NANYANG TECHNOLOGICAL UNIVERSITY

Course: EE3013/ Semiconductor Devices and Processing

School: School of Electrical and Electronic Engineering

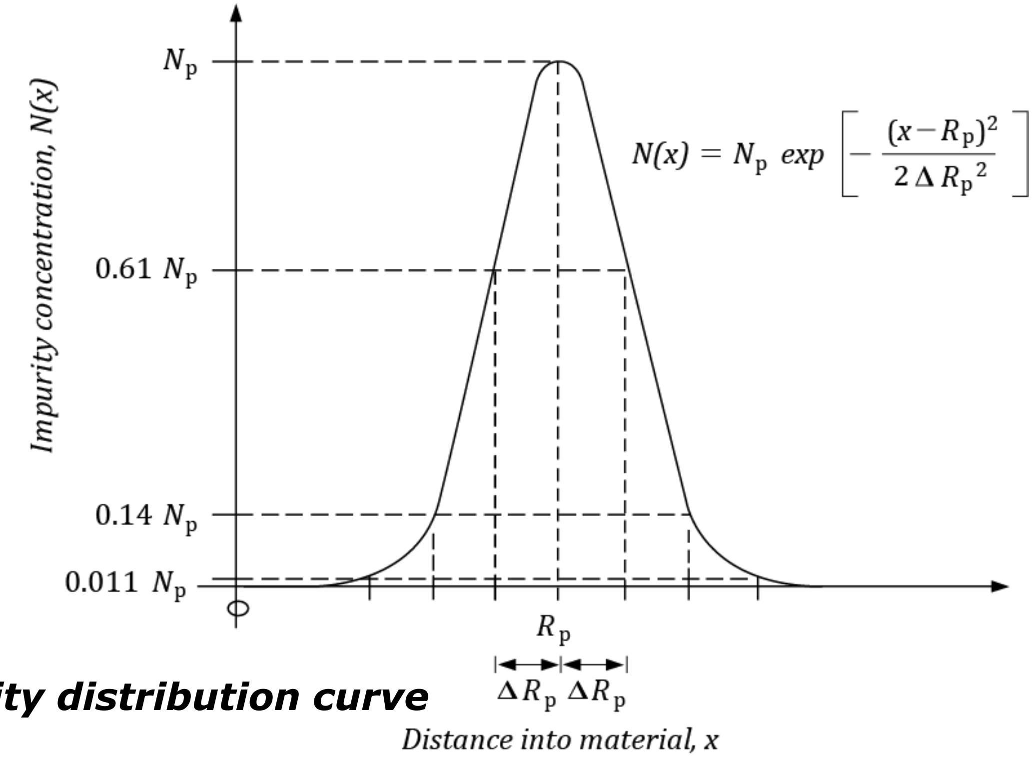
Part II - Highlights

Week 9 - Ion Implantation

Ion Implantation

- Impurity profile is approximated to a Gaussian distribution function along the axis of incidence:

$$\boxed{N_p exp\left[-\frac{(x_j - R_p)^2}{2\Delta R_p^2}\right] = N_B}$$



R_p: Projected range (average distance an ion travels)

ΔR_p: Straggle (Standard deviation of the projected range)

$N(R_p)$:N_p (maximum ion concentration)

The total ions implanted into the Si is dose = the area under the impurity distribution curve

Dose $$Q=\int_0^\infty N(x)dx = \sqrt{2\pi}N_p\Delta R_p$$

Hence $$N(x) = \frac{Q}{\sqrt{2\pi}\Delta R_p}\exp\left[-\frac{(x-R_p)^2}{2\Delta R_p^2}\right]$$

Ion Channeling

- For single crystals, there are directions in which no nuclei will be encountered and the only stopping mechanism is due to electrons. Thus, the range will be considerably increased or channelled. To avoid: e.g. tilt, surface amorphize.

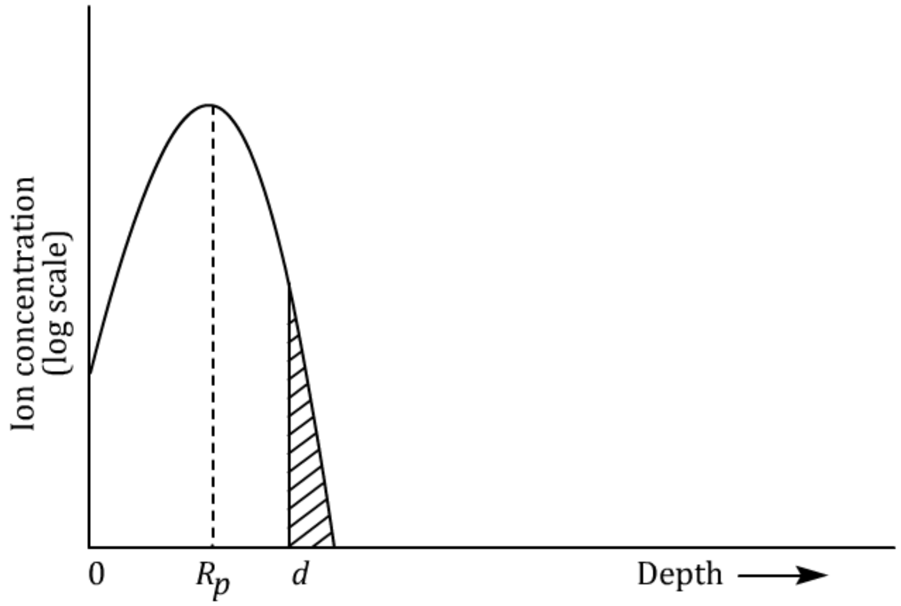
Masking During Implantation

The dose deposited in the wafer beyond depth ***d*** (shaded) is:

$$S(d) = \frac{S}{\sqrt{2\pi}\,\Delta R_p}\int_d^{\infty} \exp\left[-\frac{(x-R_p)^2}{2\Delta R_p{}^2}\right]dx$$

Fraction of dose implanted beyond depth *d* is:

$$\frac{S(d)}{S} = \frac{1}{2}\,\mathrm{erfc}\frac{(d-R_p)}{\sqrt{2}\,\Delta R_p}$$



Ion penetration beyond a depth *d*.

To achieve masking effectiveness of 99.99%

➔ masking thickness ***d*** = (3.72ΔRp+Rp)

Silicon Oxide for Masking

$$N\left(t_{ox}\right) = N_p \exp\left[-\frac{\left(t_{ox} - R_p\right)^2}{2\Delta R_p^2}\right] < \frac{N_B}{10}$$

The required oxide thickness for the mask:

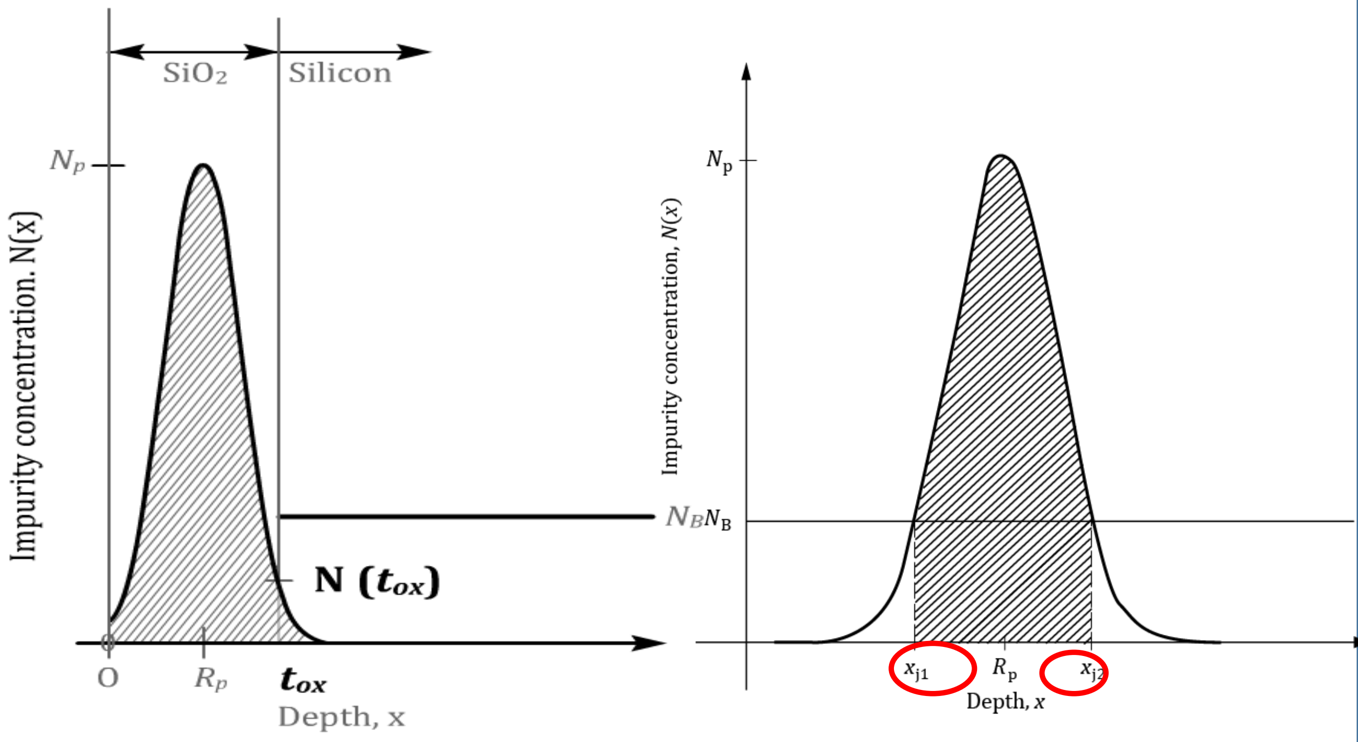
$$t_{ox} \geq R_p + \Delta R_p \sqrt{2\ln\left(\frac{10N_p}{N_B}\right)}$$

Junction Depth

$$N(x_j) = N_B$$

$$N_p exp\left[-\frac{(x_j - R_p)^2}{2\Delta R_p^2}\right] = N_B$$

$$x_j = R_p \pm \Delta R_p \sqrt{2\ln\left(\frac{N_p}{N_B}\right)}$$



Effect of Annealing on Implantation Profile

- R_p remains the same, but ΔR_p alters to:

$$\boxed{(\Delta R_p{}^2 + 2Dt)^{1/2}}$$

- Hence

$$\boxed{N(x) = \frac{Q}{\sqrt{2\pi}(\Delta R_p{}^2 + 2Dt)^{1/2}} exp\left[-\frac{(x - R_p)^2}{2(\Delta R_p^2 + Dt)}\right]}$$