CHE323/384 Chemical Processes for Micro- and Nanofabrication
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Homework #4 Solutions

1. Suppose we perform a solid solubility-limited predeposition from a doped glass source which introduces a total of Q impurities per square cm.
   a. If this predeposition was performed for a total of *t* minutes, how long would it take (total time) to predeposit a total of 3Q impurities into a wafer if the predeposition temperature remained constant?
   b. Derive a simple expression for the $(Dt)_{drive-in}$ which would be required to drive the initial predeposition of Q impurities sufficiently deep so that the final surface concentration is equal to 1% of the solid solubility concentration. This can be expressed in terms of $(Dt)_{predep}$ and the solid solubility concentration C_S.

a) This is a constant source problem, so we know (from Lecture 14) that the dose is given by

$$Q_T(t) = \frac{2}{\sqrt{\pi}} C_S \sqrt{(Dt)_{predep}}$$

Since dose varies as the square root of time, to triple the dose would require a time of $9t$.

b) The solution to the drive-in diffusion problem, from Lecture 14, is

$$C(z,t) = \frac{Q_T}{\sqrt{\pi (Dt)_{drive-in}}} e^{-z^2/4Dt}, \ \ t > 0$$

At z = 0, then, the surface concentration after drive-in is

$$C(0,t) = \frac{Q_T}{\sqrt{\pi (Dt)_{drive-in}}}$$

We want this value to be equal to $0.01C_S$, where C_S was the surface concentration for the predep step. We can use the equation in part a) above to express C_S in terms of Q_T.

$$C(0,t) = \frac{Q_T}{\sqrt{\pi (Dt)_{drive-in}}} = 0.01 C_S = \frac{0.005\sqrt{\pi} Q_T}{\sqrt{(Dt)_{predep}}}$$

Solving,

$$(Dt)_{drive-in} = \frac{(Dt)_{predep}}{(0.005\pi)^2}$$

2. A diffused region is formed by an ultra-shallow implant followed by a drive-in. The final profile is Gaussian.

a. Derive an expression for the junction depth (x_j) given a background dopant concentration (of the opposite type) of C_B.
b. Derive a simple expression for the sensitivity of x_j to the implant dose Q. Is x_j more sensitive to Q at high or low doses?

a) The solution for the drive-in diffusion, from Lecture 14, is

$$C(x,t) = \frac{Q_T}{\sqrt{\pi(Dt)_{drive-in}}} e^{-x^2/4Dt}, \quad t > 0$$

At $x = x_j$, $C = C_B$ (this is the definition of the junction depth). Solving then for x_j,

$$x_j = \sqrt{4Dt ln\left(\frac{Q_T}{C_B\sqrt{\pi Dt}}\right)}$$

b) Taking the derivative of the above result with respect to Q_T,

$$\frac{dx_j}{dQ_T} = \frac{2Dt}{x_j Q_T}$$

Thus, the junction depth is more sensitive to dose variations when the dose is small.

3. Campbell textbook, Chapter 3, problem 7.

No solution provided for this one. You are on your own!