Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.TECH (ECE-VLSI)/SEM-2/MVLSI-204-A/2011

2011
QUANTUM & NANO-SCIENCE

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 (4) from the rest.

1. Answer all questions :   7 × 2 = 14

   a) Why nanostructured materials are scientifically interesting ?

   b) Give an example of nanostructure exists in nature ?

   c) Mention an application of Nanotechnology used in modern medical science ?

   d) "To explain the phenomena of nanotechnology, understanding the quantum mechanics is essential rather than the classical physics." Explain.

   e) Write down the time-independent Schrödinger equation with proper notation.

   f) What are the critical issues for nanostructure synthesis and assembly ?

   g) What are the different modes of Atomic force microscopy system ?

30384 (M.Tech)   [Turn over
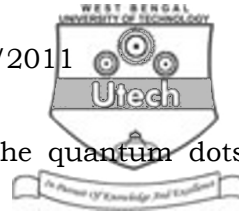
2. a) How can you distinguish between the quantum dots, quantum wire and nanotube ?

   b) Why are nanostructure materials (scientifically) interesting ?

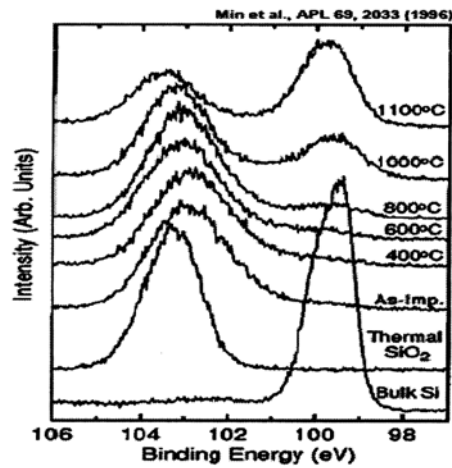   c) What are the properties of nanocrystalline materials ?

   6 + 4 + 4

3. a) *"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) A student is examining a bacterium under the microscope. The E. coli bacterial cell has a mass of m = 0·900 fg (where a femtogram, fg, is 10^{-15} gm) and is swimming at a velocity of v = 6.00 um/s, with an uncertainty in the velocity of 9.00 %. E. coli bacterial cells are around 1 μm in length. The student is supposed to observe the bacterium and make a drawing. What is the uncertainty of the position of the bacterium ? Do you think the student can able to locate the bacterium ? Explain.

   c) What is the wavelength of an electron traveling at a velocity which is 25% of the speed of light ? Planck's constant = 6.626 × 10^{-34} J-s, mass of an electron = 9.11 × 10^{-31} kg.   6 + 5 + 3
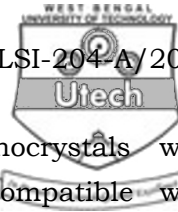
4. a) Describe a process to form Si-nanocrystals with diameter 2.5 – 5 nm, which is compatible with semiconductor processing techniques used in industry.

   b) The following figure is showing the XPS characteristic curves of Silicon implanted SiO_2 films annealed for 10 minutes with different temperatures. From the figure, at what temperature the naoncrystalline Silicon is observed and explain the other curves.

Min et al., APL 69, 2033 (1996)

   c) What are the advantages of nano-crystalline silicon over bulk silicon ?   5 + 5 + 4

5. a) You want to visualize SiO_2 molecules which are deposited on Si substrate, which technique of surface probe microscopy, you should use ? Give in detail the system components with proper schematics.

   b) Bulk gold appears yellow in color while nano-sized gold appears red in color. Why ?

   c) What is Piezoelectric effect ?   2 + 8 + 2 + 2
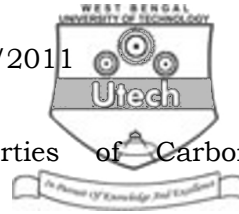
6. a) What are the important properties of Carbon Nanotube ?

   b) How can you classify the Arm chair and Zigzag geometry of Carbon Nanotube ? Which one is showing metallic behaviour ?

   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

8. a) Calculate the minimum distance between two distinguishable states for a single electron box, which can be equivalent to the minimum channel length for single electron transistor.

   b) What is the advantage of using Ultra Fast Pulses from a Free Electron Laser (FEL) method over LASER ablation method for fabrication of large scale production of Single walled carbon nanotube ?

   c) Why are conducting samples required for extracting the topology of atomic surface in case of Scanning Tunneling microscope ?   7 + 4 + 3