Indian Institute of Information Technology, Allahabad

Assignment (Solid State Physics): Engineering Physics

---

1. Find the probabilities for an electron state to be occupied at 20 °C, if the energies of these states lie 0.11 eV above and 0.11 eV below the Fermi level, respectively.

2. A uniform silver wire has a resistivity of 1.54×10^{-8} Ω m at room temperature. For an electric field of 1 V cm^{-1}, compute the mobility and average drift velocity for the electron assuming that the number of conducting electrons is 5.8×10^{28} m^{-3}. Further, calculate the relaxation time of the electrons.

3. Show that for an n-type semiconductor, the electron density is $n \approx N_D$ and the hole density is $p \approx n_i^2/N_D$, where the symbols have their usual meanings. Now consider a germanium sample which has an intrinsic carrier concentration of 2.4×10^{19} m^{-3} at room temperature. It is then doped with antimony (Sb) at the rate of one atom per 10^6 germanium atoms. If the density of Ge atoms is 4×10^{28} m^{-3}, determine the hole density. If the electron mobility is 0.35 m^2 V^{-1} s^{-1}, find the electron conductivity of the semiconductor.

4. Compare the energy density of charge carriers in a pure silicon crystal with an energy gap of 1.1 eV at temperatures 27 °C and 57 °C.

5. In a p-type semiconductor, the Fermi level lies 0.4 eV above the valence band. If the concentration of the acceptor atom is tripled, determine the new position of the Fermi level. It is given that kT =0.03 eV.

6. The intrinsic carrier concentration in germanium sample is 2.4×10^{19} m^{-3} and the mobilities of electrons and holes are 0.39 and 0.19 m^2 V^{-1} s^{-1}, respectively. If the sample has the area of 1 cm^2 and thickness 0.3 mm, and a potential difference of 2 V is applied across the face, determine the current produced in the sample.

7. The density of intrinsic charge carriers at room temperature in silicon is $1.5 \times 10^{16}\ m^{-3}$ and the mobilities of electrons and holes are 0.13 and 0.05 $m^2\ V^{-1}\ s^{-1}$, respectively. Determine the intrinsic conductivity in silicon. Now suppose a Group V impurity is added to the extent of 1 impurity atom per 10^8 silicon atoms, determine its extrinsic conductivity.

8. Consider an intrinsic semiconductor whose charge carrier concentration at 27 °C is $2.29 \times 10^{18}\ m^{-3}$. If the effective mass of the electron is 0.07 m and that of a hole is 0.4 m, determine the energy gap of the semiconductor. Sketch how to obtain the working formula required to solve this numerical.