EE566 Solid State Devices

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Dept of Electrical Engineering
University of Notre Dame
Instructor: Debdeep Jena (djena@nd.edu, x8835)

Assignment 1
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Reading: Chapters 1-3 from the textbook Mishra & Singh, (shortened to **MS**) for later assignments. This constitutes a review of the semiconductor physics necessary for studying solid state devices. For material constants not listed in this book, go to - http://www.ioffe.rssi.ru/SVA/NSM/.

Problem 1[*]
Explain, with the help of relevant sketches, the difference between a direct (D) and indirect (I) bandgap semiconductor. Compare, with physical reasoning, the following properties for D & I semiconductors:

a) Valley degeneracy & Conduction band Density of States (DOS)
b) Electron effective masses
c) Electron mobilities
d) Optical absorption coefficients & Luminescence properties
e) Minority carrier lifetimes

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 (MS).

Problem 4
Solve Problem A1.4 from the handout called "2-Dimensional Electrostatics" from MKC. (Reading the Appendix in the handout will help!)

In general, I suggest you look through the chapter-end problems of **MS** (chp 1 - 3) and make sure that you are comfortable with them (i.e., you can answer them if you have to!).

[*] 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.