

Answer on Question # 47225, Physics, Other

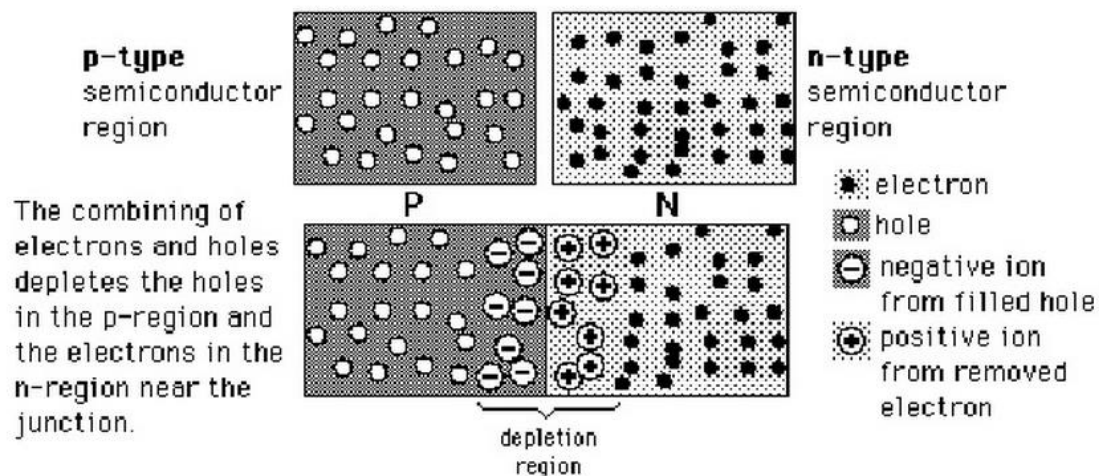
Task:

Draw energy diagrams illustrating the formation of the PN junction and depletion region at the instant of junction formation and at equilibrium.

Answer:

A p-n junction is a junction formed by joining p-type and n-type semiconductors together in very close contact. The term *junction* refers to the boundary interface where the two regions of the semiconductor meet. If they were constructed of two separate pieces this would introduce a grain boundary, so p-n junctions are more often created in a single crystal of semiconductor 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).

At the instant of the PN junction formation free electrons near the junction diffuse across the junction into the P region and combine with holes.



Filling a hole makes a negative ion and leaves behind a positive ion on the N side.

These two layers of positive and negative charges form the depletion region, as the region near the junction is depleted of charge carriers. As electrons diffuse across the junction a point is reached where the negative charge repels any further diffusion of electrons. The depletion region now acts as a barrier.

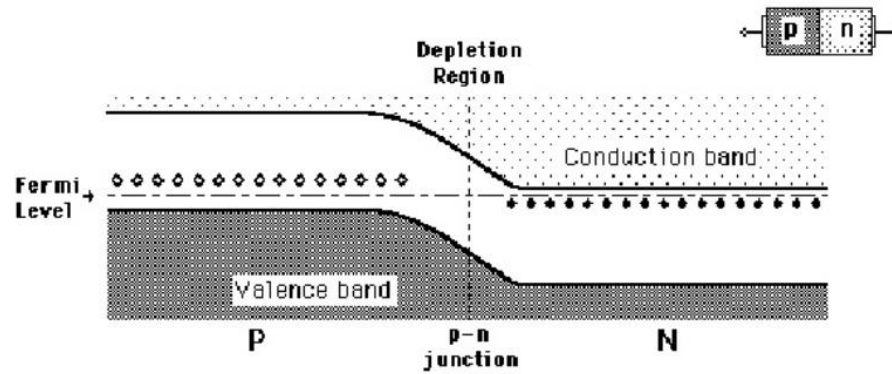
Barrier Potential.

The electric field formed in the depletion region acts as a barrier. External energy must be applied to get the electrons to move across the barrier of the electric field.

The potential difference required to move the electrons through the electric field is called the barrier potential. Barrier potential of PN junction depends on the type of semiconductor material, amount of doping and temperature.

Energy Diagrams of PN Junction:

The valence band and conduction band in N-Type material are slightly lower than that of P-Type material.

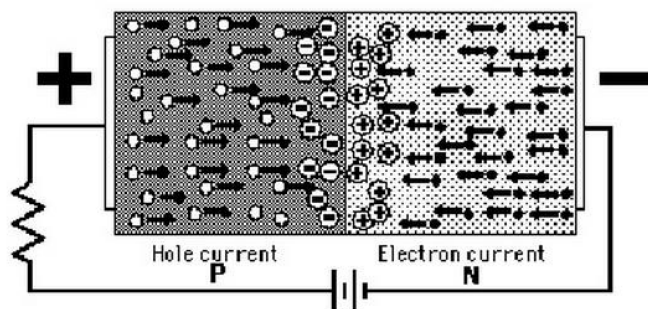


As diffusion

occurs the depletion region forms and the energy level of the N region conduction band drops, causing alignment of the top of the N region conduction band and the bottom of the P region conduction band. At this point the energy bands are at equilibrium. There is an energy gradient across the depletion region that a N region electron must climb to get to the P region.

Biasing the PN Junction.

An external D.C. voltage is applied to a PN junction to bias it. Forward bias allows

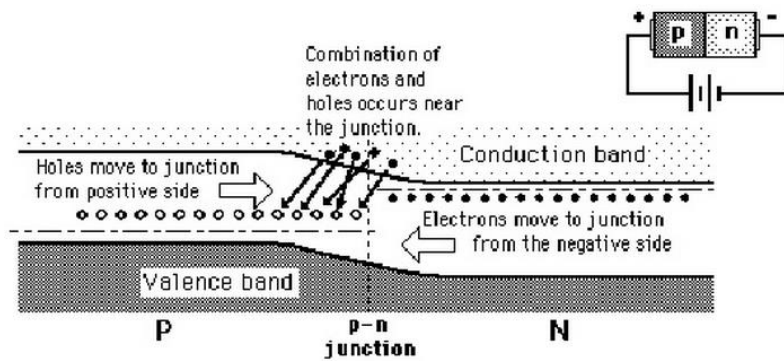


current through a PN junction. Bias voltage imparts sufficient energy to the free electrons so they overcome the barrier potential and move into the P region.

Conduction occurs with electron current in the N-Type material and hole current in the P-Type material. As more electrons and holes flow in the depletion region the number of positive and negative ions is reduced, causing the depletion region to narrow.

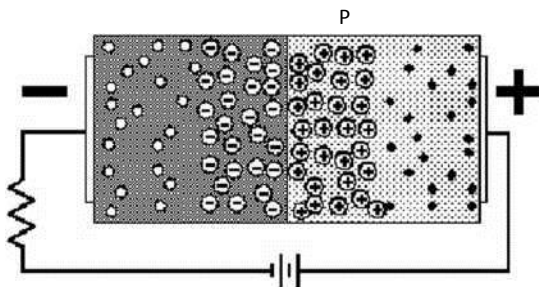
The energy loss in overcoming the barrier potential results in a voltage drop across the PN junction equal to the barrier potential.

When a PN junction is forward biased the N region conduction band is raised to a higher level that overlaps with the P region conduction band.

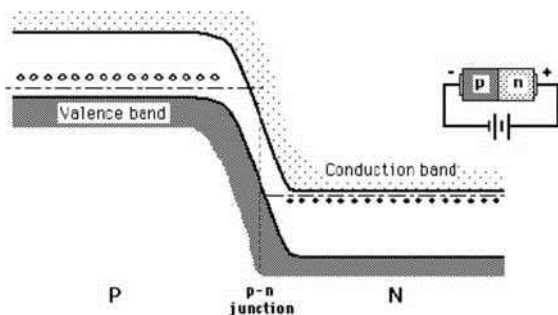


Reverse Bias

Reverse bias prevents current flow through a PN junction.



Reverse bias potential attracts the majority carriers away from the PN junction widening the depletion region. The potential across the depletion region is equal to the bias voltage. Reverse current can flow through the PN junction due to minority carriers. When a PN junction is reverse biased the energy hill increases.



Reverse Breakdown.

If the reverse bias voltage is increased to the breakdown voltage, the reverse current will drastically increase.

This is due to collisions of fast minority carriers with atoms, knocking out valence electrons. This process avalanches and results in a high reverse current damaging the PN structure.