I. PROBLEM SESSION 10

A. Problem 10.1

- How energy bands are filled with electrons? What is the difference between metal, semi-metal, semiconductor and insulator in terms of band structure and electron filling?
-Describe the meaning of the effective mass concept. Why the effective mass is different from that of the electron rest mass? Can the effective mass be negative? What does it mean?
-Recall the concept of holes in a semiconductor. Compare the properties of holes and electrons.
-Describe the concept of impurity doping of a semiconductor. How do different forms of doping alter the electronic properties of semiconductors? What is the role of temperature?
-How might phonon interactions affect the conduction properties of semiconductors?

B. Problem 10.2

Si is doped with $1 * 10^{15}$ donors/cm^3 having ionization energy of 45 meV. Estimate the concentration of free electrons in the conduction band (n) at 4, 77, 300, 600 K. Assume the effective density of states in the conduction band $N_c = 3 * 10^{19} cm^3$ and th band gap $E_g = 1.12$ eV are independent of temperature (to be more precise these are actually room temperature values, please make an argument that assuming no temperature dependence in N_c/E_g we still may do a reasonable approximation of n(T)). Calculate free electrons concentrations in undoped Si at the same temperatures/conditions. Compare electron concentrations in undoped and doped materials and illustrate similarities/differences using n versus $1/T$ plot.

C. Problem 10.3

Space charge distribution in p-n junctions: Consider a silicon-based junction as shown schematically in a fig.1 below. Derive and sketch charge density, electric field, and potential within the space charge region W of the junction. Assume

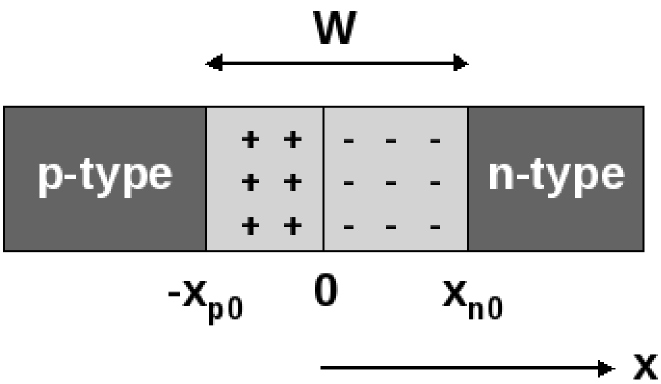

Figure 1: A p-n junction

donor and acceptor concentrations of $1 * 10^{16}$ and $4 * 10^{17} cm^{-3}$ in the n- and p-type sides of the junction. Assume the contact area A of $2 * 10^3 cm^{-2}$ and room temperature operation (i.e the intrinsic carrier concentration is $10^{10} cm^{-3}$). Calculate: a) The in-build potential b) The depth of the space charge region as well as x_{p0} and x_{n0} c) The charge associated with x_{p0} and x_{n0} d) The maximum amount (in terms of its absolute value) of the field

D. Problem 10.4

Forward and reverse bias: Sketch the changes happening in a p-n junction when forward or reverse bias is applied. Derive, sketch, and analyse the junction equation. Explain the junction equation in terms of carrier injection and diffusion.