Ain Shams University
Faculty of Engineering

ECE335: Electronic Engineering

Sheet 1
Semiconductor Review

T=300	**Si**	**Ge**	**GaAs**
n_i (cm^{-3})	1.45×10^{10}	2.4×10^{13}	1.8×10^{6}
μ_n (cm^2/Vs)	1500	3900	8500
μ_p (cm^2/Vs)	450	1900	400

Problem 1

a) Explain qualitatively the differences in intrinsic carrier concentrations (n_i) for Ge, Si and GaAs. (Why is n_i highest for Ge? Why is it lowest for GaAs?)

b) Explain qualitatively why n_i increases with increasing temperature.

Problem 2

Consider a Si sample under equilibrium conditions, doped with Boron to a concentration 10^{17} cm^{-3}.

a) At T = 300K, is this material n-type or p-type?

b) What are the majority and minority carrier concentrations?

Problem 3

Consider a Si sample maintained at T = 300K under equilibrium conditions, doped with Boron to a concentration 2×10^{16} cm^{-3} :

a) What are the electron and hole concentrations (n and p) in this sample? Is it n-type or p-type?

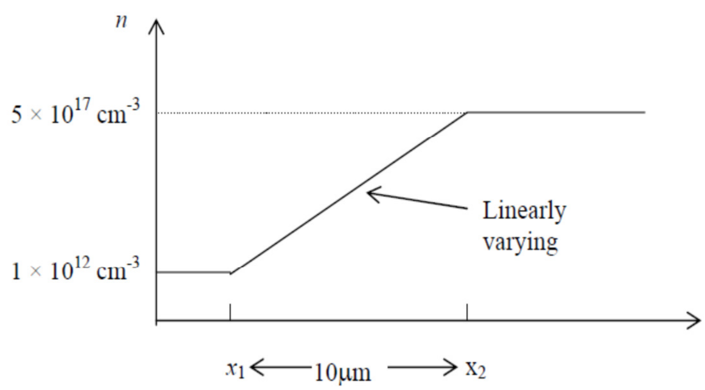
b) Suppose the sample is doped additionally with Phosphorus to a concentration 6×10^{16} cm^{-3}. Is the material now n-type or p-type? What is the resistivity of this sample?

Problem 4

Ultra-thin semiconductor materials are of interest for future nanometer-scale transistors, but can present undesirably high resistance to current flow. How low must the resistivity of a semiconductor material be, to ensure that the resistance of a 2nm-thick, 10nm-long, 100nm-wide region does not exceed 100 ohms? If this material is n-type Si, estimate the dopant concentration that would be needed to achieve this resistivity.

Problem 5

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. Assume that the mobility is constant at 1000 cm^2/Vs throughout the sample.



a) Calculate the diffusion coefficient, D_n (in cm^2/s) for the electrons

b) 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?)