Lecture 3:

Review:

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

if $N_D > N_A$ → $n > p$ → N – type

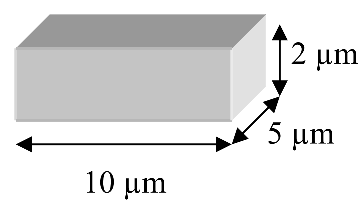
$n = N_D - N_A$ = Net Doping = N_D net
$p = n_i^2 / n$

if $N_A > N_D$ → $p > n$ → 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:

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

$$R = \rho \frac{L}{H.W} = \rho \frac{10 \times 10^{-4}}{2 \times 10^{-4} \times 5 \times 10^{-4}} = 10^4 \rho$$

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

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

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

$$\rho = \frac{1}{250 \times 9 \times 10^{15} \times 1.6 \times 10^{-19}} = 2.78\ \Omega.\text{cm}$$

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, $N_D = 10^{16} + N_A = 3.5 \times 10^{16}\ \text{cm}^{-3}$

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