

Lecture 16w: Ion ImplantationLecture 16: Ion ImplantationAnnouncements:

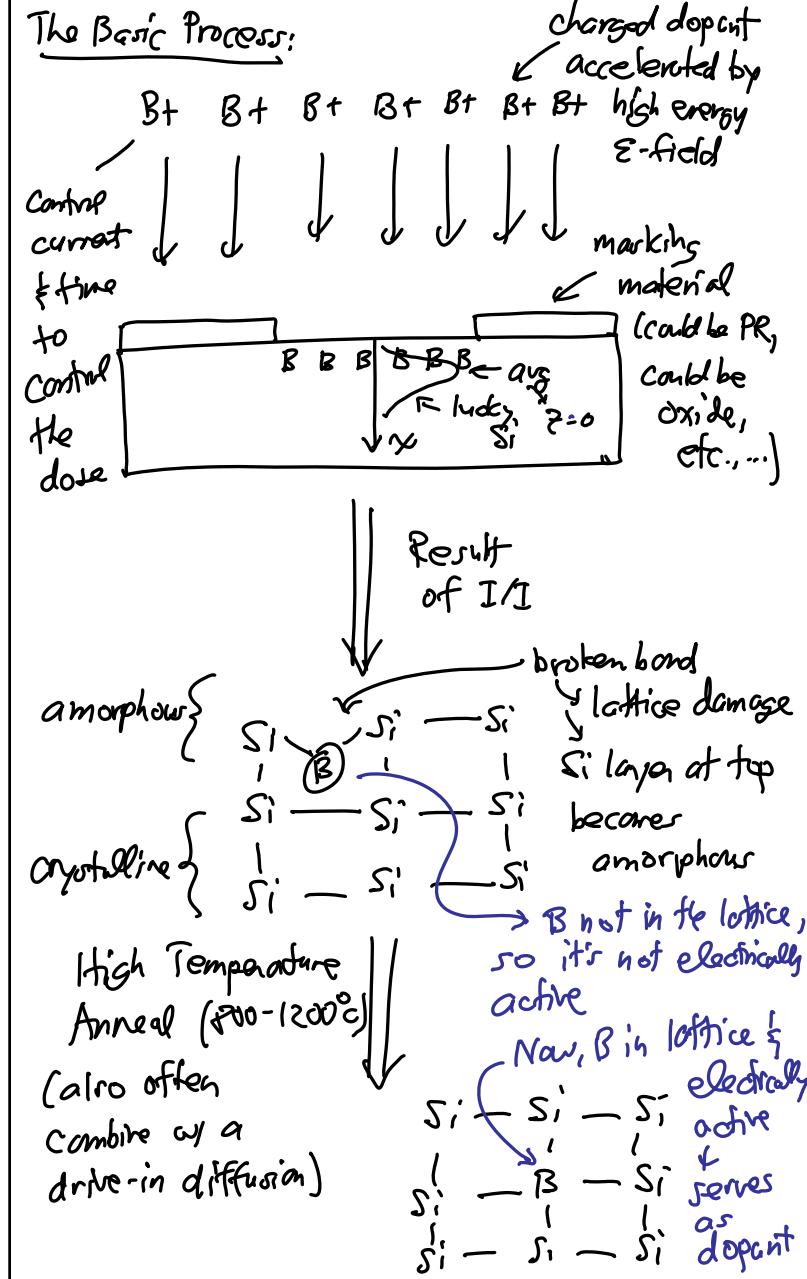
- HW#7 due this coming Friday at 8 a.m.
- Midterm Exam: coming Thursday, Oct. 30
 - It'll be during lecture
 - Will pass out information sheet on the exam next time
 - Do you want a Review Session

Lecture Topics:

- Ion Implantation
 - Gaussian Distribution
 - Range, Straggle, & Lateral Straggle
 - Masking
 - Junction Depth

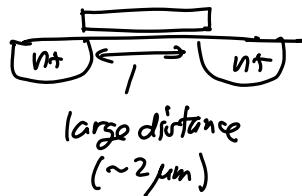
[Ion Implantation] (I/I)

⇒ method by which dopants can be introduced into Si (actually, into anything) to form, e.g., pn junctions, S/D junctions, & to set threshold voltages for MOS devices



We like this more than diffusion for shallow doping.

Old NMOS



Newer NMOS (shallow gate)



planefield current

leakage current +

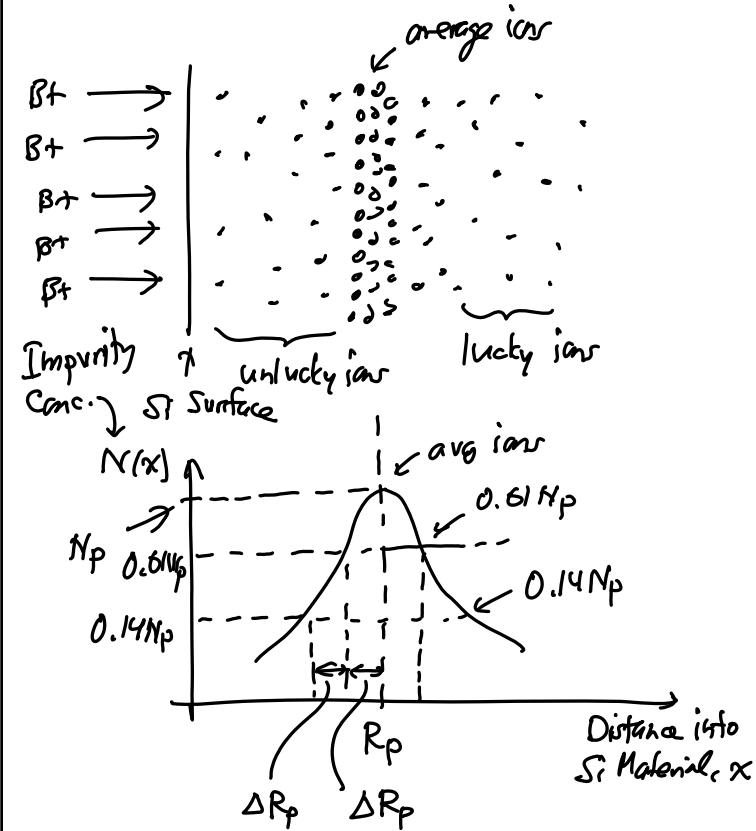
Problem for advanced
short channel devices.

Better NMOS



shallow source \rightarrow allows fr' gate to control fields
around fr' SD \rightarrow Control f' stop
punchthrough

I/I Statistics



$R_p \stackrel{\Delta}{=} \text{projected range} = \text{avg. distance an ion travels before stopping}$

$\Delta R_p \stackrel{\Delta}{=} \text{straggle} = \text{std. deviation characterizing the spread of the distribution}$

Mathematically:

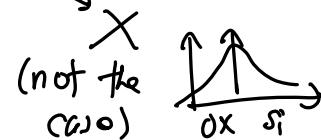
$$N(x) = N_p \exp \left[-\frac{(x-R_p)^2}{2(\Delta R_p)^2} \right]$$

Area under the impurity distribution curve:

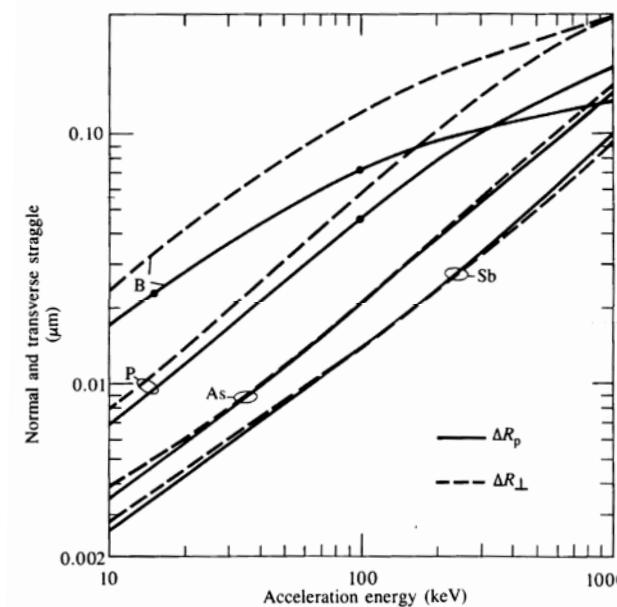
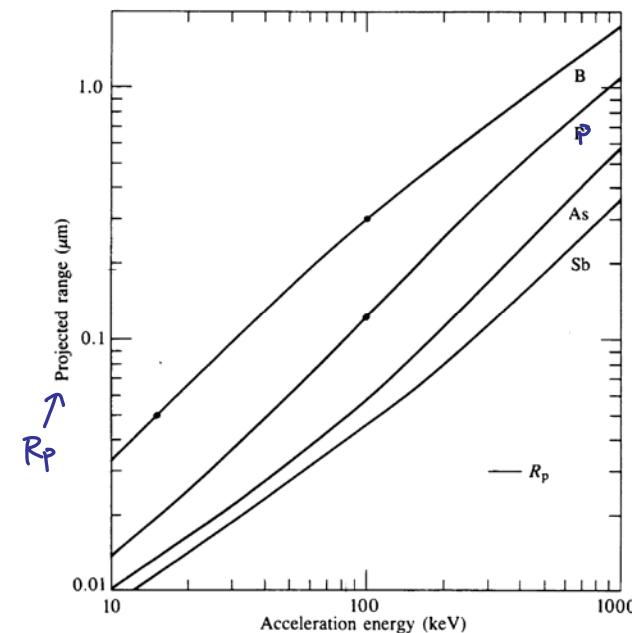
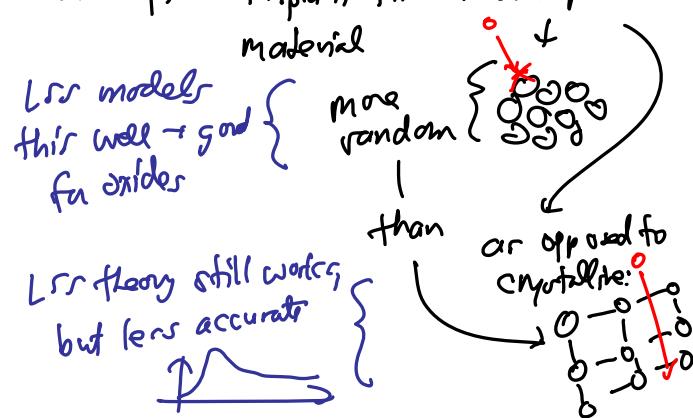
$$\text{Implanted Dose} = Q = \int_0^\infty N(x) dx \text{ [ions/cm}^2\text{]}$$

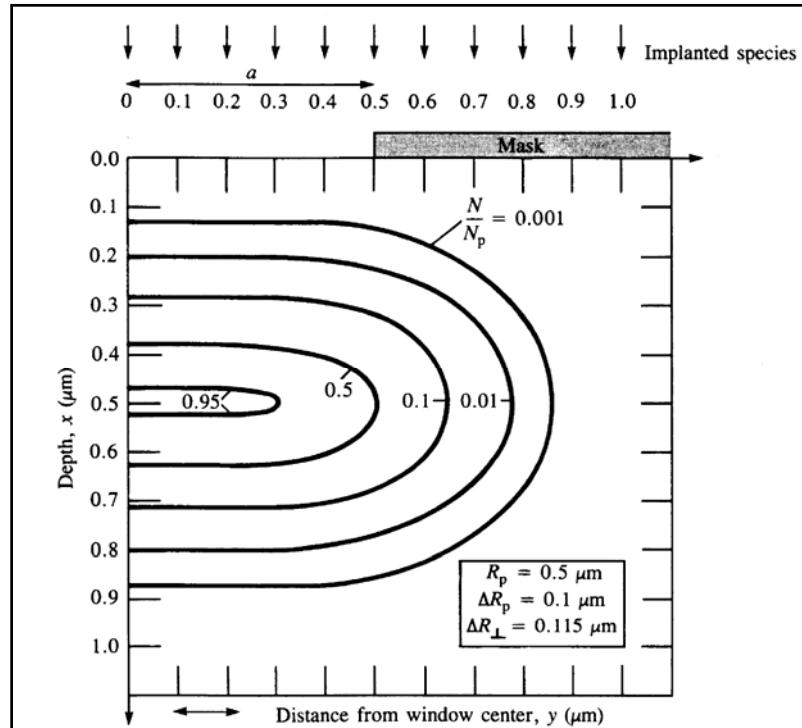
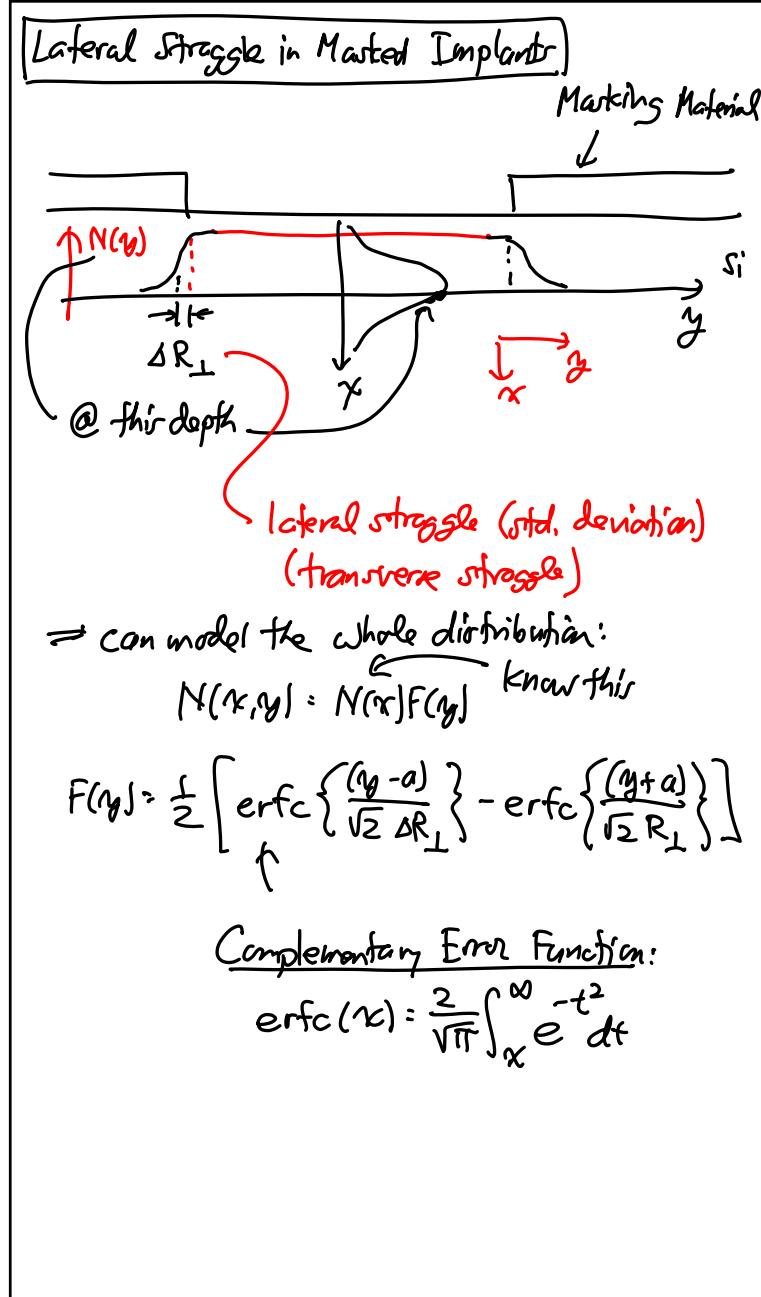
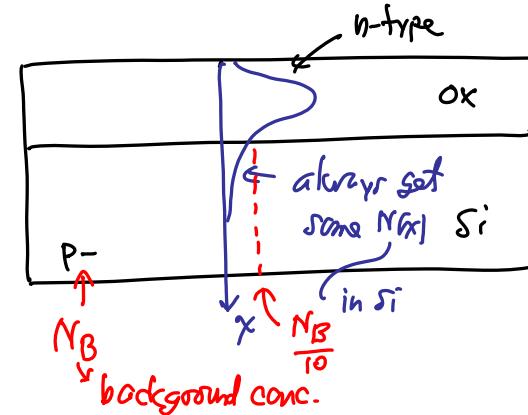
Case: For an implant completely contained in Si:

$$Q = \sqrt{2\pi} N_p \Delta R_p \rightarrow$$

Lindhard, Scharff, and Schiott (LSS) Theory:

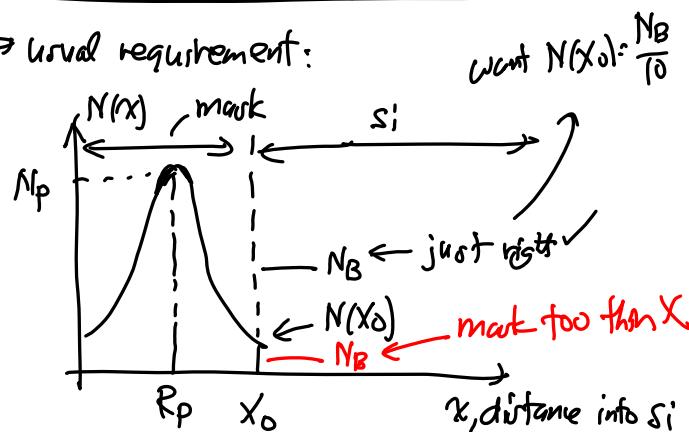
⇒ assumption: implant into an amorphous material



Lecture 16w: Ion ImplantationImplant Marking

How thick must the masking material be?

⇒ usual requirement:



$$\text{Want: } N(x_0) = \frac{N_B}{10}$$

$$N_p \exp\left[-\frac{(x_0 - R_p)^2}{2(\Delta R_p)^2}\right] < \frac{N_B}{10}$$

Solve for x_0 :

$$x_0 = R_p + \Delta R_p \sqrt{2 \ln\left(\frac{10N_p}{N_B}\right)}$$

$$= R_p + m \Delta R_p$$

↑
projected range
↑ some x straggles multiple

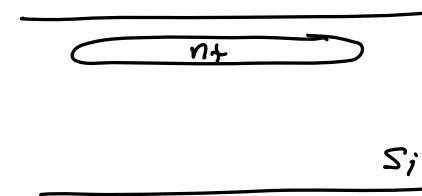
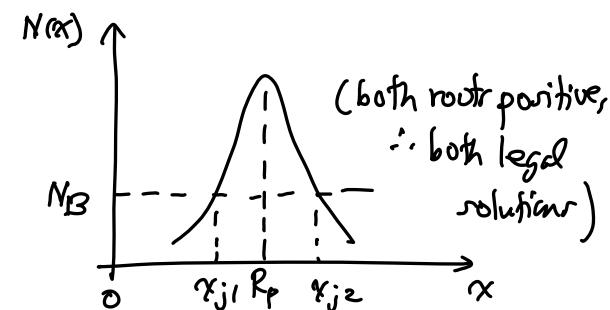
Junction Depth (x_j)

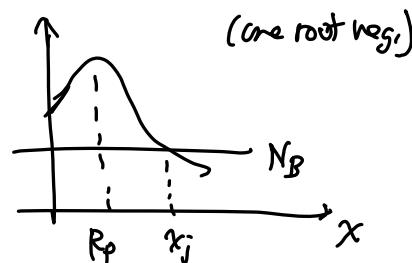
⇒ defined as the depth @ which the implanted concentration = N_B (the background conc.)

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

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

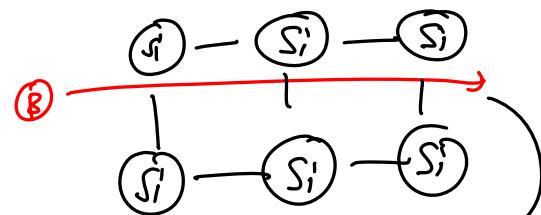
both roots may be meaningful for deep implantations





Channeling

⇒ LSS theory assumes amorphous material
 ↪ true for SiO_2 , deposited SiO_2 , & metals
 ↪ not true for Si



for this → got channeling

