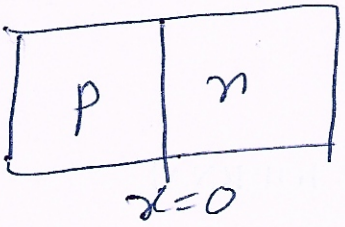
# LECTURE 23-9-2020

## Open circuited Step Graded p-n junction

Consider p-n junction at $x=0$ with uniform doping in each region. Both types of charge carriers, majority as well as minority exist in each region, assuming thermal equilibrium.



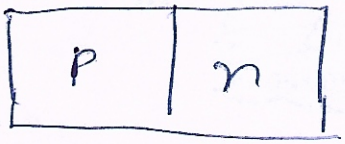

p side $p_p = N_A$ $\quad n_p << p_p$

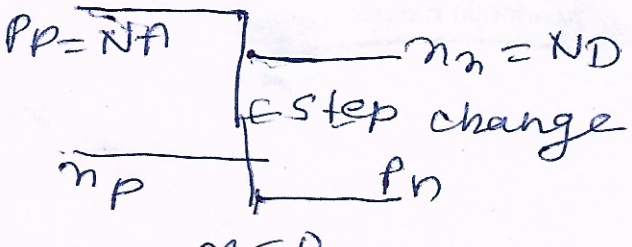
$$\therefore n_p = \frac{n_i^2}{N_A}$$

n side $n_n = N_D$ $\quad p_n << n_n$

$$\therefore p_n = \frac{n_i^2}{N_D}$$

At the junction, $x=0$ large changes in carrier concentration occur.




Sudden decrease in hole concentration from $p_p$ to $p_n$.

Sudden increase in electron concentration from $n_p$ to $n_n$.

There is a step change at $x=0$. Due to this the p-n junction is called step graded or abrupt p-n junction.

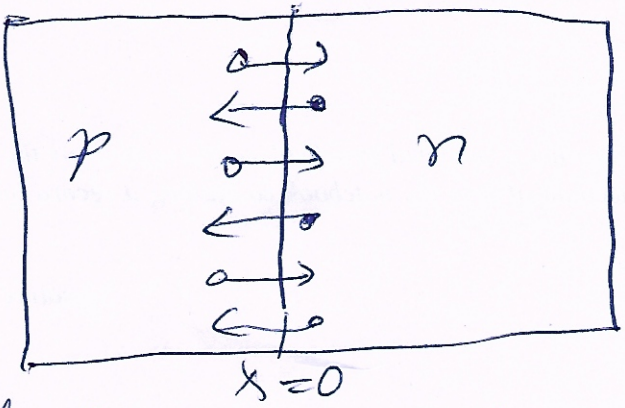
# FORMATION OF DEPLETION REGION

In a step graded p–n junction there exists a concentration gradient near the junction. There are large number of holes on p side while very small number of holes on n side. Thus holes start moving from p side to n side i.e. from high concentration area towards low concentration. This is diffusion of holes from p side to n side.

Similarly the electrons on n side start diffusing across the jn into p region

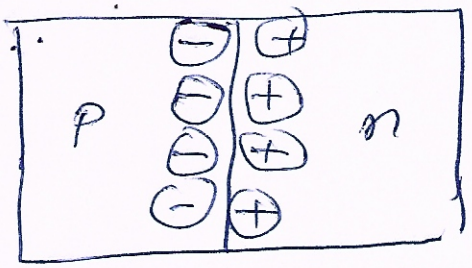
→ hole diffusion

←• Electron diffusion




As holes enter the n region, they find number of donor atoms. The holes recombine with donor atoms. As donor atoms accept additional holes they become +vely charged immobile ions. This happens immediately when holes cross the junction hence number of +vely charged immobile ions get formed near the junction on n side.

Atoms on p side are acceptor atoms The electrons diffusing from n to p side recombine with the acceptor atoms on p side As acceptor atoms accept additional electrons they become -vely charged immobile ions Such large number of -vely charged immobile ions get formed near the junction on p side




As more number of holes diffuse to n side, the large +ve charge gets accumulated on n side near the junction. The diffusing holes are +vely charged and get repelled due to accumulated +ve charge on n side The diffusion of holes stops.

Similarly due to large -ve charge accumulated on p side, the diffusing electrons get repelled and eventually electrons get repelled and eventually the diffusion of electron stops.

Thus in thermal equilibrium in the region near the junction there exists a wall of -ve immobile charges on p side and a wall of +ve immobile charges on n side.

As this region is depleted of mobile carriers it is called depletion layer / depletion region / space charge region.

The depletion region gets formed in open circuited p-n junction very quickly

Width of depletion region - 0.5 to 1 micron ($10^{-6}$ m)