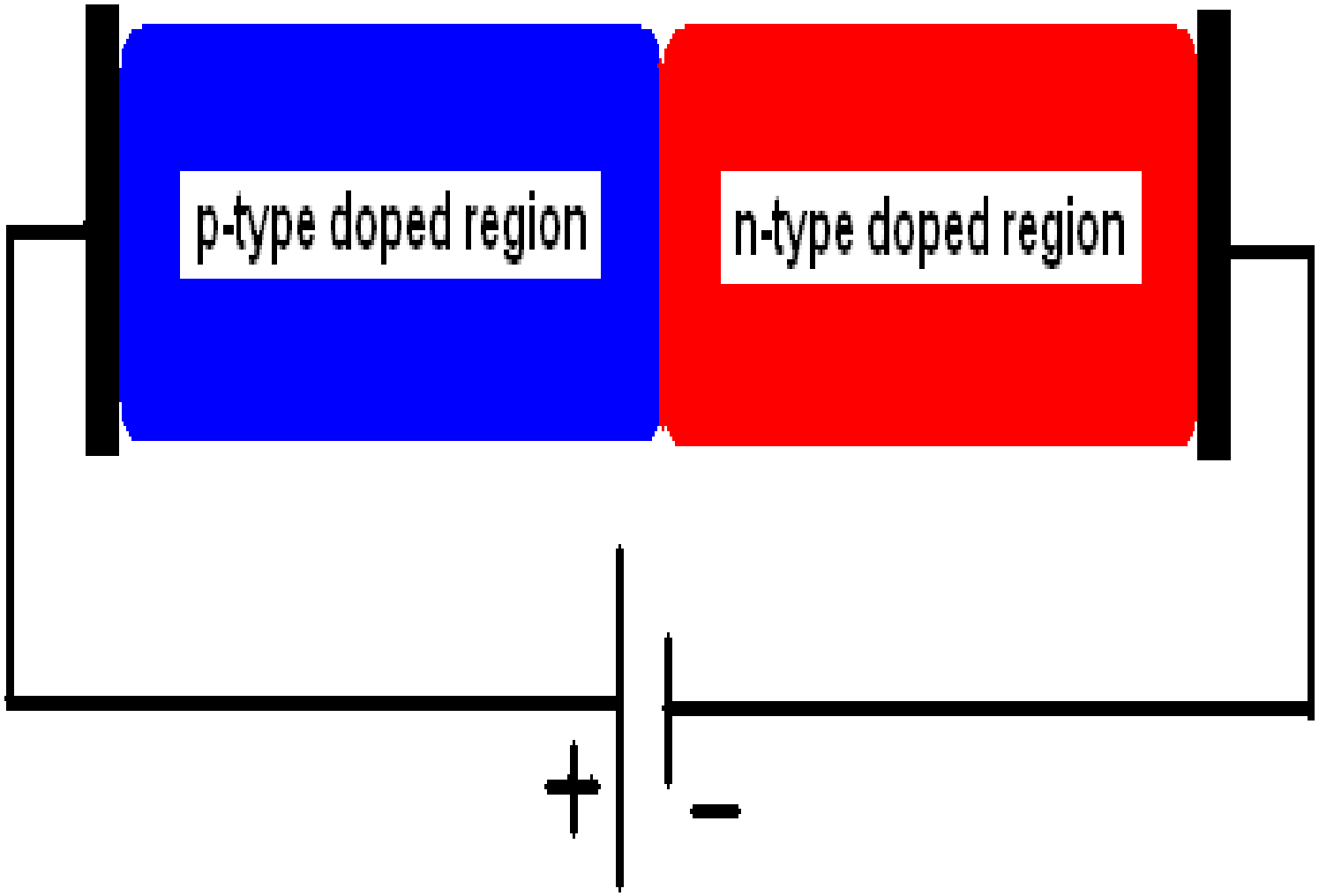
..Thickness is of the order of 10^{-6}meter

- The depletion layer contains no free and mobile charge carriers but only fixed and immobile ions.
- Its width depends upon the doping level..

- Heavy doped……..thin depletion layer
- lightly doped……..thick depletion layer

POTENTIAL BARRIER

- The electrons in the N region have to climb the potential hill in order to reach the P region
- Electrons trying to cross from the N region to P region experience a retarding field of the battery and therefore repelled. Similarly for holes from P region.
- Potential thus produced are called ..**potential barrier**
- Ge..0.3 V Si ..0.7V


p-type doped region
n-type doped region
+
−

PN junction can basically work in two modes, (***A battery is connected to the diode***)

- **forward bias mode** (positive terminal connected to p-region and negative terminal connected to n region)

- ***reverse bias mode*** (negative terminal connected to p-region and positive terminal connected to n region)

Forward biased PN junction

- It forces the majority charge carriers to move across the junction ….decreasing the width of the depletion layer.

- Once the junction is crossed, a number of electrons and the holes will recombine .
- For each hole in the P section that combines with an electron from the N section, a covalent bond breaks and an electron is liberated which enters the positive terminal
- Thus creating an electron hole pair.
- Current in the N region is carried by ....electrons
- Current in the P region is carried by .... Holes.

Reverse biased pn junction

- I f the + of the battery is connected to the n-type and the – terminal to the p-type,

the free electrons and free holes are attracted back towards the battery, hence back from the depletion layer, hence the depletion layer grows.

Thus a reverse biased pn junction does not conduct current

- Only the minority carriers cross the junction constituting **very low reverse saturation current.**

- This current is of the order of micro ampere.

VOLTAGE –CURRENT (V-I) CHARACTERISTICS OF PN JUNCTION DIODE

- The curve drawn between voltage across the junction along X axis and current through the circuits along the Y axis.
- They describe the d.c behavior of the diode.

- **When it is in forward bias, no current flows until the barrier voltage (0.3 v for Ge) is overcome.**

- Then the curve has a linear rise and the current increases, with the increase in forward voltage like an ordinary conductor.

- Above 3v, the majority carriers passing the junction gain sufficient energy to knock out the valence electrons and raise them to the conduction band.

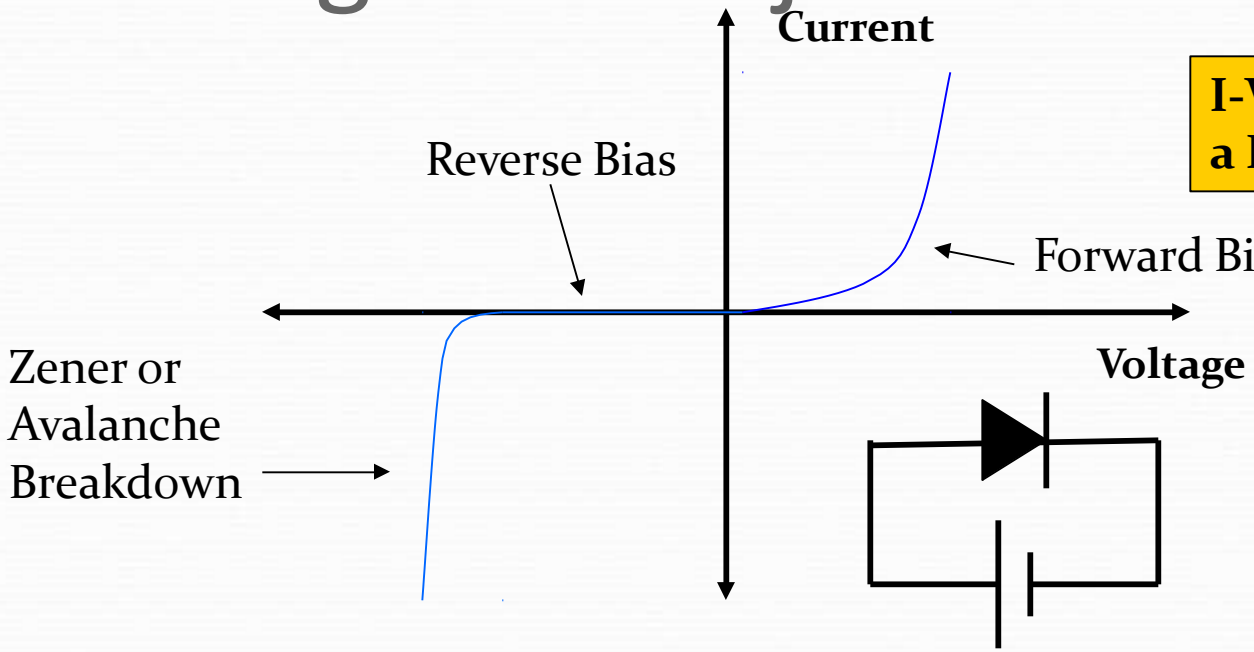
- Therefore, **the forward current increases sharply.**

- **With reverse bias,**
- potential barrier at the junction increased. … junction resistance increase…and prevents current flow.
- However , the minority carriers are accelarated by the reverse voltage resulting a very small current (**REVERSE CURRENT**)
  ….in the order of micro amperes.

- When revrese voltage is increased beyond a value ,**called breakdown voltage,the reverse current increases sharply** and the diode shows almost zero resistance .It is known as **avalanche breakdown.**

- Reverse voltage above 25 v destroys the junction permanentaly.

Working of a PN junction



I-V characteristic of a PN junction diode.

- PN junction diode acts as a *rectifier* as seen in the IV characteristic.
- Certain current flows in forward bias mode.
- Negligible current flows in reverse bias mode until zener or avalanche breakdown happens.

Refer https://nanohub.org/resources/68 for a detailed discussion on operation of PN junction.

- Thus the P N junction diode allows the electrons flow only when P is positive .

- This property is used for the conversion of AC into DC ,Which is called rectification

Automatic switch

- When the diode is forward bias, the switch is CLOSED.
- When it is reverse biased , it is OPEN

ADVANTAGES:

- No filament is necessary
- Occupies lesser space
- Long life.

APPLICATIONS

- ….as rectifiers to convert AC into DC.
- As an switch in computer circuits.
- As detectors in radios to detect audio signals
- As LED to emit different colours.