

LECTURE-8

EXTRINSIC SEMI CONDUCTOR

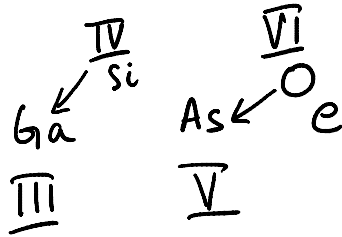
3 CASES

- 1) $n_0 > p_0$: n TYPE : $N_a^- < N_d^+$
- 2) $n_0 < p_0$: p TYPE : $N_a^- > N_d^+$
- 3) $n_0 = p_0$: INTRINSIC : THERMAL EHP
DOMINATES

DOPING FOR COMPOUND SEMI CONDUCTORS

COLUMN III-V
GaAs
InP

DONORS



1 EXTRA e {
COL. VI ELEMENTS REPLACE COLUMN V ELEMENTS
OR
COL. IV ELEMENTS REPLACE COLUMN III ELEMENTS

ACCEPTORS

1 LESS e {
COL. III-V
COL. II ELEMENTS REPLACE COLUMN III ELEMENTS
OR
COL. IV ELEMENTS REPLACE " V ELEMENTS

DERIVATION ROOM TEMPERATURE

Ex. SEMICONDUCTOR IS DOPED WITH
BOTH DONOR AND ACCEPTOR IMPURITY,
COMPLETE IONIZATION

$$\boxed{N_d^+ > N_a^-} \rightarrow \text{n-TYPE}$$

Ex

$$n_0 + N_a^- = p_0 + N_d^+ \quad \dots \quad \textcircled{1}$$

$$n_0 p_0 = n_i^2 \quad \dots \quad \textcircled{2}$$

* ALWAYS SOLVE FOR MAJORITY CARRIER FIRST!

$$n_0 p_0 = n_i^2$$

$$p_0 = \frac{n_i^2}{n_0} \dots \textcircled{3}$$

SUBSTITUTE $\textcircled{3}$ IN $\textcircled{1}$

$$\textcircled{1} \quad n_0 + (Na^- - Nd^+) - p_0 = 0$$

$$n_0 - (Nd^+ - Na^-) - p_0 = 0$$

$$n_0 - (Nd^+ - Na^-) - \frac{n_i^2}{n_0} = 0$$

$$n_0^2 - (Nd^+ - Na^-)n_0 - n_i^2 = 0$$

$$n_0 = \frac{(Nd^+ - Na^-) \pm \sqrt{(Nd^+ - Na^-)^2 - 4(-n_i^2)}}{2}$$

$$n_0 = \underbrace{\frac{(Nd^+ - Na^-)}{2}}_{\textcircled{B}} \pm \frac{1}{2} \sqrt{\underbrace{(Nd^+ - Na^-)^2 + 4n_i^2}_{\textcircled{A}}}$$

$$\textcircled{A} > \textcircled{B}$$

CHOOSE THE POSITIVE SOLUTION

$$n_0 = \left(\frac{Nd^+ - Na^-}{2} \right) + \frac{1}{2} \sqrt{(Nd^+ - Na^-)^2 + 4n_i^2}$$

$$p_0 = \frac{n_i^2}{n_0}$$



Thursday, January 10, 2013
1:22 PM

$$\text{IF } n_i \gg (N_d^+ - N_a^-)$$

$$\begin{aligned} n_0 &= \frac{N_d^+ - N_a^-}{2} + \frac{1}{2} \sqrt{4n_i^2} \\ &= \frac{N_d^+ - N_a^-}{2} + n_i \end{aligned}$$

$$n_0 \approx n_i$$

$$\text{IF } n_i \ll (N_d^+ - N_a^-)$$

$$n_0 \approx N_d^+ - N_a^-$$

Ex

Si \rightarrow RT

$N_a = 1 \times 10^{12} \text{ cm}^{-3}$ COMPLETE
IONIZATION

P-TYPE

$N_a = N_a^-$ $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$

$n_0?$ $p_0?$

ONLY ACCEPTOR IMPURITY

$$N_d^+ = 0$$

$$n_0 + N_a^- = p_0$$

$$p_0 - N_a^- - n_0 = 0$$

$$n_0 p_0 = n_i^2 \quad \Rightarrow \quad n_0 = \frac{n_i^2}{p_0}$$

$$p_0 - N_a^- - \frac{n_i^2}{p_0} = 0$$

$$p_0^2 - N_a^- p_0 - n_i^2 = 0$$

$$p_0 = \frac{N_a^- \pm \sqrt{(N_a^-)^2 - 4(-n_i^2)}}{2}$$

$$= \frac{N_a^-}{2} \pm \frac{1}{2} \sqrt{(N_a^-)^2 + 4n_i^2}$$

$$p_0 = \frac{N_a^-}{2} + \frac{1}{2} \sqrt{(N_a^-)^2 + 4n_i^2}$$

$$= \frac{10^{12}}{2} + \frac{1}{2} \sqrt{(10^{12})^2 + 4(1.5 \times 10^{10})^2}$$

Thursday, January 10, 2013
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$$\begin{aligned} & \# \text{ OF Si ATOMS PER UNIT VOLUME} \\ & = \frac{(8 \text{ ATOMS/CELL})}{(0.5431 \times 10^{-7} \text{ cm})^3} \\ & = 4.99 \times 10^{22} \text{ cm}^{-3} \end{aligned}$$

$$P_D = 1.000225 \times 10^{12} \text{ cm}^{-3}$$

$$\begin{aligned} & \# \text{ OF Si ATOMS PER ACCEPTOR ATOMS} \\ & = \frac{4.99 \times 10^{22}}{1.000225 \times 10^{12}} = \underline{\underline{4.99 \times 10^{10} \text{ Si ATOMS}}} \end{aligned}$$