M.TECH NANOSCIENCE & TECHNOLOGY, FIRST YEAR 2nd SEMESTER EXAMINATION, 2018

SUBJECT: CARBON NANOTUBES AND ITS FUNCTIONALISATIONS

Answer any five questions

1. (i) 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.

   (iv) Describe any one method with a diagram for the synthesis of diamond thin film.

   (4+6+4+6)

2. (i) Describe the sequence of events that led to the discovery of Fullerene molecule. With a clear diagram describe Smalley's experiment.

   (ii) What is mass spectroscopy? Describe the working principle of a mass spectrometer.

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

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

   (6+6+6+2)

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

   Show with neat diagrams how 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?

(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 Schottkey effect.

(iii) What are the differences between Schottkey 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?

(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. (i) Name three hydrocarbon fuels those are suitable for flame synthesis of CNT.

(ii) Why is pyrolysis zone important for flame synthesis of CNT?

(iii) How can the catalyst materials be used in flame synthesis of CNT?

(iv) In case of flame synthesis, it is found that the yield rate of CNT is more in case of nickel compared to iron. Explain the reason.

(3+8+4+5)

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7. (a) What are reciprocal lattice points? Obtain relationship among reciprocal lattice constants and direct lattice constants.

(b) By geometrical construction show that reciprocal points really form a lattice.

(c) Show that a general reciprocal lattice vector $\vec{d}^{*}_{hkl}$ is perpendicular to (hkl) plane.

(d) Why do we use Miller-Bravais Indices instead of Miller Indices for a hexagonal system of lattice? Calculate the same for a hexagonal system.

What are the advantages of reciprocal lattice concept?

(4+4+6+6)

8. 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 Spindth tip cathode
(iv)   Floating catalysts method of CNT production in powder form
(v)   Functionalisation of CNT
(vi)   Graphene and its attributes

(4x5)