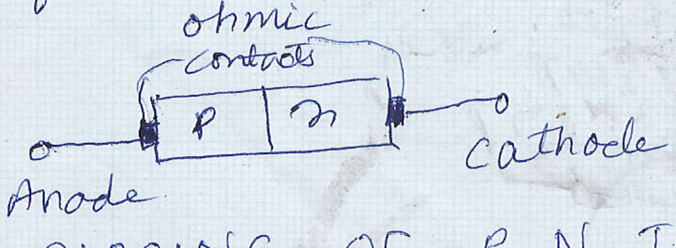
P-N junction diode

The p-n junction forms a popular semiconductor device called p-n junction diode. It has 2 terminals called electrodes, one from p region and other from n region (Hence the name di + electrode = diode

To connect the n & p regions to external terminals, metal is added to n & p region. Such a contact between metal and semiconductor is called <u>ohmic</u> contact.

Properties of ohmic contact

1. It ~~co~~ conducts current equally in both the directions
2. The drop across the contact is very small which does not effect the performance of the device



symbol.

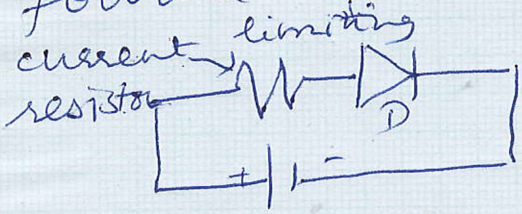
BIASING OF P-N JUNCTION

Applying external d.c. voltage to any electronic device is called biasing

There is no current in the unbiased p-n junction at equilibrium. Depending upon the polarity of the d.c. voltage externally applied to the p-n junction, the biasing is (1) Forward (2) Reverse

(1) FORWARD BIASING OF P-N JUNCTION DIODE

If an external d.c. voltage is connected in such a way that the the p region terminal is connected to the positive of d.c. voltage and n region is connected to the negative of the d.c. voltage, the biasing condition is called forward biasing and the p-n junction is said to be forward biased



Operation

When the applied voltage is less than V_B, there is no conduction.

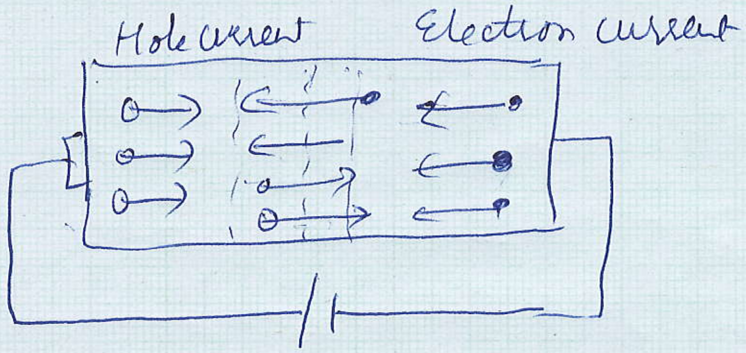
When the applied voltage is greater than V_B, the -ve terminal of the battery pushes the free electrons against the barrier potential from n to p region. Similarly +ve terminal pushes holes from p to n region

Thus the applied voltage overcomes

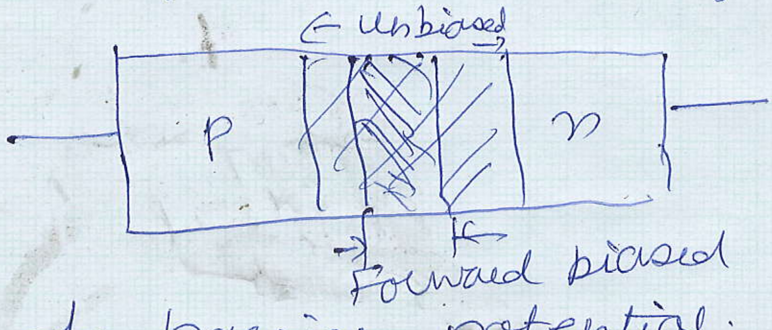
the V_B which reduces the width of ~~the~~ the depletion region.

As forward voltage is increased ~~V_B~~ ~~is~~ depletion region is narrowed and large number of charge carriers cross the junction.

The large number of majority carriers constitute a current called forward current



Effect on depletion region: More electrons flow into depletion region which reduces no. of +ve ions, Similarly flow of holes reduces the no. of -ve ions. This reduces the width of the depletion region



Effect of barrier potential.

Under the influence of applied forward bias voltage, the free electrons get energy to overcome the barrier which is a sort of hill and cross the junction. While crossing the junction the electrons give up the amount of energy equivalent to the barrier potential. This loss of energy produces a voltage drop across the p-n junction which is almost equal to the barrier potential.

Due to internal resistance there is additional small drop across the diode.

∴ Total voltage drop V_f across the p-n diode is due to

(i) Drop due to barrier potential

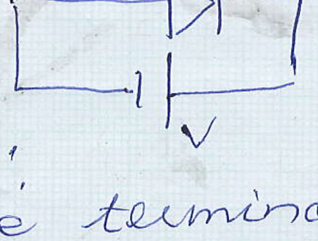
(ii) Drop due to internal resistance

$V_f = 0.7V$ Si

$= 0.3V$ Ge

(2) REVERSE BIASING OF P-N JN DIODE

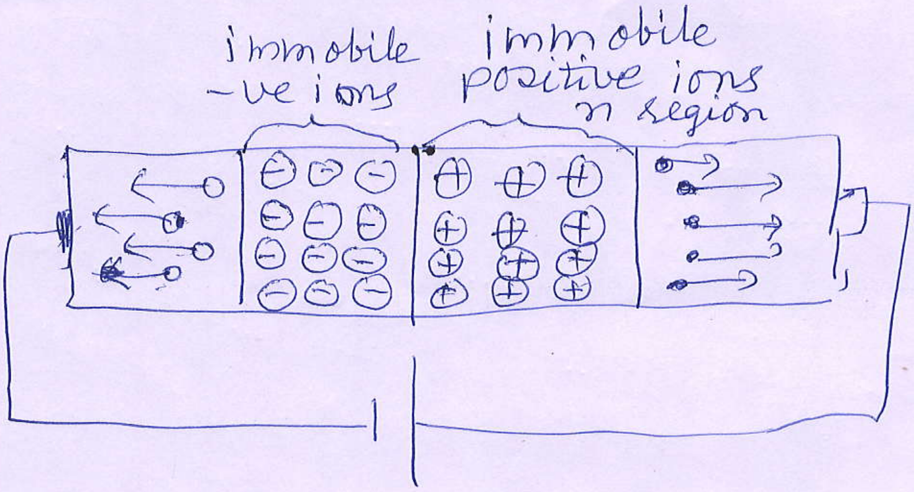
If an external d.c. voltage is connected in such a way that the p region terminal is connected to the -ve terminal of the battery and n region terminal is connected to the +ve terminal of the battery, the biasing condition is called reverse biasing of p-n junction.



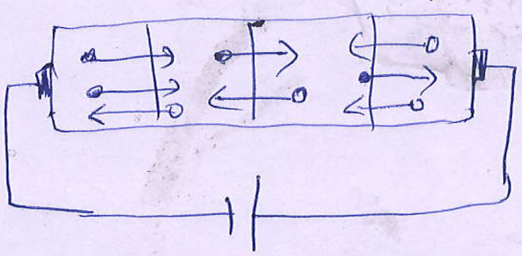
Operation:

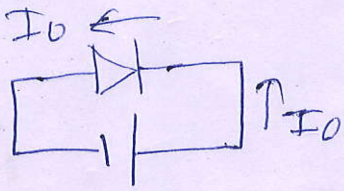
The -ve terminal attracts the holes in the p region away from the junction. The positive terminal attracts free electrons in the n region away from the junction. No charge carrier is able to cross the junction. As electrons & holes move away from the junction, the depletion region widens.

More +ve ions created in n region & more -ve ions created in p region. This is because the applied voltage helps the barrier potential.



As depletion region widens, barrier potential across the junction also increases. However this process cannot continue for a long time. In the steady state majority current ceases as holes and electrons stop moving away from the junction





The polarity of the VB is same as that of applied voltage. Due to increased VB, electrons from p region are dragged towards +ve terminal of battery.

Similarly holes from n region are dragged towards -ve terminal of battery.

The electrons on p side and holes from n side are minority charge carriers which constitute the current. Thus reverse conduction takes place.

Reverse current is always very small because it flows due to minority charge carriers. It depends on the temperature and not on the applied voltage.

For a constant temp., the reverse saturation current is almost constant. Because of the constant value, saturation word is used. This I_0 is in μA for Ge and in nA for Si diodes

CURRENT COMPONENTS IN P-N DIODE

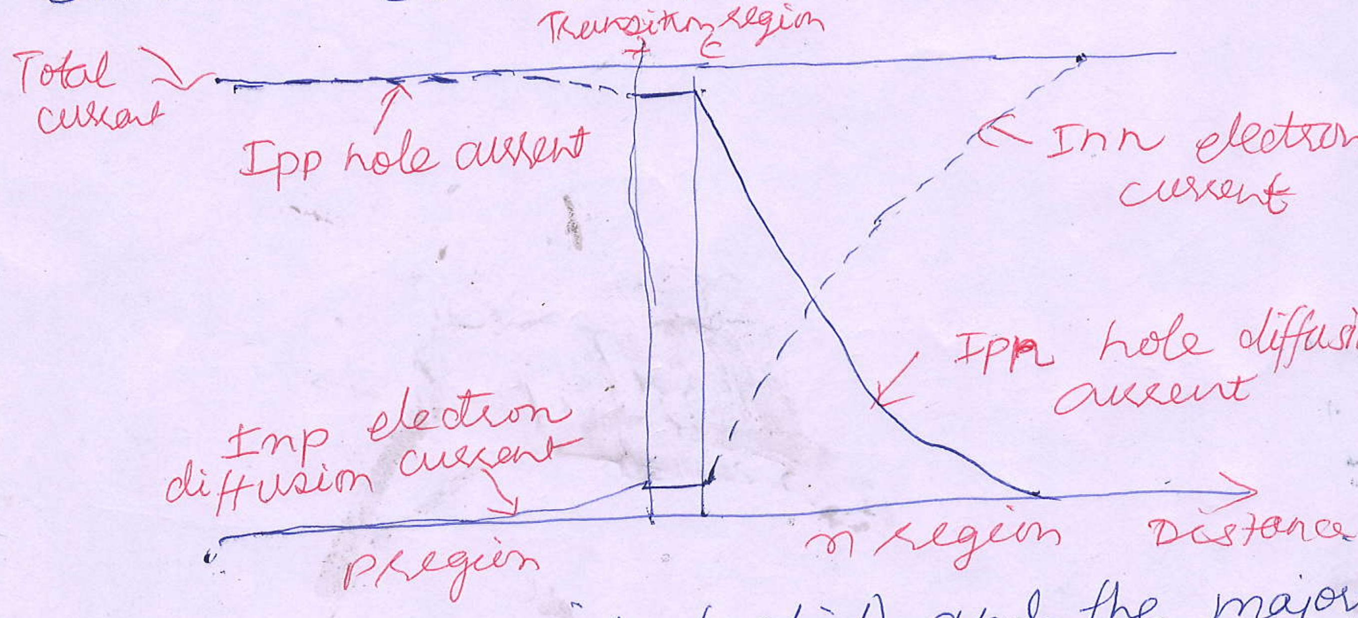


Fig: The minority (solid) and the majority (dashed) currents versus distance in a p-n diode. It is assumed that no recombination takes place in the very narrow depletion region consider from left side of the figure

Deep into the p side there is a drift current Ipp substained by a small electric field in the semiconductor. As the holes approach the junction, some of them ~~combine~~ recombine with electrons which are injected into the p side from n side. The current Ipp thus decreases towards the junction (at just proper gradient to maintain the total current constant independent of distance).

What remains of Ipp at the junction enters the n side and becomes the hole diffusion current Ipn

Similarly we can start with n side. Deep into n side there is a drift current Inn substained by electric field As the electrons approach the junction some of them combine with holes which are injected into n side from p side. The current Inn thus decreases at the junction (at just proper gradient to maintain the total current constant, independent of distance. What remains of Inn at the junction enters the n side and becomes the electron diffusion current Inp.

Thus the total current is constant throughout the p-n junction