Seventh Semester B.Tech. Degree Examination, October 2018
(2013 Scheme)
13.701 : NANOELECTRONICS (AT)

Time : 3 Hours
Max. Marks : 100

PART – A

Answer all questions. Each question carries 2 marks.

1. Differentiate quantum wires and quantum dots.

2. Why quantum dots are considered as artificial atoms?

3. Explain any one nanolayer fabrication technique.

4. How nanoparticles are formed by grinding with iron balls?

5. What are the controlling factors of self-assembly?

6. Define quantum Hall effect.

7. What are super lattices?

8. Explain resonant tunnelling effect.

9. What is Coulomb blockade?

10. Explain the principle of operation of hot electron transistors.

PART – B

Answer any one full question from each Module, each carries 20 marks.

Module – 1

11. a) Assume that an electron with mass \( m_0 = 9.8 \times 10^{-31} \) kg is placed in a quantum well with two impenetrable walls and that the distance between the walls is \( L = 10^{-6} \) cm. Calculate the three lowest subband bottom energies \( \varepsilon_1, \varepsilon_2, \) and \( \varepsilon_3 \). For these stationary states, find the probability density of finding the electron at the middle of the well at \( z = 0. \) (1x10=10 Marks)

P.T.O.
b) Compare triangular and parabolic quantum wells. \((1 \times 10 = 10\text{ Marks})\)

OR

c) Write a note on the characteristics lengths in mesoscopic systems. \((1 \times 15 = 15\text{ Marks})\)

d) Explain quantum mechanical coherence. \((1 \times 5 = 5\text{ Marks})\)

**Module – 2**

12. a) Discuss the differences between the working principles of scanning tunnelling microscopy and atomic-force microscopy. \((1 \times 10 = 10\text{ Marks})\)

b) Discuss in detail, any characterisation technique that can be used for understanding the crystallographic structure. \((1 \times 10 = 10\text{ Marks})\)

OR

c) Differentiate in detail, PVD and CVD. \((1 \times 10 = 10\text{ Marks})\)

d) Explain various techniques employed for the fabrication of nanoparticles. \((1 \times 10 = 10\text{ Marks})\)

**Module – 3**

13. a) For a gallium arsenide nipi-superlattice with equal \(N = N_D = N_A\) donor and acceptor concentrations of value \(5 \times 10^{17}\text{cm}^{-3}\).

I) Calculate the separation between levels in the conduction and valence bands.

II) Show that the value of the effective bandgap is given by

\[
E_g = E_{\text{bulk}} + E_{e1} + E_{h1} - 2V_0
\]

\((V_0\text{ is the amplitude of the periodic potential})\)

III) Show that, if \(N_A = N_D = N\), the amplitude of the periodic potential in the superlattice is given by

\[
V_0 = \frac{e^2}{2\epsilon} N z_0^2
\]

\((z_0\text{ is the depletion layer width})\).

IV) Calculate \(V_0\) and the effective bandgap assuming the previous concentration of doping as in question 13 and taking \(z_0 = 20\text{ nm}\). \((4 \times 5 = 20\text{ Marks})\)

OR
b) Explain in detail
   I) The Aharonov-Bohm Effect.
   II) Shubinikov-de Hass effect. (2x10=20 Marks)

Module – 4

14. a) With the help of a neat schematic diagram explain MODFETs. (1x10=10 Marks)

   b) Discuss the principle of operation of nanoelectronics switch made of
      conducting molecule. (1x10=10 Marks)

   OR

   c) Discuss in detail about
      I) Hot electron Transistors.
      II) Resonant tunnelling diode. (2x10=20 Marks)