Electronic Properties in Solids (Midterm Examination 2):

November 19, 2010

Name: _____ Student ID: _____

1. Consider a semiconductor with a band gap of 2.0 eV, and m_e^*=0.2m, m_h^*=0.5m. Also, be aware that the electron concentration (n) and hole concentration (p) is expressed as follow.

$$n = 2\left(\frac{2\pi m_e^* kT}{h^2}\right)^{3/2} \exp\left(-\left(\frac{E_C - E_F}{kT}\right)\right)$$

$$p = 2\left(\frac{2\pi m_h^* kT}{h^2}\right)^{3/2} \exp\left(-\left(\frac{E_F - E_V}{kT}\right)\right)$$

where, m=0.91x10^{-27}g, k=1.38x10^{-16}, h=6.63x10^{-27}. (50 points)

(a) As you noticed, there are 2 in the equation. Explain why? (5 points)

(b) In the problem, the effective mass of electron is smaller than the effective mass of hole. Is this generally true? If yes, why it is? (5 points)

(c) Calculate the Fermi energy level for the intrinsic semiconductor and the concentration of electrons and holes in the conduction and valence band, respectively. (10 points)

(d) If the semiconductor is doped with n-type elements with the concentration of 10^{17}cm^{-3}. The dopant energy level is too shallow that all the dopants are assumed to be totally activated. Calculate the Fermi energy level. (10 points)

(e) If the semiconductor is doped with p-type elements with the concentration of 10^{16}cm^{-3}. The dopant energy level is too shallow that all the dopants are assumed to be totally activated. Calculate the Fermi energy level. (10 points)

(f) If the semiconductor is doped with n-type elements with the concentration of 10^{17} cm^{-3} and p-type elements with the concentration of 10^{16}cm^{-3} at the same time. Both of the dopant energy level is too shallow that all the dopants are assumed to be totally activated. Calculate the Fermi energy level. (10 points)

2. I did spend some time to explain the formation of metal contact on semiconductor in the aspect of forming Schottly contact and Ohmic contact. Draw the band diagram for each of these contacts depending on the workfunction difference and the major carrier type of semiconductor and how each of them shows Ohmic and Schottly contact. Also explain, in practice, how you can form an Ohmic contact to the semiconductor and how it is working. (40 points)

3. Draw the band diagram of p-n diode and show what kinds of electrical properties it

shows, namely, the rectifying diode behavior. (You have to show for the case of forward bias and reverse bias applied.) Also explain how this diode works for solar cell device and LED (Light emitting diode) device. (20 points)

4. Explain the followings as detail as possible. (50 points)

   (a) Hall Effect
   (b) N-p-n bipolar transistor and its operating mechanism
   (c) Enhancement (normally-off) type n-channel MOSFET
   (d) DRAM operating principle
   (e) Dielectric Displacement (D) with respect to polarization of a material.