2015-16
M.TECH. AUTUMN SEMESTER (III SEMESTER) EXAMINATION
NANOTECHNOLOGY
NANOSENSORS AND NANODEVICES
AP-719

Maximum Marks: 60 Credits: 04 Duration: Three Hours

Answer all the questions. Notations used have their usual meanings.

1 (a) Differentiate between ‘sensors’ and ‘nanotechnology enabled sensors’. [03]

(b) What are static characteristics of sensors? Explain the terms ‘Resolution’, ‘sensitivity’, ‘Noise’ and ‘Response Time’. [12]

OR

(b”) Explain dynamic characteristics of sensors and describe perfect zero order, first order and second order systems. [12]

2 (a) Write the list of physical effects which can be employed for signal transduction in sensors. [05]

(b) Explain photoluminescence effect, electro luminescence effect, magnetostriction, magnetoresistance and GMR. [10]

OR

2’(a) Draw the schematic diagram of a SET and its I-V characteristic. Obtain pre conditions for the well defined charge states of a quantum island in a SET. What will be the minimum particle diameter of a nano particle to work as a SET at room temperature? [09]

(b) Explain resonant tunnelling and show that at resonance the transmission probability is unity. Sketch the I-V characteristic of a RTD and explain the NDR region. Write few applications of RTD. [06]

3 (a) Explain in detail how the development of biosensors meets the rapidly increasing need for clinical diagnostics in these days. [05]

(b) Define the three generations of sensor and write a note on the first generation of biosensor. [05]

(c) Biochips are essential miniaturized laboratories, Comment. [05]

4 Write notes on any three of the following:
a). ZnO nanowire based ID gas sensors [15]
b). Piezoelectric sensors
c). MEMs based accelerometer
d). Optical sensors
e). Mutation Sensing
2015-16
M.TECH. (AUTUMN SEMESTER) EXAMINATION
NANOTECHNOLOGY
CARBON NANOTUBE AND ITS FUNCTIONALIZATION
AP720

Maximum Marks: 60  Credits: 04  Duration: Three Hours

Answer ALL the questions. Notations used have their usual meanings.

1(a) By whom and when CNT was discovered. Explain why CNTs are so important?  [4]
Name the parameters on which the quality and quantity of the nanotubes depend in arc
discharge method. With the help of suitable diagrams, explain the synthesis of MWNTs
in liquid nitrogen, magnetic field and plasma rotating arc discharge method.  [6]

1(b) Describe the developments on the large scale synthesis methods of SWNTs and point
out their disadvantages.  [5]

1(c) Using suitable illustrations, explain the CoMoCat and HiPco processes for the
production of SWNTs. Also comment on effect of the growth temperature on diameter
of the tubes in CoMoCat process.  [5]

2(a) Discuss the quantum transport in one dimensional carbon nanotubes and also explain
ballistic conductance.  [9]

2(b) Describe the mechanical properties of CNTs. Explain the theoretical and the
computational models of elastic properties of the nanotubes.  [6]

2(b') Write short notes (any two of the following) on applications of CNTs in
(i) LEDS.
(ii) Hydrogen storage
(iii) Display devices.  [6]

3(a) Define endohedral and exohedral functionalizations of CNTs with suitable examples.
Explain why non-covalent functionalization is better than covalent functionalization?  [4]

3(b) Describe fluorination, addition of radicals, silylation and electrochemical reaction
methods for sidewall functionalization of CNTs.  [6]

3(c) What do you understand by biological functionalization of CNTs? Discuss the
functionalization of CNTs using protein.  [5]

4(a) Compare the preparation of fullerene by two different methods and mention their
benefits and drawbacks.  [8]

4(b) Discuss the significance of Raman spectroscopy for the characterization of CNTs and
also explain various bands in Raman spectrum of carbon nanotubes.  [3]

4(c) Give a brief introduction of DLC and nanodiamonds with their potential applications.  [4]
1(a) Mention various synthesis methods for graphene. Which method is considered to produce the purest form of graphene? Explain the CVD method of graphene synthesis and discuss the role of catalyst in the formation of graphene.

1(b) What is ARPES technique and how is it used to measure the band structure of graphene? Compare the electronic properties of graphene and common bulk semiconductors.

OR

1(b') Graphene is considered to be a wonder material, explain. Describe modified Hummer's method for the synthesis of graphene oxide.

2(a) Draw the electronic configurations of carbon atom in the ground and the excited states. Using ortho-normality conditions, obtain symmetric and anti-symmetric combinations of 2s & 2p atomic orbitals.

2(b) Derive the energy dispersion relation for graphene in the tight binding approximation with the nearest neighbour interactions. Show that in the continuum limit this relation reduces to $\varepsilon(k) = \pm \hbar v_F k$.

OR

2(b') State and prove Bloch's theorem. Prove that the density of states $g(E)$ for the graphene at low energies is given by

$$g(E) = \frac{2}{\pi(\hbar v_F)^2} |E|$$

Further, with the help of Fermi-Dirac distribution and density of states, show that the extrinsic carrier density $n_e$ in the doped graphene is

$$n_e \approx \frac{\lambda}{\pi} \left(\frac{E_F}{\hbar v_F}\right)^2$$

Contd.....2.
3(a) Discuss the role of pseudo spin and helicity in graphene. [4.0]

3(b) Explain anomalous quantum Hall effect (QHE) in graphene in the light of its theoretical and experimental aspects. Why QHE is more interesting in the bilayer graphene? [4.5]

3(c) What do you mean by Klein tunnelling? Obtain the expression for transmission probability through a potential barrier in graphene for the limit \( |V_0| \gg |E| \). [6.5]

4(a) Discuss the magneto transport properties of graphene. Giving a neat diagram, explain the experimental procedure for the measurement of magneto transport properties of graphene. [8.0]

4(b) Discuss the potential applications of graphene in any two of the following: [7.0]

(i) Photo detectors  (ii) Light emitting diodes
(ii) Sensors  (iv) Photovoltaic