2022

PHYSICS

Paper : PHY 522

(Solid State Electronics)

Full Marks : 50

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***any five*** questions.

(a) Explain the temperature variation of conductivity of an extrinsic semiconductor with the necessary diagram. Derive the expression for Debye-Hückel screening length in such a semiconductor.

(b) Starting from the expression for conductivity tensor at low temperature, show that the Hall resistance in a two-dimensional system varies in the unit of (h/e^2) by changing magnetic field. Show that the filling factor of the Landau level can be expressed as the ratio of the total number of electrons (N) to the number of flux quantum (N_ϕ).

(c) State the characteristics of the edge states. (2+2)+(2+2)+2

(a) Explain ambipolar effect in a semiconductor with a suitable diagram. Starting from the equation of continuity of electrons and holes, determine the ambipolar diffusion coefficient and mobility for an intrinsic semiconductor.

(b) Define charge neutrality level in a semiconductor. Determine the expressions for the surface charge and the space charge for an n-type semiconductor in terms of the energy difference of the conduction band minimum and the Fermi level at the surface.

(c) How are the trap levels associated with the photoluminescence in a semiconductor?

(d) What are the limitations of Haynes-Shockley experiment? 3+(1+2)+2+2

(a) State the advantages of the ion implantation process over the diffusion process.

(b) Explain the steps in the two-step diffusion process. Derive the dopant concentration at the final stage in this process. Given : $\int_0^\infty erfc(x) = \frac{1}{\sqrt{\pi}}$.

(c) Explain the interface structures developed for lattice mismatch in epitaxial growth.

(d) How the epitaxial growth rate can be monitored by the dynamic RHEED method? 2+3+3+2

4. (a) Show that for one-dimensional conduction with two leads, the conductance is given by $G = \left(2e^2/h\right) Tr\left(t^{+}t\right)$, where t is the transmission amplitude matrix. Hence explain the conductance behaviour of a quantum point contact with gate voltage.

   (b) What is Quantum size effect? Bulk Gold has Fermi energy of 5.5 eV. Estimate the number of atoms at room temperature within the Gold cluster for which it behaves as an insulator.

   (c) State the advantages of electron beam lithography over photo-lithography. What is proximity effect? (3+2)+2+3

5. (a) Draw schematic diagram of an n-channel MOSFET with the relevant circuit diagram.

   (b) Derive an expression for the drain current in such an n-channel MOSFET when applied drain voltage is small. Hence find the expressions for drain conductance g_D and mutual conductance g_m. 3+7

6. What is memory interfacing? Design a 4KB RAM and specify its address range. Explain how the memory map can be changed by modifying the hardware of the chip select line. 10

7. (a) Draw the graphical representation of field dependent mobility for Silicon and write the corresponding empirical formula.

   (b) Six bytes of data are stored in memory locations starting at 8050H. Add all the data bytes. Use register B to save any carries generated, while adding the data bytes. Store the entire sum at two consecutive memory locations, 8070H and 8071H.
   Data (H) : A2, FA, DF, E5, 98, 8B. 3+7