
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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Due: 01/26/2007

Reading

Chapter 1 of the Textbook (Muller/Kamins/Chan: MKC) & the Appendix of Chapter 1 on “Electric Fields... Gauss’s Law”.

For material constants & parameters not available in text go to - <http://www.ioffe.rssi.ru/SVA/NSM/>.

Problem 1*

Sketch the following

- Bandstructure (Energy E vs. Momenta k), with the typical *shallow* Donor and Acceptor energy levels (E_D and E_A),
- Density of states ($g(E)$ vs E) including donors and acceptors, and
- Carrier concentration for Fermi level at mid-gap and $T \sim 300K$

for

- a direct bandgap semiconductor (e.g. GaAs), and
- an indirect bandgap semiconductor (e.g. Si).

Depict the filled states by shading. Explain from your sketch why direct bandgap semiconductors are efficient light emitters whereas indirect bandgap semiconductors are not.

Problem 2

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

- Find the Fermi level in the semiconductor at $T = 300K$.
- 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.
- Indicate the donor and acceptor ionization energies in your figure.
- 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 1.16 from MKC.

Problem 4

Solve Problem A1.4 (not 1.4!) from MKC. (Reading the Appendix of Chapter 1 will help!)

* 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.