LECTURE-12

PN JUNCTION

MINORITY CARRIERS ARE FORMED BY "MAINLY" THERMAL EXCITATIONS

CAUSED BY E FIELD

Two Types of Current Phenomena
1) Diffusion
2) Drift

Particle Flow

CURRENT

Hole Diffusion

Hole Drift

Electron Diffusion

Electron Drift
AT EQUILIBRIUM

P side → \( n_{P_0} \rightarrow N_{d_p^+} \)
\( P_{P_0} \rightarrow N_{P} \)

n side → \( n_{n_0} \rightarrow N_{d_n^+} \)
\( P_{n_0} \rightarrow N_{P} \)

CONTACT POTENTIAL \( V_0 \rightarrow \text{VOLTS} \)

\[ V_0 = \frac{KT}{q} \ln \left( \frac{n_{n_0}}{n_{P_0}} \right) = \frac{KT}{q} \ln \left( \frac{P_{P_0}}{P_{n_0}} \right) \]

\[ V_0 = \frac{KT}{q} \ln \left[ \frac{(N_{P} - N_{d_p^+}) (N_{d_n^+} - N_{n_0})}{n_i^2} \right] \]

FOR EXTRINSIC DOPING

\( \left( \frac{n_{n_0}}{n_{P_0}} \right) = \left( \frac{P_{P_0}}{P_{n_0}} \right) = e^{\left( \frac{qV_0}{KT} \right)} \)
\[ qV_o = KT \ln\left(\frac{n_{no}}{n_{p0}}\right) = KT \ln\left(\frac{n_{no}}{n_i} \frac{n_i}{n_{p0}}\right) \]

\[ = KT \left[ \ln\left(\frac{n_{no}}{n_i}\right) + \ln\left(\frac{n_i}{n_{p0}}\right)\right] \]

\[ = KT \ln\left(\frac{n_{no}}{n_i}\right) - KT \ln\left(\frac{n_{p0}}{n_i}\right) \]

\[ qV_o = (E_F - E_{in}) - (E_F - E_{ip}) \]

\[ qV_o = E_{ip} - E_{in} \]

\[ qV_o = (E_F - E_{in}) + (E_{ip} - E_F) \]
ABRupt Si P-n Junction

\[ P_0 \leftarrow N_A = 10^{18} \text{ cm}^{-3} \text{ on P side} \]

\[ N_{n_0} \leftarrow N_D = 5 \times 10^{15} \text{ cm}^{-3} \text{ on n side} \]

FIND FERMI LEVELS AT 300 K ON P AND N REGIONS

\[ N_i = 1.5 \times 10^{10} \text{ cm}^{-3} \]

\[
E_F - E_{in} = kT \ln \left( \frac{N_{n_0}}{N_i} \right) = 0.0259 \ln \left( \frac{5 \times 10^{15}}{1.5 \times 10^{10}} \right) \\
= 0.329 \text{ eV}
\]

\[
E_{ip} - E_F = kT \ln \left( \frac{N_i}{N_{p_0}} \right)
\]

\[
N_{p_0} \cdot P_{p_0} = N_i^2
\]

\[
N_{p_0} = \frac{N_i^2}{P_{p_0}}
\]

\[
E_{ip} - E_F = kT \ln \left( \frac{N_i}{N_i^2 P_{p_0}} \right) = kT \ln \left( \frac{P_{p_0}}{N_i} \right)
\]

\[
= 0.0259 \ln \left( \frac{10^{18}}{1.5 \times 10^{10}} \right) = 0.467 \text{ eV}
\]
\[ q V_0 = (E_F - E_{in}) + (E_{ip} - E_F) = 0.329 + 0.467 = 0.796 \text{ eV} \]

\[ q V_0 = kT \ln \left( \frac{N_a N_d}{ni^2} \right) = 0.796 \text{ eV} \]

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There is a diagram showing the energy levels of a semiconductor, with labels for various energy levels such as \( E_{cp} \), \( E_{ip} \), \( E_F \), and \( E_{vn} \). The diagram illustrates the band structure with energy differences marked, such as 0.467 eV and 0.329 eV.

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\[ * \quad IF \quad q V_0 = 0.796 \text{ eV} \]

\[ V_0 = 0.796 \text{ V} \]