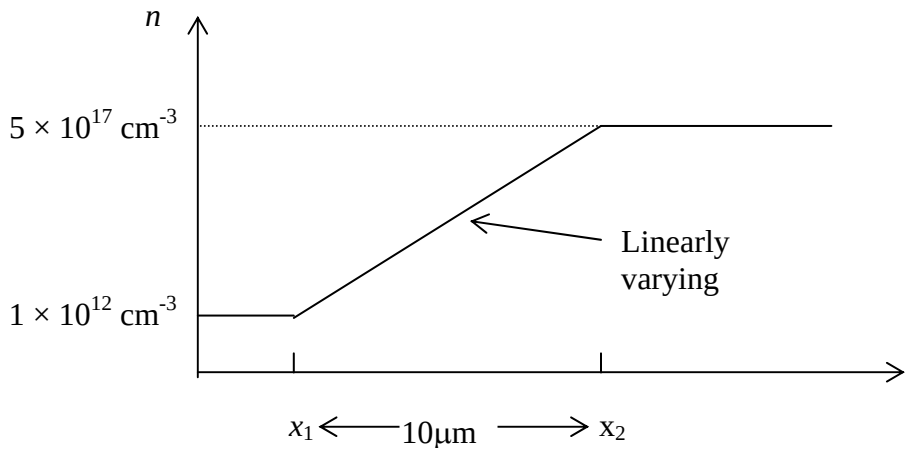
ECSE-2210 Microelectronics Technology
Fall 2005 Homework 3

Reading Assignment: Pages 74-104

1. A silicon sample maintained at 300 K under thermal equilibrium has a non-uniform doping concentration profile, such that the electron concentration, n, varies linearly from 1×10^{12} cm^{-3} to 5×10^{17} cm^{-3} while going from point x_1 to point x_2 (see figure below). Assume that the mobility is constant at 1000 cm^2/Vs throughout the sample. Answer the following.



   (a) Calculate the diffusion coefficient, D_n (in cm^2/s) for the electrons.
   (b) Explain why the electrons do not diffuse everywhere such that the concentration is uniform throughout.
   (c) Plot the diffusion current density (A/cm^2) for the electrons as a function of x. Mark the numerical value on the graph. (Hint: What is the equation for diffusion current density?)
   (d) Plot the drift current density for electrons as a function of x (Hint: What should be the total current? Then, obtain answer to this from part c).
   (e) Plot the energy band diagram as a function of x. (Hint: Plot the band diagram for $x < x_1$ and for $x > x_2$ and then plot qualitatively between x_1 and x_2).
   (f) What is the potential difference (give a numerical value) between the two ends of the sample? (Hint: Read it off from the band diagram!)
   (g) Plot a graph of the electric field versus x. (Hint: You can get this from part d and from the equation for the electron drift current density).

2. A 5-Ω resistor is to be made from a bar-shaped piece of n-type Si. The bar has a cross-sectional area of 10^{-2} cm^2. The silicon is doped with $N_D = 5 \times 10^{17}$cm^{-3} and $N_A = 4 \times 10^{17}$ cm^{-3}. Determine the length of the silicon bar.