Review:

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

if $N_D > N_A$ → $n > p$ → N – type

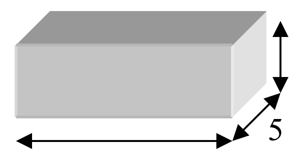
$n = N_D - N_A$ = Net Doping = N_D net
$p = n_i^2 / n$

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. Acceptors are added at a concentration of $10^{16} cm^{-3}$. What is the type of the resulting material and its resistance?



Sol:

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

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

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

Hence $\rho = \frac{1}{\mu_p p q}$ $\qquad$ let $\mu_p = 250$

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

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

R = 2.78 x 104 = 27.8 kΩ

Ex4:

p-type Si has a Resistivity of $1\Omega.cm$. 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 $\mu_n = 600$

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

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

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

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