Lecture 3:

Review:

$$n\,p = n_i^2$$
$$N_D + p = n + N_A$$

if $N_D > N_A \rightarrow n > p \rightarrow$ N – type

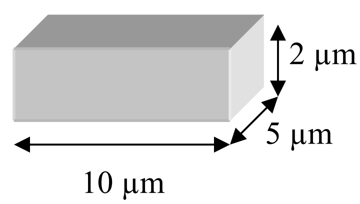
$n = N_D - N_A$ = Net Doping = N_D net
$p = n_i^2 / n$

if $N_A > N_D \rightarrow p > n \rightarrow$ P – type

$p = N_A - N_D$ = Net Acceptor Concentration = N_A net
$n = n_i^2 / p$

Ex3:

An N-type piece of Si has 10^{15}cm^{-3} donors concentration. Acceptors are added at a concentration of 10^{16}cm^{-3}. What is the type of the resulting material and its resistance?



Sol:

$ND = 10^{15}\text{cm}^{-3}$
$NA = 10^{16}\text{cm}^{-3}$ $\qquad N_A >> N_D \rightarrow$ p-type silicon

$$R = \rho\frac{L}{H.W} = \rho\frac{10\times10^{-4}}{2\times10^{-4}\times5\times10^{-4}} = 10^4\rho$$

$$\rho = \frac{1}{\sigma_n + \sigma_p} = \frac{1}{\sigma_p}$$ $\rightarrow$ we ignored σ_n Since $N_A >> N_D \rightarrow p >> n \rightarrow \sigma_p >> \sigma_n$

Hence $\rho = \dfrac{1}{\mu_p pq}$ $\qquad$ let $\mu_p = 250$

$$p \approx N_A - N_D = 10^{16} - 10^{15} = 9\text{x}10^{15}\ \text{cm}^{-3}$$
$$= 10\text{x}10^{15} - 10^{15} = 10^{15}(10-1) = 9\text{x}10^{15}\text{cm}^{-3}$$

$$\rho = \frac{1}{250\times9\times10^{15}\times1.6\times10^{-19}} = 2.78\ \text{k}\Omega.\text{cm}$$

R = 2.78 x 104 = 27.8 kΩ

Ex4:

p-type Si has a Resistivity of 1Ω.cm . What is the required doners concentration to invert is i.e (make it n-type) while keeping Resistivity the same ?

sol.

$$\rho = \frac{1}{\mu_n pq + \sigma_p}$$

for n-type → ignore hole conductivity

let $\mu_n = 600$

$$n = \frac{1}{600 \times 1.6 \times 10^{-19}} \approx 10^{16} \text{ cm}^{-3}$$

n = $N_D - N_A = 10^{16}$ cm^{-3}

when it was p-type

$$\rho = 1 = \frac{1}{\mu_p pq + \sigma_n}$$

let $\mu_p = 250$

$$p = \frac{1}{250 \times 1.6 \times 10^{-19}} = 2.5 \times 10^{16} = N_A$$

So, $N_D = 10^{16} + N_A = 3.9 \times 10^{16}$ cm^{-3}

n = 10^{16} → p = 10^{20} \ 10^{6} = 10^{4} (which is small – ignored -)