

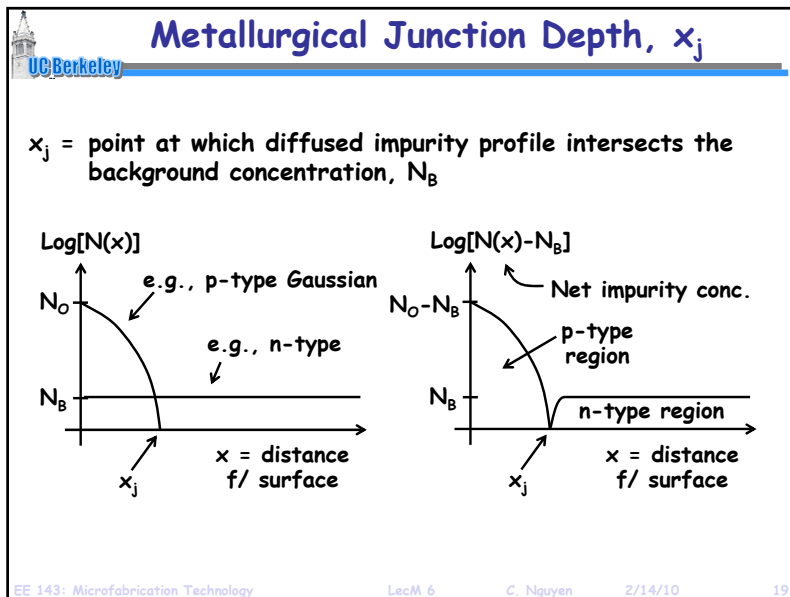
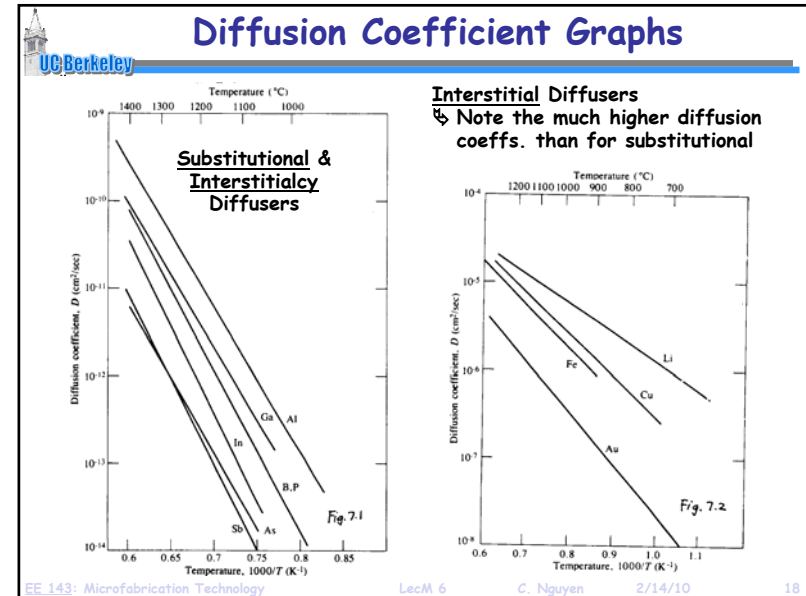
The Diffusion Coefficient

$$D = D_o \exp\left(-\frac{E_A}{kT}\right) \quad (\text{as usual, an Arrhenius relationship})$$

Table 4.1 Typical Diffusion Coefficient Values for a Number of Impurities.

Element	$D_o(\text{cm}^2/\text{sec})$	$E_A(\text{eV})$
B	10.5	3.69
Al	8.00	3.47
Ga	3.60	3.51
In	16.5	3.90
P	10.5	3.69
As	0.32	3.56
Sb	5.60	3.95

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Expressions for x_j

- Assuming a Gaussian dopant profile: (the most common case)

$$N(x_j, t) = N_o \exp\left[-\left(\frac{x_j}{2\sqrt{Dt}}\right)^2\right] = N_B \rightarrow x_j = 2\sqrt{Dt \ln\left(\frac{N_o}{N_B}\right)}$$

- For a complementary error function profile:

$$N(x_j, t) = N_o \operatorname{erfc}\left(\frac{x_j}{2\sqrt{Dt}}\right) = N_B \rightarrow x_j = 2\sqrt{Dt} \operatorname{erfc}^{-1}\left(\frac{N_B}{N_o}\right)$$

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Sheet Resistance

- Sheet resistance provides a simple way to determine the resistance of a given conductive trace by merely counting the number of effective squares
- Definition:**

$$R = \frac{\rho L}{A} = \left(\frac{\rho}{t}\right) \frac{L}{W} = R_s \left(\frac{L}{W}\right)$$

$A = tW$ (area)
 R_s (ohms per square)
 $\frac{L}{W}$ (number of squares)

Uniformly doped material w/ resistivity $\rho = \frac{1}{\sigma}$
 $\sigma = \text{conductivity} = q(\mu_n n + \mu_p p)$

What if the trace is non-uniform? (e.g., a corner, contains a contact, etc.)

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Squares From Non-Uniform Traces

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Sheet Resistance of a Diffused Junction

- For diffused layers:

Majority carrier mobility

Net impurity concentration

Effective resistivity

Sheet resistance

$$R_s = \frac{\rho}{x_j} = \left[\int_0^{x_j} \sigma(x) dx \right]^{-1} = \left[\int_0^{x_j} q \mu N(x) dx \right]^{-1}$$

depletion region

[extrinsic material]

depletion region

Fixed Charge

- This expression neglects depletion of carriers near the junction, $x_j \rightarrow$ thus, this gives a slightly lower value of resistance than actual
- Above expression was evaluated by Irvin and is plotted in "Irvin's curves" on next few slides
 - Illuminates the dependence of R_s on x_j , N_0 (the surface concentration), and N_B (the substrate background conc.)

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Irvin's Curves (for n-type diffusion)

Example. p-type

Given:

$N_B = 3 \times 10^{16} \text{ cm}^{-3}$

$N_0 = 1.1 \times 10^{18} \text{ cm}^{-3}$

(n-type Gaussian)

$x_j = 2.77 \text{ } \mu\text{m}$

Can determine these given known predep. and drive conditions

Determine the R_s .

Using Fig. 7.7:

$R_s x_j = 470 \text{ } \Omega \cdot \mu\text{m}$

$\therefore R_s = \frac{470}{2.77} = 170 \text{ } \Omega/\square$

$N_0, N_B, x_j, R_s \rightarrow$ given any 3, can find the 4th!

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