M.Tech. in NANO TECHNOLOGY

II SEMESTER

DESIGN AND FABRICATION TECHNIQUES

Sub Code	**:**	**16NT21**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**04**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**50**	**Exam Marks**	**:**	**80**

Course Objectives

The learning objectives of the course are to provide students with the knowledge of miniaturization concept and Quantum mechanical aspects. Understand the principles of Nanofabrication process; determine the suitability of nanostructures for fabrication of devices. The course provides a strong theoretical and analytical understanding of nanostructures and devices fabrication process for its applications.

Module 1:

The Science Of Miniaturization

Miniaturization of Electrical and Electronic Devices, Moore's law and technology road map, Quantum Mechanical Aspects, Simulation of the Properties of Molecular Clusters, Formation of the Energy Gap, Confinement Effects, Discreteness of Energy Levels, Tunneling Currents.

10 Hours

Module 2:

Nanofabrication by Photons

Principles of Optical Projection Lithography, Process of Optical Lithography. Photoresists Characteristics. Optical Lithography at Shorter Wavelengths-Deep UV, Extreme UV and X-ray Lithography. Optical Lithography at High Numerical aperture, Near-Field Optical Lithography.

10Hours

Module 3:

Nanofabrication by Ion Beam

Introduction, Liquid Metal Ion Sources, Focused Ion Beam Systems , Ion Scattering in Solid Materials , FIB Direct Nanofabrication , Ion Sputtering, Ion Beam Assisted Deposition, Applications, Focused Ion Beam Lithography, Ion Projection Lithography .

10 Hours

Module 4:

Nanofabrication by Scanning Probes

Introduction, Principles of Scanning Probe Microscopes, Exposure of Resists- Exposure of Resist by STM, Exposure of Resist by NSOM, Additive Nanofabrication, Field Induced Deposition, Dip-Pen Nanolithography, Subtractive Nanofabrication-Electrochemical Etching, Field Induced Decomposition, Thermomechanical Indentation, Mechanical Scratching, High Throughput Scanning Probe Lithography.

10 Hours

Module 5:

Fabrication of micro/nano devices

Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Lithium Ion Battery and Super capacitors device fabrication, Operating and structure of Solar cells-CIGS solar cells, Dye-Sensitized solar cells, and Perovskite solar cell. MEMS and NEMS based devices

10 Hours

Text Book:

1. Guozhong Cao, Nanostructures & Nanomaterials Synthesis, Properties G; Z: Applications, World Scientific Publishing Private, Ltd., Singapore (2004).
2. W.R.Fahrner, Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques, SpringerVerlag Berlin, Germany (2006).
3. R. H. J. Hannink and A. J. Hill, Nanostructure control of materials, Woodhead Publishing Limited and CRC Press LLC, Cambridge, England (2006).
4. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science + business media, New York (2008).

Reference Book

1. Hari Singh Nalwa, Handbook of Nanostructured Materials and Nanotechnology (Vol. 3)- Electrical Properties, Academic Press, San Diego, USA (2000).
2. Huff, Howard, Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106), Springer Series in Materials Science, Springer-Verlag Berlin (2009).
3. Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, 2nd Edition, CRC Press, California, USA (2002).
4. Kostya (Ken) Ostrikov and Shuyan Xu, Plasma-Aided Nanofabrication: From Plasma Sources to Nanoassembly, WILEY-VCH Verlag GmbH & Co. KGaA (Weinheim) (2007).

Course Outcomes:

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

1. Understand and appreciate the importance of nanostructure and its impact device fabrication
2. Differentiate between nanofabrication process and understand the advantages and limitations of process for device fabrication
3. Understand the miniaturization of devices to Nano devices, process challenges and analyze theory for emerging Nano scale devices
4. Evaluate the advances in Nano scale technology and device fabrication their application in electronics, sensors, biomedical and energy generation and storage.

NANOELECTRONICS

Sub Code	**:**	**16NT22**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**04**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**50**	**Exam Marks**	**:**	**80**

Course Objectives:
The learning objectives of the course in nanoelectronics are to understand the importance of nanoelectronics, technology roadmap in nanoelectronics and limitations of existing CMOS technologies for design of electronic circuits. The course provides an insight on the advances in nanoelectronics devices such as High-K devices, FINFETs, CNTFETs, Molecular Electronics and Spintronics. The course provides a strong theoretical and analytical understanding of nanoelectronic devices and its applications in design of electronic circuits.

Course Syllabus:
Module 1:
Introduction to nanoelectronics: Technology roadmap of nano-electronics, Scaling of devices and technology jump, Challenge of the CMOS technologies, More-Moore and More-than-Moore. Review of semiconductor devices, Quantum statistical mechanics, Energy bands in silicon, **Metal Oxide Semiconductor Field Effect Transistors (MOSFET),** MOSFET Operation, Threshold Voltage and Subthreshold Slope, Current/voltage characteristics, Finite Element Modeling of MOS, CMOS technology, Challenges of the CMOS technologies, High-k dielectrics and Gate stack, Future interconnect.

10 Hours

Module 2:
Nanoscale MOSFETs: MOSFET as digital switch, Propagation delay, Dynamic and static power dissipation Moore’s law, Transistor scaling, Constant field scaling theory, Constant Voltage Scaling, Generalized scaling, Short channel effects, Reverse short channel effect, Narrow width effect, Subthreshold conduction leakage, Subthreshold slope, Drain Induced Barrier Lowering, Gate Induced Drain Leakage, Design of NanoMOSFET, Halo implants, Retrograde channel profile, Shallow source/drain extensions, Twin well CMOS process flow, Gate Tunneling : Fowler Nordheim and Direct Tunneling, High k gate dielectrics, Metal gate transistor, Transport in Nanoscale MOSFET, Ballistic transport, Channel quantization.

12 Hours

Module 3:
Designing with FINFETs: Evolution of FinFET, Principle of FinFET, Finfet Technology, FinFET Schematic, Compact Drain-Current equation, Small Signal Model of Si- Based FinFET, FinFET Fabrication Flow, Power dissipation in FinFETs, Leakage power reduction techniques, Power gating, Dual sleep, Dual stack, Sleepy stack, Basic gate design using FinFET’s, combinational logic, sequential logic, Adders, Multiplier, SRAM cell design

10 Hours

Module 4:
Designing with CNTFETs: Introduction to CNTs, CNT structure, metallic and semiconductor CNTs, energy bands in CNTs, types of CNTs: Single walled and multiwalled, physical, electrical and thermal properties of CNTs, fabrication of CNTs. CNTFETs, structure and model, small signal model, predictive technology models, N-Channel and P-Channel CNTFETs, model files of CNTFETs, basic gates using CNTFET, VI characteristics

of CNTFET based inverter, designing of sub systems using CNTFETs, combinational and sequential circuits using CNTFETs, adders, multipliers and SRAM cell using CNTFETs.

10 Hours

Module 5:

Advances in Nanoelectronics: MOLECULAR NANOELECTRONICS: Electronic and optoelectronic properties of molecular materials, TFTs- OLEDs- OTFTs – logic switches, SPINTRONICS: Spin tunneling devices - Magnetic tunnel junctions- Tunneling spin polarization, -spin diodes - Magnetic tunnel transistor - Memory devices and sensors - ferroelectric random access memory- MRAMS

08 Hours

Course Outcomes:

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

1. Understand and appreciate the importance of nanoelectronics and its impact in next generation electronics and electronic products
2. Differentiate between MOS and emerging nanodevices technology, understand the advantages and limitations of MOS based circuits
3. Understand the technology migration from MOS to nano devices, process challenges and analyze the mathematical models for emerging Nanoscale devices
4. Design logic circuits, sub systems and complex digital circuits using FINFETs and CNTFETs
5. Evaluate the advances in Nanoscale technology development and understand the importance of emerging devices and technologies of molecular electronics and spintronics

Text Books:

1. Yuan Taur and Tak H. Ning, Fundamentals of Modern VLSI Devices, Cambridge
2. Karl Goser, Peter Glosekotter, Jan Dienstuhl, ―Nanoelectronics and Nanosystems‖, Springer (2004)
3. Cyril Prasanna Raj P., Designing with FINFETs and CNTFETs, MSEC E-Publication (2016)
4. Sadamichi Maekawa, ―Concepts in Spin Electronics‖, Oxford University Press (2006)

Reference Books:

1. V. Mitin, V. Kochelap, M. Stroscio, Introduction to Nanoelectronics, Cambridge University Press (2008)
2. Edward L. Wolf, ―Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience‖, Wiley-VCH (2006)
3. Streetman and Banerjee, Solid State Electronic Devices, Prentice-Hall
4. Rainer Waser, ―Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH

ADVANCED MATERIALS

Sub Code	**:**	**14INT23**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**04**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**50**	**Exam Marks**	**:**	**80**

Course Objective

Provide foundation about crystal structure, arrangement of atoms in different structure. Course gives an over view of various advance materials and their application. Enrich students with advanced material science techniques.

Course Content

Module 1:

Crystal structure: Crystal systems, Crystal classes, Bravais lattice. Unit cell: Wigner-Seitz cell, equivalent positions in a unit cell. Notations of planes and directions. Atomic packing: packing fraction, Co-ordination number. Examples of simple crystal structures: NaCl, ZnS and diamond. Symmetry operations, point groups and space groups.

10 Hours

Module 2:

Crystal bonding: Types of bonding. Van der Waals-London interaction, Repulsive interaction. Modelung constant. Born's theory for lattice energy in ionic crystals and comparison with experimental results. Ideas of metallic binding, Hydrogen bonded crystals. Vibrations of monoatomic lattices. First Brillouin zone. Quantization of lattice vibrations - Concept of Phonon, Phonon momentum. Specific heat of lattice (qualitative).

10 Hours

Module 3:

Photonic Materials: Need for New Photonic Materials, composite materials for nonlinear optics, nanostructured waveguides for nonlinear optics quantum and nonlinear optics for advanced imaging applications.

Spintronics Materials: Modeling the growth of Mn on semiconductor substrates, Dilute magnetic semiconductor nanocrystals, Advances in wide bandgap materials for semiconductor spintronics

10 hours

Module 4:

Smart Materials and Systems: Thermoresponsive materials, piezoelectric materials, electrostrictive and magnetostrictive materials, Magnetic materials, superparamagntism in metallic nanoparticles, Giant and colossal magnetic materials, ferrofluids, ER and MR fluids, biomimetic materials, smart gel, shape memory alloys and polymers.

10 Hours

Module 5:

Advanced Materials in Catalysis: Bimetallic Catalysts, Supported Bimetallic Catalysts, Graphite Intercalation Compounds as catalysts, Carbides, Nitrides, and Borides for Catalysis, Synthetic Layered Silicates and Aluminosilicates; Complex Catalysts on Inorganic Supports.

Advanced materials in Biomedical Application: Zeolite Structures as Drug Delivery Systems, Mesoporous Silica Nanoparticles and Multifunctional Magnetic Nanoparticles in Biomedical Applications, Metal-Organic Frameworks for Biological and Medical Applications

10 Hours

Text Books

1. Introduction to Solid State Physics, C. Kittel, Wiley Eastern
2. A practical approach to X-Ray diffraction analysis by C.Suryanarayana
3. Semiconductor Physics, P. S. Kireev, MIR Publishers.

References

1. Solid State Physics, A. J. Dekkar, Prentice Hall Inc.
2. Introduction to Superconductivity, M. Tinkham, McGraw-Hill, International Editions
3. Elementary Solid State Physics: Principles and applications, M. A. Omar, Addison-Wesley.
4. Advanced Materials in Catalysis, Frank Bolz, Academic Press, 1977
5. Advanced Healthcare Materials Tiwari, A. (ed) (2014), John Wiley & Sons, Inc., Hoboken, NJ, USA.

Course Outcome:

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

1. Understand the crystal structure and characterization of various nanomaterials
2. Evaluate the characteristic crystal structure and their influence on properties of the materials.
3. Demonstrate their knowledge in advanced material science which helps in applications of various materials in engineering applications.

CHARACTERIZATION TECHNIQUES

Sub Code	**:**	**14INT24**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**04**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**50**	**Exam Marks**	**:**	**80**

Course Objective:

The course aims at providing overview of various characterization techniques. Analyze the data obtained from different techniques and evaluate size, structure, morphology and properties of nanomateirals.

Module 1:

X-Ray based characterization: Principles and applications of X-ray diffraction, powder (polycrystalline) and single crystalline XRD techniques; Debye-Scherrer equation to treat line broadening and strain induced in nanoparticles and ultra-thin films. Basics of structure refinement (Reitveld). Rotating anode and synchrotron based X-ray diffraction for probing structure. X-ray photoelectron spectroscopy – basic principle, instrumentation, X-ray absorption techniques: XANES, EXAFS.

12 Hours

Module 2:

Electron microscopy techniques: Introduction, Principles and applications of Electron beam, Electron beam interaction with matter. Scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM/HRTEM), Electron-diffraction, SAED**.** Scanning Probe Microscopy: Principles and applications, Atomic Force Microscope, Scanning Tunneling Microscope.

12 Hours

Module 3:

Spectroscopic techniques: UV-VIS Spectrophotometers, IR/FTIR Spectrophotometers, Principles, operation and application for band gap measurements. Raman spectroscopy principles and applications. Optical microscope: Nanoparticle size measurement by Dynamic light scattering methods zeta potential.

10 Hours

Module 4:

Magnetic characterization: Types of magnetic materials, Magnetic susceptibility, Curie-Weis plot for paramagnetic materials, Neel temperature, Curie temperature VSM and SQUID magnetometers – M vs H, M vs T, MH-loops.

10 Hours

Module 5:

Electrical measurements: Cyclic Voltameter, Impedence Measurement, IV, AC and DC electric measurements, impedance spectral information.

06 Hours

Text Books

1. Characterization of Nanostructure materials by XZ.L.Wang
2. Instrumental Methods of Analysis, 7th edition- Willard, Merritt, Dean, Settle
3. *Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology)- Roland Wiesendanger*

Reference Books

1. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition
   - Harold P. Klug, Leroy E. Alexander
2. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set**)-** David B. Williams and C. Barry Carter
3. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM **- Ray F. Egerton**

Course Outcome:

Students will be able to

1. Identify the characterization technique suitable for their studies
2. Analyze the data from various characterization techniques used to evaluate nanomaterial structure, size, morphology and properties.
3. Understand the size and structure relationship and their suitability for an given engineering application.

ELECTIVES – II

SENSORS AND ACTUATORS

Sub Code	**:**	**16NT251**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**03**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**40**	**Exam Marks**	**:**	**80**

Course Objectives

The learning objectives of the course are to Understand the basic concept and features of sensors. Learn the relation between physical effects on the main sensing/transduction mechanisms. Determine the suitability of nanostructures for sensors application. Knowing how to gather, interpret and use scientific and technical information on sensors and biosensors. The course provides a strong theoretical and analytical understanding of Nano sensor and their application

Module 1:

Fundamentals of sensors: Micro and nano-sensors, biosensor, packaging and characterization of sensors, method of packaging at zero level, and first level. Thermal energy sensors: temperature sensors, heat sensors, electromagnetic sensors, electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetic sensors, Mechanical sensors, pressure sensors, gas and liquid flow sensors, position sensors, chemical sensors, optical and radiation sensors- gas sensor.

08 Hours

Module 2:

Sensor Characteristics and Physical Effects:

Active and Passive sensors – Static characteristic: Accuracy, offset and linearity – Dynamic characteristic: First and second order sensors, Physical effects involved in Signal Transduction: Photoelectric effect – Photodielectric effect, Photoluminescence Effect – electroluminescence effect – chemiluminescence effect, Doppler effect, Barkhausen effect, Hal effect – nernst / Ettinshausen effect, Thermoelectric effect – Peizoresistive effect – piezoelectric effect, pyroelectric effect, magneto-mechanical effect (magnetostriction) – Magnetoresistive effect, Faraday-Henry Law, magneto optice Kerr effect, Kerrand Pockels Effect.

08 Hours

Module 3:

Sensor Architecture and Classification:

Sensor characteristics : linearity, repeatability, hysteresis and drift. Sensor models in the time & frequency domains. Sensors for physical measurands: strain, force, pressure, acceleration, flow, volume, temperature and biopotentials. **Nano based Inorganic Sensors:** One dimensional gas sensors:- gas sensing with nanostructured thin films, absorption on surfaces, metal oxide modifications by additives, surface modifications, Nano optical sensors, nano mechanical sensors, plasmon resonance sensors with nano particles, AMR, Giant and colossal magnetoresistors, magnetic tunneling junctions.

08 Hours

Module 4:

Actuators: What is an actuator, Transducing materials as a basis for actuator design, Energy domains and transduction phenomena, Transducer basics, The role of the actuator in a control system: sensing, processing and Actuation- Impedance matching. Emerging versus traditional actuator, Other actuator technologies - Electrostatic actuators, Thermal, Magnetic shape memory actuators , Piezoelectric actuators

08 Hours

Module 5:

Biological Sensors-2: Noninvasive Biosensors in Clinical Analysis. Applications of Biosensor-based instruments for the bioprocess industry. Application of Biosensors for environmental samples. Introduction to Biochips and their application to genomics. BIAcore, an optical Biosensor. Photoinduced Electron Transport in DNA: Electronic Devices Based on DNA Architecture, DNA Nanowires, Charge Transport, DNA-Based Nanoelectronics, Electrical Manipulation of DNA on Metal Surfaces, Nanostructured Biocompartments, DNA-Gold nanoconjugates.

08 Hours

Text Books

1. Nanotechnology enabled sensors by Kouroush Kalantar – Zadeh, Benjamin Fry, Springer Verlag New York, (2007)
2. Biosensing: International Research and Development, Jerome Schultz, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins, Springer 2006
3. Sensors and signal conditioning, 2nd edition Ramon Pallas-Areny, John G. Webster John Wiley & Sons (2001).

References:

1. Handbook of Biosensors and Electronic Noses: Medicine, Food and the Environment: CRC-Press; 1 edition;1996.
2. D. L. Wise, Biosensors: Theory and Applications, CRC Press,1993.
3. Rao & Guha, Principles of Medical Electronics & Biomedical Instrumentation, Orient Longman.2001.

Course outcome

Students will be able to

1 Demonstrate the basics knowledge of sensors and actuators

2 Interpretat and analyze the signal data from sensors measurement

3 Applications of nanostructures in sensors and actuators

MEMS AND NEMS

Sub Code	**:**	**16NT252**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**03**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**40**	**Exam Marks**	**:**	**80**

Course Objectives

1. Learn about basics and typical applications of microsystems
2. Illustrate scaling laws & microsensors and microactuators
3. Illustrate the various principles of operations of mems transducers
4. Learn basic electrostatics and its applications in MEMS sensors and actuators
5. Learn about ways to fabricate& a packaging needs MEMS device

Course Content

Module 1:

Introduction to MEMS : Historical background of Micro Electro Mechanical Systems, Feynman' s vision, Nano Technology and its Applications Multi-disciplinary aspects, Basic Technologies, Applications areas, Scaling Laws in miniaturization, scaling in geometry, electrostatics, electromagnetic, electricity and heat transfer.

10 Hours

Module 2:

Micro and Smart Devices and Systems: Principles : Transduction Principles in MEMS Sensors: Micro sensors-thermal radiation, mechanical and bio-sensors, Actuators: Different actuation mechanisms - silicon capacitive accelerometer, piezo-resistive pressure sensor, blood analyzer, conductometric gas sensor ,silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic comb-driver , Smart phone application, Smart buildings

10 Hours

Module 3 :

Materials and Micro manufacturing: Semiconducting Materials., Silicon, Silicon dioxide, Silicon Nitride , Quartz, Poly Silicon, Polymers, Materials for wafer processing, Packaging Materials Silicon wafer processing, lithography, thin-film deposition, etching (wet and dry), wafer-bonding. Silicon micromachining: surface, bulk, LIGA process, Wafer bonding process.

10 Hours

Module 4:

Electrical and Electronics aspects: Electrostatics, Coupled Electro mechanics, stability and Pull-in phenomenon, Practical signal conditioning Circuits for Microsystems. Characterization of pressure sensors, RF MEMS. Switches varactors , tuned filters. Micromirror array for control and switching in optical communication, Application circuits based on microcontrollers for pressure sensor, Accelerometer, Modeling using CAD Tools (Intellisuite)

10 Hours

Module 5:

Integration And Packaging Of Microelectromechanical Systems: Integration of microelectronics and micro devices at wafer and chip levels. Microelectronic packaging: wire and ball bonding, flip-chip. Microsystem packaging examples, Testing of Micro sensors, Qualification of Mems devices

10 Hours

Text Book:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. K. Aatre, "Micro and Smart Systems", Wiley India, 2010.
2. T R Hsu, "MEMS and Microsystems Design and Manufacturing", Tata McGraw Hill, 2nd Edition, 2008

Reference Books

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. S. D. Senturia, "Micro System Design", Springer International Edition, 2001.

Course outcome

Students will be able to

1. Understand the basics and develop applications for microsystems
2. operations of mems transducers
3. Applications of electrostatics in MEMS sensors and actuators
4. Fabricate MEMS device

NANOTECHNOLOGY AND DRUG DELIVERY SYSTEMS

Sub Code	**:**	**16INT253**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**03**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**40**	**Exam Marks**	**:**	**80**

Course Objective:
Students will learn underlying principles of drug delivery systems. Understand the application of nanostructures as drug delivery systems. Nanoparticles based drug formulation for cancer therapy and bio imaging application.

Course Content
Module 1:
Principles of drug delivery systems (DDS): Design of drug delivery systems, Aims of DDS, Modes of drug delivery, ADME hypothesis – controlled drug delivery, site specific drugs , barriers for drug targeting, passive and active targeting, Strategies for site specific, time and rate controlled delivery of drugs, antibody based and metabolism-based targeting.

8 Hours

Module 2:
Nano sized Drug Carriers: Structure and Preparation- Liposomes, Cubosomes and Hexosomes, Solid Lipid Nanoparticles (SLP). Lipid based colloidal system, Liposomal Drug Carriers, Dendrimer (PAMAM), Polymer Micelle, Ceramic and Magnetic nanoparticle, Polymer drug conjugates. Nanotubes, Nanowires, Nanocage, Nanorods, Nanofibers, and Fullerenes, Carbon nanotubes biocompatibility. Smart drug delivery systems, Multifunctional Drug carriers, organic and inorganic composites. Problems with DDS, Drug loading efficiency in nanovehicles, complexity of Nanocarriers, interface between synthetic materials and biological tissues or components, safety and ethical issues, Nanotechnology for future DDS.

08 Hours

Module 3:
Drug Discovery & Cancer therapy: Drug Discovery Using Nanocrystals, Drug Discovery Using Resonance Light Scattering (RLS) Technology. Nanosensors in Drug Discovery, Drug Delivery Applications, Nanorobots, Benefits of Nano-Drug Delivery. Use of microneedles and nanoparticles for local highly controlled drug delivery. Metal nanoparticles in drugs discovery. Nanotechnology for Cancer therapy-Nanobodies, Nanoparticles, nanoshells, Nanobombs, pebbles for brain tumor therapy, Targeting through angiogenesis and Folate receptors Liposomal formulation in cancer therapy, application of liposomes in pharmaceutical and cosmetic applications.

08 Hours

Module 4:
Nanomedicines: Introduction, Applications of nanobiotechnology in medicine, Role of nanotechnology in methods of treatment, Nanomedicines for Nervous system, Developing Nanomedicines, Protocols for nanodrug Administration, Nanotechnology in Diagnostics applications, materials used in Diagnostics and Therapeutic applications - Molecular Nanomechanics, Molecular devices, Nanomedicines for Skin disorders, wound healing, eye diseases, infections, Nanotubes for detection and destruction of bacteria.

08 Hours

Module 5:

Nanoanalytics: Nanoparticles for biological labelling, Nano-Imaging Agents, Nano particles molecular labels, Immunogold-silver staining, combined fluorescent and gold probes, Protein Labeling, gold cluster labelled peptides, gold cluster conjugates of other small molecules, gold-lipids metallosomes, Larger covalent particles labels, gold targeted to His Tabs, gold cluster nanoscrystals.

08 Hours

Text Books

1. Nanotechnology in Drug Delivery: Melgardt M. de Villiers, Pornanong Aramwit, glen s. Kwon, Springer, 2009
2. NanoBiotechnology: BionInspired Devices and Materials for the Future: Oded Showeyov, Ilan Levy, Humana Press, New Jersey 2010
3. Nanobiotechnology, Concepts applications and Perspectives: C. M. Niemeyer and Chad A. Mirkin, Wiley VCH, 2009

Reference

1. Bionanotechnology Global prospects II: david E Reisner, CRC Press 2012
2. Nanoparticulate Drug Delivery Systems Deepak Thassu, Michel Deleers (Editor), Yashwant Pathak
3. Drug Delivery and Targetting, A.M.Hillery, CRC Press, 2002.
4. Bio-Applications of Nanoparticles Warren C.W. Chan
5. Lisa Brannon-Peppas, James O. Blanchette Nanoparticle and targeted systems for cancer therapy Advanced Drug Delivery Reviews 56 (2004) 1649– 1659

Course Outcome:

Students will be able to

1. Demonstrate the knowledge to develop nanoparticle based new types of biomedical markers and therapeutic agents.
2. Evaluate the suitable nanostructure for drug delivery systems application.
3. Develop nanoparticles based drug formulation for cancer therap.

NANOPHTONICS

Sub Code	**:**	**16INT254**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**03**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**40**	**Exam Marks**	**:**	**80**

Course Objective:
The course gives an introduction to basic concepts of nanophotonics. It also provides overview of various semiconductor nanomaterials and their characteristics features along with its applications.

Course Content
Module 1:
Introduction to Nanophotonics:
Nano photonics at a Glance, Multidisciplinary approach, Photons and Electrons: Similarities and Differences, Propagation, Nanoscale Optical Interaction, Free-Space Propagation, Confinement of Photons and Electrons, Nanoscale Confinement of Electronic Interactions.

08 Hours

Module 2:
Quantum-Confined Materials and characterization
Inorganic Semiconductors, Quantum Wells, Wires Dots, Rings, Manifestations of Quantum Confinement Dielectric Confinement Effect, Super lattices, Core-Shell Quantum Dots and Quantum Dot-Quantum Wells Quantum-Confined Structures as Lasing Media, Organic Quantum-Confined Structures, Characterization of Nanomaterials, Different techniques- X Ray, Electron Microscopy.

08 Hours

Module 3:
Photonic Crystals
Basics Concepts, Theoretical Modeling of Photonic Crystals, Features of Photonic Crystals, Methods of Fabrication , Photonic Crystal Optical Circuitry, nonlinear Photonic Crystals, Photonic Crystal Fibers (PCF), Photonic Crystals and Optical Communications, Photonic Crystal Sensors.

08Hours

Module 4:
Nanolithography
Two-Photon Lithography, Near-Field Lithography, Near-Field Phase-Mask Soft Lithography, Plasmon Printing, Nanosphere Lithography, Dip-Pen Nanolithography, Nanoimprint Lithography, Photonically Aligned Nanoarrays.

08 Hours

Module 5:
Silicon Photonic Applications
Communications and Interconnects, Radio-over-fiber (RoF) RF Applications, Nonlinear Optical Effects in Silicon and Applications, Silicon Amplifiers and Lasers, Wavelength Conversion, Sensing - Physical Sensors, Chemical Sensors, Biochemical Sensors, Integrated Lab-on-a-chip, Power Generation and Conversion, Information Technology, Sensor Technology, Nanomedicine.

08 Hours

Text Books

1. Paras N Prasad, Nanophotonics, Wiley Interscience, 2004
2. Graham T Reed, Silicon Photonics, John Wiely and Sons, 2008
3. David G. Bucknall. Nanolithography and patterning techniques in microelectronics, CRC Press,

Course Outcome:

Students will be able to

1. Understand the basic principles involved photonics and electronics applications
2. Demonstrate knowledge about photonic, semiconductor nanostructures in developing their applications
3. Knowledge to apply nanolithography for nanphotonics based devices.

DEVICE FABRICATION AND MEASUREMENT LAB

Sub Code	**:**	**16INT26**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**03**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**36**	**Exam Marks**	**:**	**80**

Course Objective:
The learning objectives of the course are
Knowledge to design and develop the nanostructured based devices, hands on experience to fabricate the devices based on nanomaterials, Knowledge of device operation and data measurement and analyze the device performance and application.

1. Gas/Pressure Sensors device fabrication and device parameter measurement and analysis
2. Dye sensitized solar cell device fabrication, I-V measurement and Efficiency calculation
3. To preparation of electrodes for supercapacitor and calculate its specific capacitance using Cyclic voltammetry.
4. To fabricate metal oxide thin/thick film and analyze surface features using AFM
5. Fabrication of thin/thick films and its Crystal structure analysis using XRD
6. Design and Synthesis of 1D inorganic nanostructures and analyze their size and morphology by scanning electron micrograph
7. Preparation of 2D nanostructures and measure their thickness and morphology by AFM.
8. Modification of electrodes by nanomaterial for voltammetric applications
9. Fabrication of electrode for electrochemical oxidation of organic molecules.
10. Battery device Fabrication and its performance data analysis.

Course Outcome:
Students will be able to
1. Design the nanomaterial for suitable application
2. Basic hands on experience to fabricate selected nanomaterials based devices
3. Knowledge to operate the device and measure data .