UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Electrical and Computer Engineering

Homework 1 – due October 19, 2018 by 5:00pm

1. Calculate the approximate donor binding energy for GaAs ($\epsilon_r = 13.2, m_n^* = 0.067m_0$).

2. An unknown semiconductor has $E_g = 1.1\ eV$ and $N_c = N_v$. It is doped with 10^{15} cm^{-3} donors, where the donor level is $0.2\ eV$ below E_c. Given that E_F is $0.25\ eV$ below E_c, calculate n_i and the concentration of electrons and holes in the semiconductor at 300 K.

3. Calculate the bandgap of Si from $n_i = \sqrt{N_c N_v}e^{-E_g/2kT}$ and from the plot of n_i vs. $1000/T$ (see Fig. 3-17 in Streetman). [*Hint*: The slope cannot be measured directly from a semilogarithmic plot; read the values from two points on the plot and take the natural logarithm as needed for the solution.]

4. (a) Show that the minimum conductivity of a semiconductor sample occurs when $n_0 = n_i\sqrt{\mu_p/\mu_n}$. [*Hint*: Begin with $J_x = q(n\mu_n + p\mu_p)\mathcal{E}_x = \sigma\mathcal{E}_x$, and apply $n_0 p_0 = n_i^2$.

   (b) What is the expression for the minimum conductivity σ_{min}?

   (c) Calculate σ_{min} for Si at 300 K and compare with the intrinsic conductivity.

5. (a) A silicon sample is doped with 3×10^{16} cm^{-3} boron atoms and a certain number of shallow donors. The Fermi level is 0.38 eV above E_i at 300 K. What is the donor concentration N_d?

   (b) A silicon sample contains 10^{16} cm^{-3} Indium (In) acceptor atoms and a certain number of shallow donors. The In acceptor level is 0.16 eV above E_v, and E_F is 0.26 eV above E_v at 300K. How many (cm^{-3}) In atoms are un-ionized (i.e., neutral)?

6. Reading Assignment: *Streetman*: Ch. 1 (sections 1.1 and 1.2), Ch. 2 (sections 2.1-2.3), Ch. 3 (all)