Indian Institute of Technology, Delhi
Fundamentals of Dielectrics and Semiconductors (PYL201)

Minor 2

Max. marks 20

1. (a) The phosphorous (donor) concentration in a region of a silicon crystal varies linearly from a concentration of 10^{14} cm^{-3} at $x = 0$ to a concentration of 10^{17} cm^{-3} at $x = 1$ mm. The diffusion constant for electrons is 22.5 cm^2/s, the diffusion constant for holes is 5.2 cm^2/s, and the temperature is 300 K. What is the diffusion current density in the positive x-direction? ......3 marks

   (b) Plot (approximately) the current density versus electric field. How can the diffusion constant be determined from this plot? Why the graph is nonlinear after certain Electric field? ... 3 marks

2. A semiconductor has a band gap of 2 eV, an effective mass of 0.8 m_0, and a mobility of 700 cm^2/Vs. Use the condition above to estimate the electric field where impact ionization will take place. (The condition, $E_g = \frac{1}{2}m^*v_d^2$, can be used to estimate the critical field where impact ionization begins.)   ..3 marks

3. (a) Define what is 'exciton' and give a comparative description of 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

4. Give short description of major optical processes (absorption coefficient dependence with energy) in direct and indirect bandgap materials. Provide relevant expressions and diagrams)......3 marks

5. Compare the competition between rate constants of Radiative (band-to-band), nonradiative (defect level) and Auger recombination processes in direct and indirect bandgap semiconductors (with relevant expressions and diagrams) .. 4 marks