EE566 Solid State Devices

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Dept of Electrical Engineering
University of Notre Dame
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Assignment 1
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Due: 01/27/2006

Reading
Chapter 2 of Textbook & Appendix on "Electric Fields… Gauss's Law" handed out in the class.
For material constants & parameters not available in text go to - http://www.ioffe.rssi.ru/SVA/NSM/.

Problem 1*

Briefly describe in your own words (& sketches) the basic differences between metals, semiconductors, and insulators – the three component materials of any solid-state device. For each type of material, you should touch upon

a) Bandstructure, Fermi Level, Carrier concentration
b) Conductivity/Resistivity
c) Dielectric constant
d) Methods of growth/deposition used to create each of the materials.

Problem 2

Magnesium is a relatively "deep acceptor" in the wide bandgap semiconductor GaN. The acceptor ionization energy is E_A~160meV. Consider a GaN sample doped with $N_A=10^{19}/cm^3$ of Magnesium atoms. In the process of doping this sample with Magnesium, unintentional donors of density $N_D=10^{16}/cm^3$ (E_D=10meV) also incorporate into the semiconductor.

a) Find the Fermi level in the semiconductor at T=300K.
b) For T=300K, Plot n, p, N_A^-, N_D^+, $n+N_A^-$, and $p+N_D^+$ as a function of the Fermi level E_F. Remember the Fermi level can be within the gap or in the conduction or valence bands. Therefore choose values of E_F from below E_V to above E_C. Indicate in the plot where the real Fermi level at 300K is. Explain.
c) Indicate the donor and acceptor ionization energies in your figure.
d) What are the densities and types of mobile carriers in the sample at 300K? Is the sample n- or p-type?

Problem 3

Solve Problem 2.16 from the textbook.

Problem 4

Solve Problem A1.2 from the handout on Electric Fields and Gauss's Law. (Appendix from Muller/Kamins/Chan).

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* Remember to use proper units and label every figure/plot. Turn in your answers worked out neatly. Please attach this question sheet to your solution when you turn it in.