Indian Institute of Technology, Delhi

Fundamentals of Dielectrics and Semiconductors (PYL201)

Minor 2

Max. marks 20

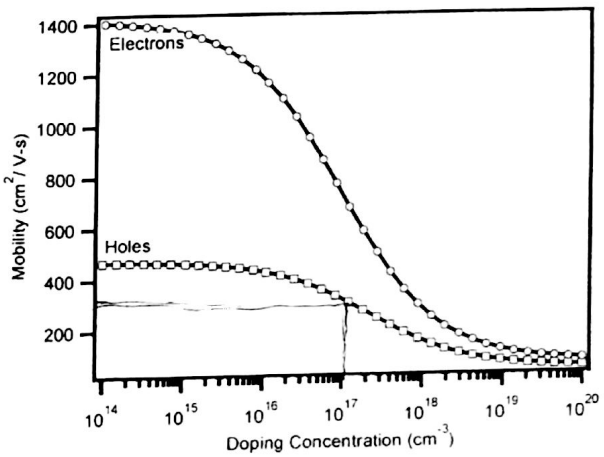
1. (a) Define excitons and categorise Mott and Frankel excitons (with at least 5 important points with possible diagrams) (b) Estimate the first and second order exciton peaks in a pure GaAs semiconductor♣. .... 4 marks

2. Prove that the cross-over energy between Urbach tail and direct band absorption edge is temperature sensitive. ♣ Why this is not true in indirect bandgap materials? .....3 marks

3. Explain, with the help of schematic representations, variation of carrier drift velocity in typical semiconductors under the influence of electric field. Specify various regions of interest. ... 4 marks

4. *Short Answers only*

   (a) In a compensated n-type silicon, the conductivity is 16 $(\Omega\text{-cm})^{-1}$ at room temperature. If the acceptor concentration is $10^{17}cm^{-3}$, then estimate donor concentration and electron diffusion coefficient. If required, you may use the graph shown here.



   (b) GaAs and Si absorption coefficients close to the band edge are 10^4 and 10^3cm^{-1} respectively. Find the minimum thickness required to have 90% transmission from the respective samples.

   ..... 4 marks

5. In two (say A and B) atoms per basis primitive cell, briefly explain the phonon energy E-k diagram. (b) Explain various possible scattering mechanisms involved in the carrier mobility of a doped semiconductor in low (or zero) electric field region. . 5 marks

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♣ For GaAs : E_g=1.424V, m_h*=0.51m_0, m_e*=0.063m_0 ; static dielectric constant = 12.9); k_b= $8.617.10^{-5}$ eVK^{-1}., Electron rest mass m_0= $9.1\cdot10^{-31}$ kg, $\hbar = 1.05.10^{-34}$J-s
For Si,: n_i (at 300K) = $1.5x10^{10}cm^{-3}$; E_d (for P) =0.045eV; E_g=1.12eV; m_e* =1.08m_0; m_h* (valance)=0.55m_0