



Name :

Roll No. :

Invigilator's Signature :

CS/M.Tech (ECE)/SEM-2/MVM-204A/2010

2010

QUANTUM & NANOELECTRONICS

Time Allotted : 3 Hours

Full Marks : 70

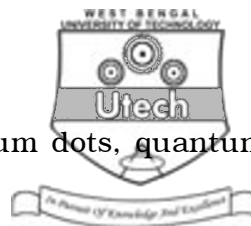
The figures in the margin indicate full marks.

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

Answer Question No. 1 and any four from the rest.

1. Answer any seven questions : 7 × 2

- i) What are the nanostructured materials ?
- ii) Define Quantum dot ?
- iii) Mention a few applications of nanostructured materials ?
- iv) What are the advantages of Silicon-nanocrystal over the bulk Silicon ?
- v) Write down the time-independent Schrodinger equation with proper notation ?
- vi) What are the different modes of using Atomic force microscopy ?
- vii) What are the critical issues for nanostructure synthesis and assembly ?
- viii) What is chiral vector and chiral angle ?
- ix) What materials are used for tip fabrication of Atomic force microscopy system ?



2. a) How can you differentiate the quantum dots, quantum wire and nanotube ?
- b) Why are nanostructure materials (scientifically) interesting ?
- c) What are the properties of nanocrystalline materials ?

6 + 4 + 4

3. a) Describe a process to form Si-nanocrystals with diameter 2.5 – 5 nm, which is compatible with semiconductor processing techniques used in industry.
- b) The following figure is showing the XPS characteristics curves of Silicon implanted SiO_2 films annealed for 10 minutes with different temperature. From the figure, at what temperature the nanocrystalline Silicon is observed ? Explain the other curves.

Binding Energy (eV)

- c) You want to form the Germanium nanoparticles by decomposing organogermane in the presence of octanol ($\text{C}_8\text{H}_{18}\text{O}$) as capping ligand in SC-hexane at 400-500° C. Describe the detail process.



4. a) “A catalyst of 10 nm nanoparticles is 100 times more reactive than the same amount of material in 1 micron particles”. Justify the above statement with a simple experiment.
- b) Imagine that an electron is trapped in a one-dimensional box whose length is 1.1 nm. Starting with the following equation for electron wavefunction in H_2 atom :

$$-\frac{\hbar}{2m} \frac{d^2\psi}{dz^2} + V(z)\psi(z) = E\psi(z)$$

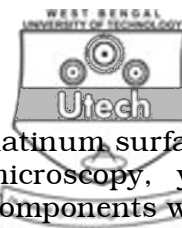
Infinite well : $V_0 \rightarrow \infty$

Calculate the energy eigenvalues and sketch the eigenfunctions for $n = 1 - 6$.

- c) What is the wavelength of an electron traveling at a velocity which is 39% of the speed of light ?

Plank's constant = 6.626×10^{-34} J-s, Mass of an electron = 9.11×10^{-31} kg.

6 + 4 + 4



5. a) You want to see the following image of Platinum surface. Which technique of surface probe microscopy, you should use ? Give in detail, the system components with proper schematics.
- b) Define piezoelectric effect with proper diagram.
- c) What is the function of photodetector in Atomic force microscopy ? 1 + 5 + 5 + 3
6. a) What are the important properties of Carbon Nanotube ?
- b) How can you classify the Arm chair and Zigzag geometry of Carbon Nanotube ? Which one is showing metallic behavior ?
- c) How can you form the Single-walled Nanotube as well as Multi-walled Nanotube using ARC discharge method ? 2 + 3 + 1 + 8
7. a) What is the difference between Single Electron Transistor (SET) and conventional MOSFET ?
- b) Explain the functionality of SET with basic operation of Single electron box.
- c) What is Coulomb Blockade ? 4 + 7 + 3
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