Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.012
Microelectronic Devices and Circuits
Spring 2007
February 14, 2007 - Homework #1
Due - February 21, 2007

Problem 1

A piece of silicon is doped with $N_a = 2x10^{15}$ cm^{-3} and $N_d = 1x10^{15}$ cm^{-3}

a) What is the majority carrier? Is the silicon type n or type p?
b) Find the electron and hole concentration and mobility at room temperature.
c) We want increase the electron concentration to $1x10^{17}$ cm^{-3}. What is the additional dopant type and concentration? What is the new electron mobility?

Problem 2

A piece of silicon is doped with $N_d = 1x10^{15}$ cm^{-3}. Below is a table for the intrinsic electron concentration for three different temperatures.

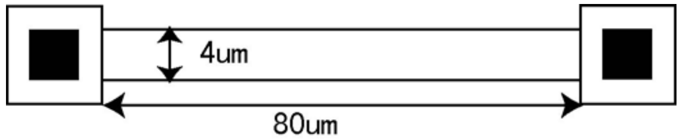
n_i	Temperature
$1x10^{10}$ cm^{-3}	300 K (room temp.)
$1x10^{15}$ cm^{-3}	600 K
$1x10^{17}$ cm^{-3}	1150 K

Calculate the total hole and electron concentration for all three temperatures.

Problem 3

Given a uniformly n-type ion-implanted layer with thickness t = 1 um and doping concentration $N_d = 10^{17}$ cm^{-3}.

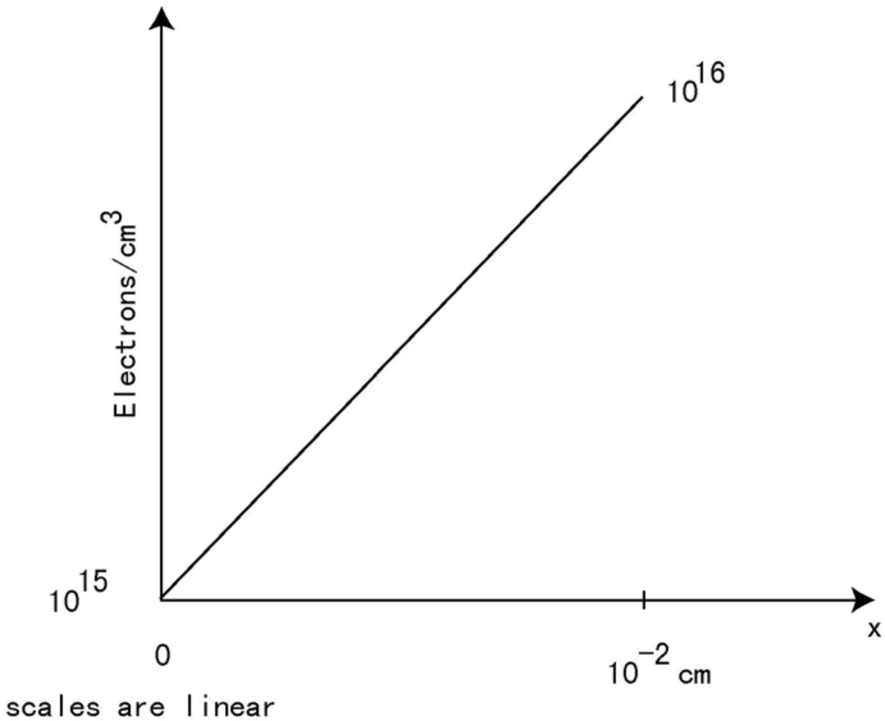
a) What is the sheet resistance?
b) What is the resistance of the layout shown below? Assume that the contacts each contribute .65 squares.



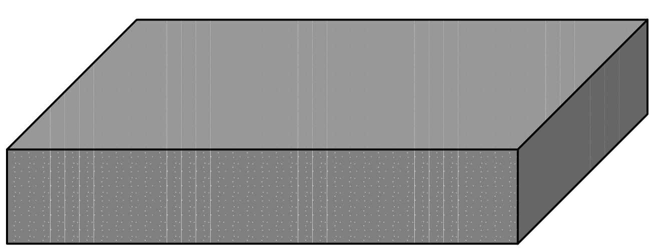
c) By adding additional dopants, we make a new n-type ion-implanted resistor with an average doping concentration $N_{d1} = 2x10^{17}$ cm^{-3} over the depth 0 < d < 0.5 μm and $N_{d2} = 10^{17}$ cm^{-3} over the depth 0.5 μm < d < 1 μm. Find the new sheet resistance.

Problem 4

A slab of silicon has the following electron distribution.



a) Assume thermal equilibrium. Plot the potential ϕ as a function of x.
b) What is the electron diffusion current density? Hole diffusion current density? Assume $D_n = 2 \times D_p = 26\ \text{cm}^2/\text{s}$
c) The hole and electron diffusion current densities do not sum to zero; however, the silicon cannot have a net current since it is an open circuit. Explain what is happening.



Silicon Slab