ECSE-2210 Microelectronics Technology
Homework 1

Reading Assignment: Pages 3-40 except section 1.2.4. Late submissions will be penalized. Hand in your solutions during the class.

1. Problem 1.13 in text. Treating atoms as rigid spheres with radii equal to one-half the distance between nearest neighbors, find the ratio of the volume occupied by the atoms to the total available volume in the various crystal structures: (a) simple-cubic (b) body-centered cubic (c) face-centered cubic (d) diamond lattice.

2. The lattice constant of GaAs at 300 K is 5.65 Å. Determine the number of Ga atoms/cm^3 and the number or As atoms/cm^3. Calculate the mass density of GaAs. The molar weights of Ga and As are 69.7 g and 74.9 g, respectively. Avogadro's number is 6.02×10^{23} atoms (or molecules)/mole.

3. In class (see class notes), we have calculated the energy required to remove the electron from the ground state of hydrogen atom to be 13.5 eV. Supposing the H atom is inside a Si crystal, estimate the energy required to free up the electron from the hydrogen atom. Assume that the relative dielectric constant of Si is 11.8 and the effective mass of the electron in Si is 1.1 m_o. This gives you an idea of the approximate ionization energy of donors in Si.

4. The bonding model for a semiconductor is explained in Figs 2.3 and 2.4 in the textbook.
   a. Draw the bonding model for GaAs depicting the removal of one Ga and one As atom.
   b. Redraw the bonding model showing the insertion of Si atoms into the missing Ga and As sites.
   c. Is the GaAs p- or n-type when Si atoms replace Ga atoms? Explain.
   d. Is the GaAs p- or n-type when Si atoms replace As atoms? Explain.
   e. Suppose it takes an energy amount equal to 1.43 eV to break one of those bonds shown in the figure, draw the band model for GaAs.
   f. Draw the band model for GaAs when GaAs is doped with Si on (i) Ga sites and (ii) on As sites. Assume typical values for the ionization energy.