EE486 Integrated Circuit Fabrication

Spring 2017

Homework 5

Due in class on <u>Monday</u>, May 15, 2017

1. Consider the implantation of As into silicon at an energy of 20 keV. Assume that the implant is Gaussian with R_p = 16 nm and σ = 8 nm independent of dose (negligible channeling). Assume that stopping is dominated by nuclear collisions and the damage associated with each implanted atom is centered near that atoms final location (damage is actually skewed towards the surface). Use the Kinchin-Pease formula ($N = E_n/2E_d$) with E_d = 18 eV and assume that the threshold for amorphization is 10% (5×10^{21} cm^{-3}).
   (a) What is the minimum dose to start getting amorphization at the implant peak?
   (b) What is the minimum dose to get a continuous amorphous layer all the way to the surface? How would this answer change if we used the true energy deposition profile (skewed towards surface)?
   (c) How does the net excess interstitial concentration below the amorphous crystalline interface scale with dose (increase, decrease, no change)? Explain. Assume the +1 net damage model.
2. Consider a 40 keV boron threshold adjust implant of $2\text{x}10^{14}$ cm^{-2} annealed at 750˚C in a furnace or at 1000˚C in an RTA.
   (a) How long will it take to remove the implant damage at the two different temperatures? Use interstitial solubility plot/equation from the text.
   (b) Calculate the additional Dt due to TED at each temperature.
   (c) What would be the final junction depths for a uniform well doping of $2\text{x}10^{17}$ cm^{-3}.
3. Use Sentaurus to simulate the implant and anneal conditions of Problem 2. Compare the simulation results to your calculations and comment on the similarities/differences.
4. (a). Plot the deposition rate (on a log scale) versus 1/T (Kelvin), for 600-1200°C, for a CVD system with the following parameter values:

   h_G = 0.2 cm sec^{-1}

   k_S = $2\text{x}10^6$ exp(-1.5 eV/kT) cm sec^{-1}

   Partial pressure of incorporating species = 1 Torr

   Total pressure = 1 atm

   C_T/n=1/10,000

   Identify the reaction and mass transfer limited regimes.

   (b). Redo the problem when the total pressure is decreased to 1 Torr, so that h_G increases by 100 times. Assume that the partial pressure of the incorporating species remains the same, and C_T decreases by the same factor as the total pressure. (Since both the total pressure and the partial pressure of the incorporating species equal 1 Torr, this means that the gas is made up of only the incorporating species in this case.)
5. The new deposition engineer installed the company's new evaporation system. Hoping to get uniform depositions on all the wafers mounted on the inside of the spherical wafer holder, he installed the evaporation source crucible at the center of the sphere. If the evaporation source behaves like an ideal small area planar source, what will be the deposition rate as a function of θ, as defined below? (let the evaporation rate equal $2\text{x}10^{-3}$ gm sec^{-1}, radius r_o equal 15 cm, and the density of the material being deposited equal 10 gm cm^{-3}). Sketch a plot of d versus θ for θ from -90° to +90°, and specify the deposition rate at a point directly facing the planar source (at θ = 0°) and at θ = 90°. Will uniform deposition result?