EE486 Integrated Circuit Fabrication
Spring 2017

Homework 2
Due in class on Monday, April 17, 2017.

1. Based on the values in table on page 18 of Diffusion notes, plot on log-log scales the equilibrium diffusivity at 1000° C of As, B, Sb and P versus absolute value of net doping concentration. Use two separate plots, one for *n*-type $(N_d^+ - N_a^- > 0)$ and another for *p*-type $(N_d^+ - N_a^- < 0)$ material. Include the equations you are plotting.

2. An arsenic diffusion is performed in silicon such that the maximum arsenic concentration is 10^{19} cm^{-3}. For what range of diffusion temperatures will electric field effects and concentration dependent diffusion coefficients be important?

3. Design a boron predep at 900°C and drive-in at 1000°C (with source removed) to achieve a dose of 2x10^{14} cm^{-2} based on:

   (a) Simple Gaussian expressions and fixed D (intrinsic value).

   (b) Simple Gaussian expressions and fixed D (extrinsic value equal to peak doping at end of process).

   (c) Sentaurus simulation.

   Comment on similarities and differences between results and the shape of the simulated diffusion profile compared to a Gaussian.

4. At concentrations below the chemical solubility, As deactivates due to formation of As_4V clusters via the reaction $4As+V \Leftrightarrow As_4V$. At 1000 C, 10% of As is inactive when the total As concentration is 2x10^{20} cm^{-3}. The chemical solubility is 2x10^{21} cm^{-3}.

   (a) Plot the active doping concentration versus the total doping concentration.

   (b) What is the stable peak electron concentration achievable at this temperature with As doping?

2. Sentaurus includes several options for the diffusion models to be used. The "Fermi" model includes electric field effects and the dependence of diffusivity on the carrier concentration, but not the coupling of dopant diffusion to point defect concentrations which leads to the phosphorus "kink and tail" (and similar effects for B). These are included in the "Pair" model. Using a fixed surface P concentration of 3x10^{20} cm^{-3}, run a simulation of 60 minute diffusion at 900 C using the "Fermi" and "Pair" models. Plot the doping profiles and unpaired interstitial ("Int") profiles for the two cases using a log scale for concentration. Comment on the features and differences in the doping profiles.