ECE609 Spring06

HOMEWORK 3

Review: Physics of semiconductors

1 Semiconductors Fundamentals (25pts)

A silicon sample contains an acceptor of $N_A = 10^{16} cm^{-3}$.

1. Determine the concentration of donor atoms that must be added so that the Silicon is N-type and the Fermi energy is $0.2eV$ below the conduction band edge. Assume complete ionization, temperature $T = 300K$, $2.8 * 10^{-19} cm^{-3}$ for the effective DOS for the electrons, and $ni = 1.5 * 10^{10} cm^{-3}$.
2. If the donor in-band energy level is $0.15eV$ below the conduction band, what fraction of the donor atoms are ionized ?
3. From questions 1 and 2, what concentration of donor atoms must then be added ?
4. What concentration of donor atoms should be added at $T = 400K$ (we note $Eg = 1.11eV$) ?

2 Theory of Electrical Conduction (15pts)

1. Electrons in undoped gallium arsenide have a mobility of $8,800 cm^2/V.s$. Calculate the average time in picosecond between collisions (we will use $0.067m_0$ for the effective mass of the electrons). Calculate the distance traveled between two collisions in nanometer (also called the mean free path). Use an average velocity of $10^7 cm/s$.
2. A piece of silicon is doped with arsenic ($N_d = 10^{17} cm^{-3}$). Calculate the resistivity of this N-type semiconductor (we consider $727 cm^2/V.s$ for the mobility).
3. The hole density in an N-type silicon wafer ($N_d = 10^{17} cm^{-3}$) decreases linearly from $10^{14} cm^{-3}$ to $10^{13} cm^{-3}$ between $x = 0$ and $x = 1\mu m$. Calculate the hole diffusion current density at $T = 300K$ (the hole mobility is equal to $317 cm^2/V.s$).

3 Summary of Chapter I- (60pt)

Using your own words, write a report (summary) of the chapter I: Physics of semiconductors. You will not use more than 4 pages, the use of a computer is recommended (11pt at least) but it is not a requirement. This report has to be clear, well illustrated with the essential equations, concepts and physics explanations, be creative... A ECE student with no knowledge in the field, should be able to understand your report. A ECE student with background in the field, should be able to use only this report as support for an exam.