Nanoelectronics (GE)

Credits: Theory -03 **Theory Lectures: 45h**

Course Learning Objectives

The syllabus includes the basic concepts and principles to categories and understand nanomaterial. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural properties are discussed. Interesting experiments which shape this filed are introduced. The important applications areas of nanomaterials are introduced.

Course Learning Outcomes

At the end of this course, students will be able to

CO1 Describe the principles of nanoelectronics and the processes involved in making nano components and material.

CO2 Explain the advantages of the nanomaterials and appropriate use in solving practical problems.

CO3 Explain the various aspects of nano-technology and the processes involved in making nano components and material.

CO4 Differentiate between various nanomaterials synthesis processes.

Prerequisite: Basic knowledge of the semiconductor theory

L-T-P: 3-0-1

Syllabus Contents

Unit-1 **(12 Lectures)**

Introduction: Definition of Nano-Science and Nano Technology, Applications of Nano-Technology.

Introduction to Physics of Solid State: Size dependence of properties, bonding in atoms and giant molecular solids, Electronic conduction, Systems confined to one, two or three dimension and their effect on property

Introduction to Quantum Theory for Nano Science: Time dependent and time independent Schrodinger wave equations. Particle in a box, Potential step: Reflection and tunneling (Quantum leak). Penetration of Barrier, Electron trapped in 2D plane (Nano sheet), Quantum confinement effectin nanomaterials.

Quantum Wells, Wires and Dots: Preparation of Quantum Nanostructure; Size and Dimensionality effect, Fermi gas; Potential wells; Partial confinement; Excitons; Single electron Tunneling, Infrared detectors; Quantum dot laser Superconductivity.

Unit-2 **(11 Lectures)**

Growth Techniques of Nanomaterials: Synthetic aspects: bottom up and top down approaches, Lithograpahic and Nonlithograpahic techniques, Sputtering and film deposition in glow discharge, DC sputtering technique (p-$CuAlO_2$ deposition). Thermal evaporation technique, E-beam evaporation, Chemical Vapour deposition(CVD), Synthesis of carbon nano-fibres and multi-walled carbon nanotubes, Pulsed Laser Deposition, Molecular beam Epitaxy, Sol-Gel Technique (No chemistry required), Synthesis of nanowires/rods, Electro deposition, Chemical bath deposition, Ion beam deposition system, Vapor-Liquid–Solid (VLS) method of nanowire.

Unit-3 **(12 Lectures)**

Methods of Measuring Properties and Characterization techniques: Microscopy: Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), Field Ion Microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) including energy dispersive X-ray (EDX) analysis, Infra-red and Raman Spectroscopy, X-ray Spectroscopy, Magnetic resonance, Optical and Vibrational Spectroscopy, Characterization and application like biopolymer tagging and light emitting semiconductor quantum dots.

Unit-4 **(10 Lectures)**

Carbon nanotubes, nano cuboids, graphene, carbon quantum dots: Fabrication, structure, electrical, mechanical, and vibrational properties and applications. Use of nano particles for biological application, drug delivery and bio-imaging, Impact of nanotechnology on the environment.

References

1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
2. Nanomaterials: synthesis, properties and applications, Institute of Physics, 1998.
3. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
4. Electron Microscopy and analysis, 2nd ed. Taylor and Francis, 2000.
5. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Publishers.
6. Quantum dot heterostructures, Wiley, 1999.
7. Modern magnetic materials: principles and applications, John Wiley & Sons, 2000.
8. Nano: The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
9. Nanobiotechnology, concepts, applications and perspectives, Wiley-VCH, 2004.

Nanoelectronics Lab

Credit Practical : 01 **Practical Lectures : 30h**

Course Learning Outcomes

At the end of this course, students will be able to

CO1 Choose appropriate technique for the synthesis of nanomaterials based on its type and application

CO2 Calculate the material parameters of nanomaterials using suitable characterization techniques.

CO3 Visit to Research laboratories/USIC and use advanced tools/techniques for synthesis and characterization of nanomaterials.

CO4 Prepare a technical reports of the experiments carried out.

Suggested List of Practicals (any 6 from the list, Practical no. 10 should preferably be included in the list)

1. Synthesis of at least two different sizes of Nickel Oxide/ Copper Oxide/ Zinc Oxide Nano Particles Using Sol- Gel Method
2. Polymer synthesis by suspension method / emulsion method
3. B-H loop of nanomaterials.
4. Magneto resistance of thin films and nanocomposite, I-V characteristics and transientresponse.
5. Particle size determination by X-ray diffraction (XRD) and XRD analysis of the given XRD spectra
6. Determination of the particle size of the given materials using He-Ne LASER.
7. Selective area electron diffraction: Software based structural analysis based on TEM based experimental data from published literature. (Note: Later experiment may be performed in the lab based on availability of TEM facility).
8. Surface area and pore volume measurements of nanoparticles (a standard sample and a new sample (if available)).
9. Spectroscopic characterization of metallic, semiconducting and insulating nanoparticles.
10. Visit to Research Lab/institutions to see the live demonstrations of synthesis and characterization of the processes.