3.155J/6.152J
Microelectronic Processing
Fall Term, 2005

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Problem Set 3 **Out Sept. 21, 2005** **Due Oct. 3, 2005**

Diffusion: Read Plummer Chap. 7, sections 7.1-7.4, 7.5.2, 7.5.3, 7.5.8

1. Show that $c(z,t) = \frac{Q}{\sqrt{\pi Dt}} \exp\left[-(z/a)^2\right]$, with $a = 2\sqrt{Dt}$, is a solution to Fick's second law of diffusion, $\frac{dc(z,t)}{dt} = D\frac{d^2c(z,t)}{dz^2}$.
2. Calculate the diffusion length for boron in an undoped Si crystal for 30 min at 900ºC.

3. a) What is the intrinsic carrier concentration in Si at 1000 K?
   b) Calculate the effective diffusivity (including first-order, charged-vacancy corrections) for boron impurities in Si at 1000 K for two cases: i) $c_B = 1 \times 10^{18}$ cm^{-3} and ii) $c_B = 2 \times 10^{18}$ cm^{-3}. (Use Table 7.5 in Plummer.)
   c) What is the diffusion length in each case for $t = 1$ hr.

4. You start with a uniformly doped ($N_D = 10^{15}$ cm^{-3}), *n*-type silicon wafer. Then it is exposed to a boron-containing gas at 1200ºC (B concentration is equal to its solubility limit; see class notes, Diffusion slide 3). This process takes 18 min, then the gas is flushed from the reactor.
   a) What is the surface dose, Q, of boron?
   After the deposition, a "drive-in" anneal was made at 1200ºC.
   b) For how long must the "drive-in" anneal be carried out to put the *n*-*p* junction 0.4 microns beneath the surface? (Here you have to make an approximation about the role of t).

Ion implantation: Read Plummer Chap. 8, sections 8.1-8.4, and 8.5.1-8.5.6, Campbell 5.1-5.6

4. A 40-keV implant of B is done into bare, undoped silicon. The dose is 10^{12} cm^{-2}.
   a) What is the depth of the *peak* of the implanted profile?
   b) What is the concentration at this depth?
   c) What is the concentration at a depth of 3,000 Å (0.3 μm)

5. A particular silicon device needs to have an implant of boron with a peak at a depth of 0.2 μm (2,000 Å) and a peak concentration of 10^{17} cm^{-3}. Determine the implant energy and dose that should be used for this process. Find the as-implanted junction depth if the substrate is *n*-type with a concentration of 10^{15} cm^{-3}.