EI-27003: Electronics Devices and Circuits
Lecture - 16

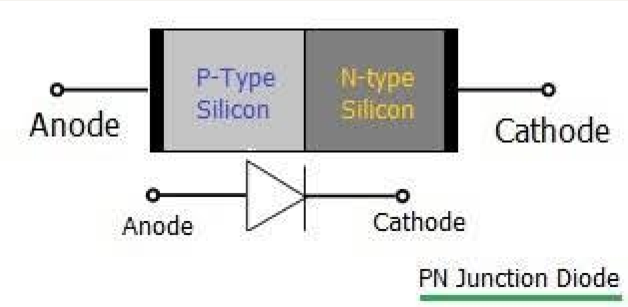
Subject Incharge: Mr. Rajesh Khatri
Associate Professor

LECTURE - 16

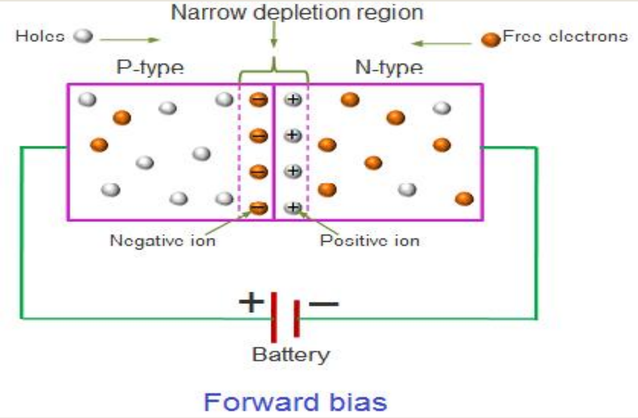
Year: 2020-21

Unit – 2/3 : Diode and BJT Modeling

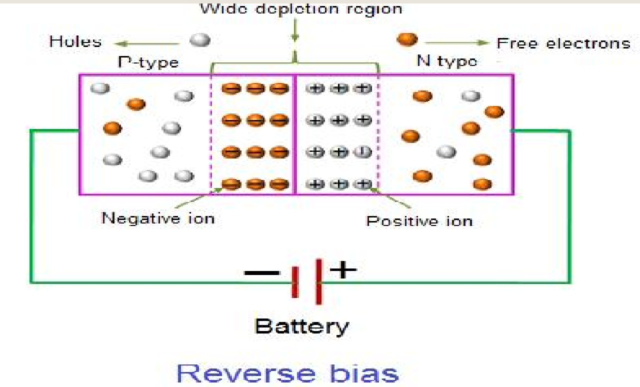
- PN Junction Diode



- Forward Bias Diode:



- Reverse Bias Diode:



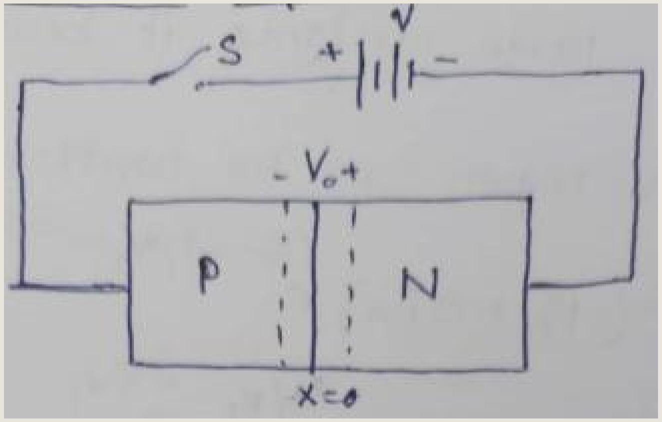
Diode Equations

- Here we will obtain the equations:

➢ Diode current Equation: I_D

➢ Built-in Potential V_0

➢ Width of Depletion layer W



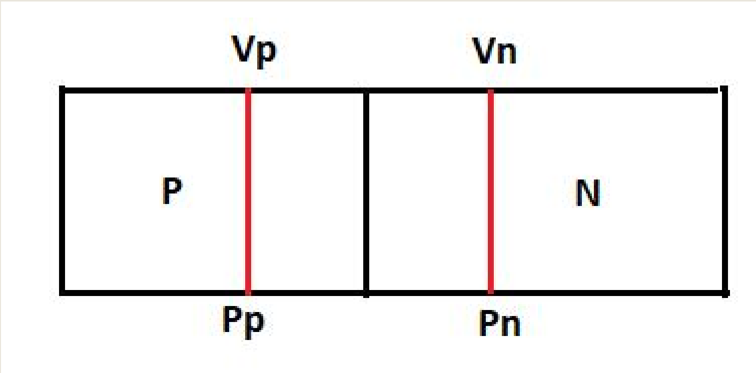
➢ We know in semiconductor, current is due to both drift and diffusion.

Built-in Potential

- We know that, at equilibrium, the drift and diffusion components of hole current cancels
  - OR
  - $J_p = q\mu_p pE - qD_p\frac{dp}{dx} = 0$
  - $= q[\mu_p pE - D_p\frac{dp}{dx}] = 0$
- Rearrange
  - $\frac{\mu_p}{D_p}E(x) = \frac{dp(x)}{dx}\frac{1}{P(x)}$ ------(1)
  - Where x direction is taken arbitrarily from p to n.
- The electric field can be written in terms of the gradient in the potential.
  - $E(x) = -\frac{dV(x)}{dx}$ ------(2)
  - Therefore eq(1) becomes
  - $-\frac{dV(x)}{dx}\frac{\mu_p}{D_p} = \frac{dp(x)}{dx}\frac{1}{P(x)}$ ------(3)

Built-in Potential

- Einstein's equation $\frac{D_p}{\mu_p} = \frac{KT}{q}$
- Hence eq.(3) becomes
  - $-\frac{q}{KT}\frac{dV(x)}{dx} = \frac{1}{P(x)}\frac{dp(x)}{dx}$ -------(4)
- This equation can be solved by appropriate boundary condition



- Let Vp and Vn be potential at either side of junction.
- Let Pp and Pn be hole concentration on either side of junction.

Built-in Potential

- $-\frac{q}{KT}\int_{Vp}^{Vn} dV = \int_{Pp}^{Pn} \frac{1}{P}$ dp

- $-\frac{q}{KT}$(Vn –Vp) = ln(Pn) – ln(Pp) = ln$\frac{Pn}{Pp}$

- The potential difference (Vn-Vp) is called as contact potential/ Potential Barrier V0

-

  - $V_0 = \frac{KT}{q}\ln\frac{P_p}{P_n}$ but

$P.n = n_i^2$

p-type Semiconductor: $P_p \cdot n_p = n_i^2$

but $P_p = Na$

$\therefore n_p = n_i^2/Na$

n-type Semiconductor: $P_n \cdot n_n = n_i^2$

but $n_n = Nd$

$P_n = n_i^2/Nd$

- If Na be acceptor atoms/cm3 on p-side and Nd be donor atoms on n-side

  - $$\boxed{V_0 = \frac{KT}{q}\ln\frac{Na.Nd}{N_i^{\,2}}}$$

Built-in Potential

- From eq. (3)

$$\frac{P_p}{P_n} = e^{qV_0/KT}$$

Attendance Link

https://forms.gle/ZRFwBfkV8rnXwxtd7