Course: Department Specific Elective 3 – HPHDS5032T & HPHDS5032P

Semester	V
Paper Number	HPHDS5032T & HPHDS5032P
Paper Title	Nano materials and Applications
No. of Credits	06 (Theory – 4, Lab – 2)
Theory/ Composite	Composite
No. of periods assigned	Th:4 periods/week Pr:3 periods/week
Name of Faculty member(s)	
Course description/ objective	The Nanomaterials and application course is an emerging domain of physics with interdisciplinary flavour having interface with practically all major areas of science & technology like Chemistry, Biology, Medicine etc. It conveys an understanding of how it has contributed to the rapidly changing technological developments in our society. It will enable the student to employ basic skills of classical and quantum theories in the reduced dimensions of nanomaterials. On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence: From the Knowledge point of view, the student is able to explain the reduced dimensionality (3D, 2D, 1D and 0D), basic understanding of synthesis of nanomaterials and their characterization, explain electrical and optical properties and finally the wide areas of applications. From the Skill point of view, the student is able to critically distinguish the synthesis methods suitable for nanomaterials and proper characterization techniques needed. And finally in terms of General competence, the student should have the ability to 1) explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale. 2) choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties. 3) correlate properties of nanostructures with their size, shape and surface characteristics. 4) appreciate enhanced sensitivity of nanomaterial based devices and their novel applications in industry.
Syllabus	As enclosed
Texts	As enclosed

Reading/ Reference Lists	As enclosed
Evaluation	Total – 100 (Theory – 60, Practical – 40) Theory – CIA – 10 Semester Examination – 50 Group A (25 marks) Group B (25 marks) One 10 marks qs out of two qs One 10 mark qs out of two qs Three 5 mark qs out of five qs Three 5 mark qs out of five qs

Syllabus:

HPHDS5032T - NANO MATERIALS AND APPLICATIONS [Credits – Theory - 04, Practical – 02; Lectures : Theory – 52, Lab – 39]

Module A [26 Lectures]

NANOSCALE SYSTEMS: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nanosystems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

[10 Lectures]

SYNTHESIS OF NANOSTRUCTURE MATERIALS: Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapour deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapour deposition (CVD).Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods.MBE growth of quantum dots.[8 Lectures]

CHARACTERIZATION: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunnelling Microscopy.[8 Lectures]

Module B [26 Lectures]

OPTICAL PROPERTIES: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostructures and nanostructures. [10 Lectures]

ELECTRON TRANSPORT: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunnelling and hopping conductivity. Defects and impurities: Deep level and surface defects. [6 Lectures]

APPLICATIONS: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Nano-composites, CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Nano Electromechanical Systems (NEMS).[10 Lectures]

Reference books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. H.F. Tibbals et al. Introduction to Nanoscience and Nanotechnology (CRC Press)
3. B.S. Murthy et al. Textbook of Nanoscience and Nanotechnology (Springer)

4. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.

HPHDS5032P - NANO MATERIALS AND APPLICATIONS LAB (39 Lectures)

1. Synthesis of metal nanoparticles by chemical route.

2. Synthesis of semiconductor nanoparticles.

3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.

4. XRD pattern of nanomaterials and estimation of particle size.

5. To study the effect of size on colour of nanomaterials.

6. To prepare composite of CNTs with other materials.

7. Growth of quantum dots by thermal evaporation.

8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.

9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.

Reference Books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
3. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
4. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).

DSE Paper Structure for laboratory

(a) Marks for experiment : **30 marks**
   (i) Class performance on any one expt. – 8
   (ii) Lab. Viva on the same experiment as (i) - 7
   (iii) LNB for each of the three experiments - 5 x 3 = 15

(b) Grand Viva – **8 marks**

(c) Attendance – **2 marks**

[Students are to complete 3 experiments]