2017-2018
M.TECH. AUTUMN SEMESTER (IIrd SEMESTER) EXAMINATION
Nanosensors and Nanodevices
(INC-719)
(Credits: 04)

Maximum Marks: 60
Duration: Two Hours

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

1. (a) What are static and dynamic characteristics of nanosensors? Write the names of various static characteristics. 
   (b) Describe transient properties of dynamic sensors in zero order, 1st order and 2nd order system. 
   [4] [8]

2. (a) What are the important physical effects employed for transduction in sensors? 
   (b) Discuss Electroluminescence effect, Hall effect and thermo resistive effect and their applicability in fabrication of nanosensors. 
   [4] [8]

3. (a) What is a SET? Discuss electron transport through a SET device and explain the appearance of Coulomb Blockade in such devices. What is the Helmholtz free energy of a SET and what are its other components? 
   (b) Discuss the condition for Coulomb Blockade and estimate minimum tunnel resistance for single electron charging. What are possible applications of a SET? 
   [6] [6]

   OR

   (b) Discuss components of biochips and write potential diagnostic applications of biochips.

   [6]

4. (a) Consider a Double Tunnel Junction biased with an ideal voltage source. Draw the Equivalent circuit and calculate change in free energy for an electron tunnelling through junction 1 and 2. Discuss the results. 
   (b) Calculate the voltage required to charge an island of radius 1nm in air. What shall be the charging voltage for an island of radius 100 nm? Discuss the results. 
   [10] [2]

5. Write notes on any three of the following 
   (a) Resonant tunnelling diode (RTD) 
   (b) Nano FET 
   (c) Quantum Dot solar cells and Quantum Dot display 
   (d) Doppler effect and its use in sensor technology 
   (e) Biosensors 
   [12]
2017-2018
M.TECH. AUTUMN SEMESTER (IIIrd SEMESTER) EXAMINATION
Carbon Nanotube and its functionalization
(INC-720)
(Credits: 04)

Maximum Marks: 60  Duration: Two Hours

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

1. (a) Discuss the structure and properties of CNTs. [5]
   (b) Discuss the CVD and other methods of preparation of carbon nanotubes. [5]
   (c) How can the metallic and semiconducting carbon nanotubes be separated? [5]

2. (a) What do you understand by the functionalization of CNTs and what are the methods by which this can be achieved? [5]
   (b) Explain the filling of CNTs by spontaneous phenomenon of capillary action. [5]
   (c) Write some applications of functionalized carbon nanotubes. [5]

3. (a) Discuss the wet chemistry approach for filling carbon nanotubes resulting in preparation of silver nanoparticles and platinum nanorods within the CNTs. [7]
   (b) Explain exohedral functionalization of CNTs via oxidation followed by esterification or amidation. What do you understand by non-covalent exohedral functionalization and solvent free functionalization of CNTs. [8]

4. (a) Draw diamond crystal lattice structure and discuss its salient features. [3]
   (b) What are nanodiamonds and discuss their synthetic and natural sources. Discuss TNT donation method for synthesizing nanodiamonds and PCVD method for producing ultranano crystalline diamonds. [4]
   (c) Discuss optical properties of nanodiamonds and their potential applications. [4]
   (d) Write a note on DLC. [4]
2017-2018
M.TECH. AUTUMN SEMESTER (III SEMESTER) EXAMINATION
Graphene and its Applications
(INC-727)
(Credits: 04)

Maximum Marks: 60
Duration: Two Hours

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

1. Answer any three questions from the following:
   a. Calculate the area of a unit cell of graphene in nm$^2$. Based on the area, calculate the density of a monolayer graphene sheet. (1 amu = 1.66 x 10$^{-24}$ gm) [5]
   b. Like graphene, is it theoretically possible to synthesize a monolayer graphene sheet (a 2D network of carbon atoms, each bonded to four carbon atoms with sigma bonds on a square lattice)? [5]
   c. Discuss Quantum Hall Effect (QHE) in graphene. [5]
   d. Discuss the application of graphene as a transparent conducting electrode. [5]

2. Answer any three questions from the following:
   a. Describe Raman spectroscopy in the context of the characterization of graphene. [7]
   b. Describe fabrication of graphene using Molecular Beam Epitaxy (MBE) method. [7]
   c. What is Klein tunneling? Other than graphene, where else it may be observed? [7]
   d. Consider a thin film of graphene oxide nanoparticles in contact with a metal electrode, at the time of contact electrons from the film side are transferred to the metal side. Calculate the relative permittivity ($\varepsilon_r$) of the film if charge density in the depletion region is $10^{17}$ cm$^{-3}$ and the Schottky barrier height ($\Phi_b$) is 0.5 eV. ($\varepsilon_0 = 10^7/(4\pi e^2)$ and $e = 1.6 \times 10^{-19}$ C) [7]

3. Calculate the first Brillouin zone of a monolayer thin graphene sheet, considering the first primitive vector ($a_1$) of the first triangular sub-lattice along x-axis. Show the values of all the coordinates of six Dirac points in the momentum space. Qualitatively describe the electronic structure of a monolayer graphene sheet. [12]

4. Starting from the 2D Dirac equation, calculate the energy eigen values and eigen states of the 2D Dirac Hamiltonian for graphene. Why low energy electrons in graphene are called relativistic massless fermions? [12]