M. Sc. (Physics) 4th Semester Examination 2019

PHY – 522 (Solid State Electronics)

Full Marks-50 **Time: 2 Hrs.**

The figures in the margin indicate full marks

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

Question 1 is compulsory and answer any ***three*** from the rest.

1. Answer any *five*

(a) Determine the degeneracy of Landau levels at T = 0K for a two dimensional electron gas. Show that this expression can lead to the expression of magnetic length. Determine the value of magnetic length for a magnetic field of 2.5 Tesla. 4

(b) What is ambipolar effect? Starting from the equation of continuity of electrons and holes determine the ambipolar diffusion coefficient and mobility for high level carrier injection. 1 + 3

(c) Define charge neutrality level. Explain with necessary diagram, how can the position of the Fermi level at the semiconductor surface be determined? 1 + 3

(d) Explain atom lithography using scanning tunneling microscope by parallel process. State the advantages of electron beam lithography over photolithography. 2 + 2

(e) Explain the memory map of 1 K memory 4

(f) Draw the electric field versus mobility graph for silicon and write the corresponding empirical formula.

Hence find an expression for I_D in terms of V_D and other relevant parameters for a MESFET having field dependent mobility. 1+3

2(a) How can you determine the diffusion coefficient of minority carriers in a semiconductor using Haynes-Shockley experiment? What are the limitations of this experiment? 3 + 2

(b) What are polarons? In ionic crystal, the ion displacement from equilibrium and polarization satisfies the following matrix equations; $\ddot{\overline{w}} = b_{11}\overline{w} + b_{12}\overline{E}$ and $\overline{P} = b_{21}\overline{w} + b_{22}\overline{E}$. Determine the coefficients of these equations. 1 + 4

3. (a) Distinguish between electron trap and recombination center in terms of trapping / emission mechanism. On the basis of Shockley-Read-Hall theory find an expression for the net trapping rate under steady state conditions. 2 + 4

(b) Ground state energy of two dimensional electrons in a triangular well can be written as $E_1 = C_1 n_{2D}^{2/3}$, where n_{2D} is the density of two dimensional electron gas. Determine the mean well width in terms of E_1 *and* n_{2D}. Plot the variation of density of states for this triangular well with energy and explain the nature of the plot. 2 + 2

4(a) Energy dispersion of intrinsic Graphene is expressed as $E = \hbar V_f q$, where the symbols have their usual meaning. Derive the expression of density of states. Estimate the temperature variation of carrier density. Determine the cyclotron mass of at T = 0 K. 2 + 2 + 2

(b) Landauer–Büttiker formula for multi lead system is expressed as: $I_m = \sum_n T_{mn}(V_m - V_n)$, where symbols have their usual meaning. Construct the conductance matrix for six–lead Hall bar with high magnetic field normal to the plane of two dimensional electron gas. Hence explain Quantum Hall effect. 2 + 2

5. 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,F5,98,8B] 10

6. (a) Draw the neat sketch of a MESFET under appropriate biasing condition. 1

(b) Starting from the Poisson's equation derive an expression for the drain current I_D in terms of other relevant parameters for a MESFET having constant mobility. 7

(c) Also prove that the drain conductance in the linear region is equal to the mutual conductance in the saturation region. 2