Tutorial questions – 01

ESP5403 Nanomaterial for Energy Systems

22/08/2021

1. Determine the temperature at which an energy level which is 0.3 eV below Fermi energy is 2% unoccupied by an electron.

2. The value of p_o in Si at T = 300 *K* is 10^{15} cm^{-3}. Determine the following:
   (i) The position of Fermi energy below conduction band edge, and
   (ii) Equilibrium concentration of electrons

   Note that for Si at 300 *K*, N_V= 1.04×10^{19} cm^{-3} and N_C = 2.8×10^{19} cm^{-3}.

   Assume E_g of Si is 1.12eV.

3. A semiconductor has N_C = 10^{19} cm^{-3}, N_v = 5 x 10^{18} cm^{-3} and E_g = 2 eV doped with 10^{17} cm^{-3} donors (fully ionized)
   (a) Calculate the intrinsic, electron and hole concentrations at 627^{o}C
   (b) Where is E_F located relative to E_i?
   (c) Sketch the simplified band diagram, showing the position of E_F (assume the E_i is nearly at the midgap).

4. The Ge is now doped with Boron and with Phosphorous. Both dopants have the same concentration. Assume the Boron and Phosphorous energy levels are each 40 *meV* from the band edge. If m_n^*/m_p^* = 0.01, draw the band diagram of the doped Ge as accurately as you can, showing E_g , E_f and E_i . Assume E_g of Ge is 0.67eV.

5. Consider a GaAs semiconductor illuminated with photons of energy 1.65 eV.
   The absorption coefficient at 1.65 eV is 10^4 cm^{-1}.
   (a) Determine the thickness of the material so that 75% of the energy is absorbed.
   (b) Determine the thickness so that 75% of the energy is transmitted.

6. The optical properties of silicon measured at 300K are given below:

Wavelength (*nm*)	Absorption coefficient (cm^{-1})	Refractive index	Extinction coefficient
400	1×10^4	5.59	0.3
700	1.90×10^3	3.77	0.01

Two monochromatic light sources at 400 *nm* and 700 *nm* are available to illuminate a silicon solar cell of 1 μm thick. Recommend the most suitable source for illumination. Assume that the light incidents normally on the front surface of the solar cell with an intensity of 10 W/cm^2.