M.TECH NANOSCIENCE & TECHNOLOGY, FIRST YEAR 2nd SEMESTER EXAMINATION, 2024

SUBJECT: CARBON NANOTUBES AND ITS FUNCTIONALISATIONS

Answer any five questions

1. (i) Define state and phase of a material.
   Draw the phase diagram of carbon and show the regions where diamond and graphite are stable phases? What is metastability?

   (ii) What is diamond anvil cell? Describe the high pressure high temperature synthesis of diamond from graphite using diamond anvil cell.

   (iii) Why does low pressure low temperature synthesis of diamond thin films was thought difficult? Mention the role of atomic hydrogen for the synthesis of LPLT diamond.

   (8+5+7)

2. (i) Describe the sequence of events that led to the discovery of Fullerene molecule.
   With a clear diagram describe Smalley's experiment. Why laser in pulsed mode was used?

   (ii) What is Euler's theorem? Using this theorem determine the number of pentagons and hexagons in a C60 and C70 molecule.

   (iii) Mention how synthesized fullerene can be purified to get pure fullerene crystal.

   (iv) Why were the results of Smalley's experiment and Ando's experiment different?
   (10+4+3+3)

3. (i) Draw a honeycomb lattice and show the two basis vectors.

   Show with neat diagrams how does the above lattice can be folded to get the following:

   (a) Arm-chair Carbon nanotubes
   (b) Zig-Zag carbon nanotubes
   (c) Chiral carbon nanotubes

   (ii) Define chirality and chiral angle. Obtain an expression for the chiral angle.

Find the chiral angle of (20,20) and (20,0) carbon nanotube.

(iii) Define translational vector. Prove that number of unit cells in a CNT can be expressed as

$$= 2/d_R(n^2+m^2+mn)$$

where the symbols have their usual meaning.

(6+8+6)

4. (i) Mention the requirements of a good display technology? What are the different technological options? Make a comparison about the advantages and disadvantages of different technology options.

(ii) By assuming a flat emitting surface and applying the concept of image charge show that the reduced barrier with the application of an external field can be expresses as

$$V = -e\sqrt{eE}$$ where the symbols have their usual meanings.

Hence explain the Schottky effect.

(iii) What are the differences between Schottky effect and Field emission? Show the variation of the potential barrier under increasing electric field. Write the governing equation for field emission. Explain why CNT is a good candidate for field emission based display technology

(4+6+10)

5. (i) What are catalysts? Why transitional metals are good catalyst for CNT synthesis? Write Sabatier principle for selecting a good catalyst.

(ii) Describe the method of evaporation followed by reduction method for the fabrication of catalyst nanopartciles.

(iii) Briefly describe the different growth models for carbon nanotubes. Draw diagrams for Russian doll MWCNT and parchment CNT.
Why it is easier to grow MWCNT than SWCNT?

(6+8+6)

6.   Discuss briefly about catalyst substrate and catalyst aerosol used for flame synthesis.

'The pyrolyzing zone of the flame is conducive for carbon nanostructure synthesis' – discuss.

Nickel catalyst yields more CNT than iron catalyst in flame synthesis. Explain this phenomenon.

(8+6+6)

7. Write Short notes on (any four)

(i)   ICP RF plasma CVD of CNT growth
(ii)   Arc discharge growth method of SWCNT
(iii)   Field emission in Spindt tip cathode
(iv)   Floating catalysts method of CNT production in powder form
(v)   Functionalisation of CNT
(vi)   Graphene and its attributes

(4x5)