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Microelectronics HW1

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

r = a/2
Ratio = 4/3 pi r^3 / a^3
Ratio = 0.523598775598

    b) body-centered cubic

r = sqrt((a/2)^2*3) /2
Ratio = 2* 4/3 pi r^3 / a^3
Ratio = 0.680174761588

    c) face-centered cubic

r = sqrt(a/2)^2*2) /2
Ratio = 4* 4/3 pi r^3 / a^3
Ratio = 0.740480489693

    d) diamond lattice.

r = sqrt(a/4)^2*3) /2
Ratio = 8* 4/3 pi r^3 / a^3
Ratio = 0.340087380794

2) The lattice constant of GaAs at 300 K is 5.65 Å. Determine the number of Ga atoms/cm3 and the number of As atoms/cm3. 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.

Atoms/cm^3 = 8/((5.65x10^-8)^3) = 4.4355210386×10^22
Ga atoms/cm3=As atoms/cm3=2.2177605193×10^22
Mass of Ga = 2.56773933878g
Mass of As = 2.7593066926g

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 mo. This gives you an idea of the approximate ionization energy of donors in Si.

13.6eV
$K_{S,\ Si}$ = 11.8
m_n/m_0 = 1.1
13.6*1.1/(11.8^2)=0.107eV