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6 SEM TDC DSE PHY (CBCS) 2 (H)

2022

(June/July)

PHYSICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–2

(Nanomaterials and Applications)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option from the following : 1×5=5

(a) A material with one dimension in nano range and the other two dimensions are large, is called

(i) micro material

(ii) quantum wire

(iii) quantum well

(iv) quantum dot

(b) What is the procedure in top-down fabrication method?

(i) Nanoparticles → Powder → Bulk

(ii) Powder → Bulk → Nanoparticles

(iii) Bulk → Powder → Nanoparticles

(iv) Nanoparticles → Bulk → Powder

(c) The empirical formula for obtaining crystallite size from XRD studies is given by

(i) $D = 2n\lambda \sin\theta$

(ii) $D = 2n\lambda \cos\theta$

(iii) $D = \frac{0{\cdot}99\lambda}{\beta \cos\theta}$

(iv) $D = \frac{n\lambda}{2 \sin\theta}$

(d) Excitons are

(i) negatively charged

(ii) positively charged

(iii) neutral

(iv) None of the above

(e) The main application of GMR is in

(i) hard disk

(ii) biosensors

(iii) MEMS

(iv) All of the above

(Continued)

2. *(a)* What is a quantum dot? 1

(b) What is meant by quantum confinement? What happens to the band gap of a material in the nano-regime? 1+1=2

(c) Write the expressions for wave function and energy due to quantum confinement within one-dimensional potential well. Draw the schematic diagram of wave functions and energies of the first three confined states of an infinite-depth potential well. 1+1+3=5

Or

Define density of states of materials at nano-regime. How does the three-dimensional (3-D) density of states differ from the two-dimensional (2-D) and one-dimensional (1-D) density of states? Explain with the help of schematics and plots. 1+4=5

3. *(a)* What do you mean by top-down and bottom-up approaches of nanostructured material synthesis? Give examples of each case. 2+1=3

(b) Write briefly with necessary diagram, the thermal evaporation method for depositing nanostructured thin films. 4

Or

Discuss the ball milling technique with necessary sketch. What are the advantages of this technique? 3+1=4

4. *(a)* What is an atomic force microscope? 2

Or

Why is optical microscope not suitable for characterization of nanomaterials? What do you mean by resolution of a microscope?

(b) Explain with necessary diagram, the working principle of SEM. 4

5. Answer any *three* of the following questions : 3×3=9

(a) What is Coulomb interaction in solids? How is dielectric confinement related to the Coulomb interaction?

(b) What is excitonic Bohr radius? How does dielectric constant affect the excitonic Bohr radius of a semiconductor material?

(c) What are the radiative and non-radiative electron-hole recombination processes in semiconductor nanoparticles?

(d) Write about optical properties of nano-structures.

6. *(a)* What do you mean by thermionic emission? Give an example where thermionic emission takes place. 1+1=2

(b) Explain the Coulomb blockade effect. What conditions must be satisfied for this effect to be observed? 2+2=4

(Continued)

7. Answer any *three* of the following questions : 4×3=12

(a) Why are quantum dots identified as attractive candidates to be applied for LED devices? Describe the basic structure of quantum dot LED with suitable diagram.

(b) Discuss the CNT-based transistor with necessary diagram. Write the advantages of CNT-based transistor over semi-conductor field effect transistor.

(c) What is meant by magnetic storage data? Name some magnetic storage devices. How does application of nano-technology improve the data storage capacity of magnetic storage device?

(d) Write a short note on nano-electromechanical system (NEMS).

(e) Write a short note on quantum dot heterostructure laser.

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