

ME4252 Nanomaterial for Energy Engineering

Tutorial questions – 01

26/08/2022

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_0 in Si at $T = 300\text{ K}$ is 10^{15} cm^{-3} . Determine the following:
 - (i) The position of Fermi energy below conduction band edge, and
 - (ii) Equilibrium concentration of electronsNote that for Si at 300 K, $N_V = 1.04 \times 10^{19}\text{ cm}^{-3}$ and $N_C = 2.8 \times 10^{19}\text{ cm}^{-3}$. Assume E_g of Si is 1.12 eV.
3. A semiconductor has $N_C = 10^{19}\text{ cm}^{-3}$, $N_V = 5 \times 10^{18}\text{ cm}^{-3}$ and $E_g = 2\text{ eV}$ doped with 10^{17} cm^{-3} donors (fully ionized)
 - (a) Calculate the intrinsic, electron and hole concentrations at 627°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 0.67 eV.

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})	Refraction coefficient R
400	1×10^4	0.49
700	1.90×10^3	0.34

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/cm².