Example:

n-type silicon, dopant $N_D = 10^{17}/cm^3$,

find electron and hole concentration (room-temp)

N_D: concentration of the donor

$N_D = n_n = 10^{17}/cm^3$

n_n → concentration of electrons; n → n-type

$n_n \cdot p_n = n_i^2 = (1.5 \times 10^{10})^2$

$p_n = \frac{n_i^2}{n_n} = \frac{(1.5 \times 10^{10})^2}{10^{17}}$

$= 2.25 \times 10^3$ carries/cm^3

p-type ... $N_A = 10^{17}/cm^3$

find .... (room-temp).

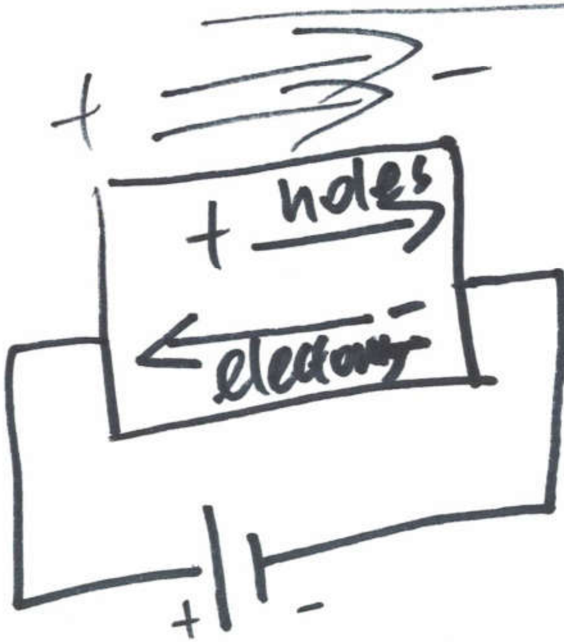
$$N_A = p_p = 10^{17}/cm^3$$

concentration of holes. p-type

$$p_p \cdot n_p = n_i^2$$

$$n_p = \frac{n_i^2}{p_p} = 2.25 \times 10^3 \text{ carriers}/cm^3$$

Drift Current in Semiconductors



$\frac{m/s}{V} = \frac{m}{V \cdot s} = \frac{m \cdot 1}{V s}$

velocities $\begin{cases} V_{n\text{-drift}} = -\mu_n \cdot E \\ V_{p\text{-drift}} = \mu_p \cdot E \end{cases}$

$\begin{cases} \mu_n : \text{electron mobility} \\ \mu_p : \text{hole mobility} \end{cases}$

$$\boxed{\mu_n > \mu_p}$$

electrons move faster ! easier than holes.

Resistivity:

$$\rho = \frac{1}{q(p\mu_p + n\cdot\mu_n)}$$

Conductivity:

$$\sigma = q(p\mu_p + n\mu_n) = \frac{1}{\rho}$$

q: magnitude of electron charge
1.6×10^{-19} C

Intrinsic Silicon:

Given: $p = n = n_i = 1.5 \times 10^{10} / cm^3$, $\mu_n = 1350\ cm^2/V$, $\mu_p = 480\ cm^2/V$. ρ?

$$\rho = \frac{1}{q(\mu_n \cdot n + \mu_p \cdot p)}$$

$$= \frac{1}{1.6 \times 10^{-19}(1350 \cdot 1.5 \times 10^{10} + 480 \cdot 1.5 \times 10^{10})}$$

$$= \ldots\ldots$$

P.T

p-type

Given: $N_A = 10^{16}/cm^3$, $\mu_n = 1110\ cm^2/v$,

$\mu_p = 400\ cm^2/v$, ρ?

$$\rho = \frac{1}{q(\mu_n n + \mu_p p)}$$

$$p = N_A$$

$$n = \frac{n_i^2}{p} = \frac{(1.5\times 10^{10})^2}{10^{16}}$$

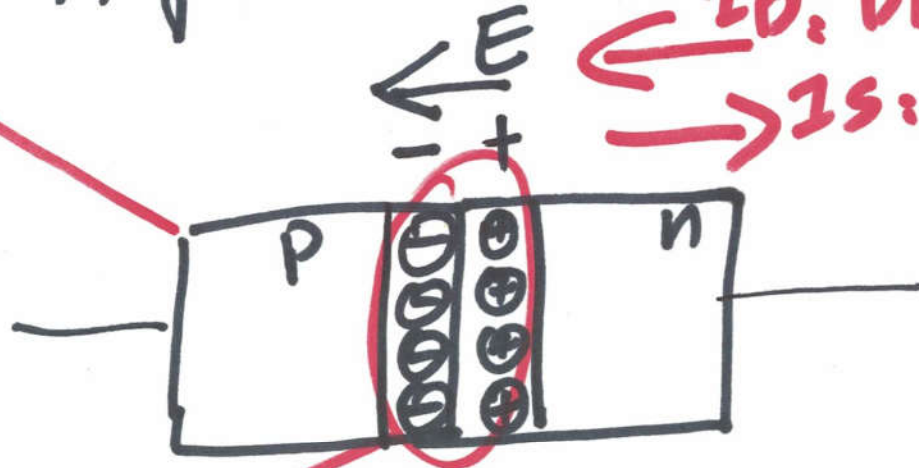
$= \square$ carriers/cm^3

(b)

Pn Junction

Diffussion Current

High Concentration → Low Concentration

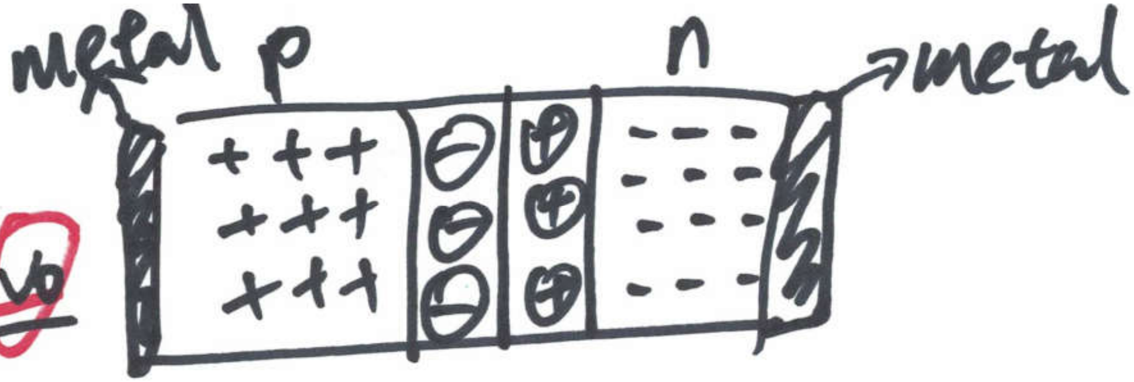


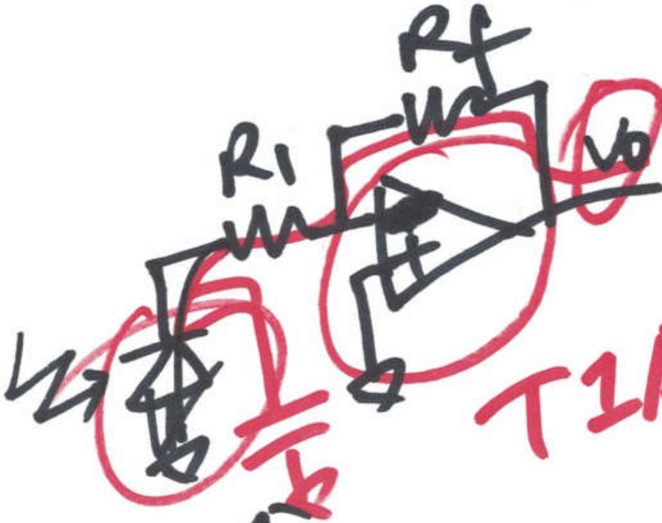
I_D: Drift Current.

I_S: diffusion current

△ Will stop at a thickness.

△ Depletion region form an Electric Field E, and opposes more diffusion to happen.





TIA Transimpedance Amplifier

CMOS-Imager