JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

Revised Course Structure and Syllabi for
M.Tech- Micro & Nano Electronics
Offered by Department of ECE
for Affiliated Engineering Colleges 2012-13

I YEAR I Semester

S. No	Course code	Subject	Theory	Lab.
1.	12D86101	Advanced Computing Methods	4	0
2.	12D86102	Microelectronic Technology & IC fabrication	4	0
3.	12D86103	Materials for Nanotechnology	4	0
4.	12D86104	Micro sensors & Actuators	4	0
5	12D86105	Nano CMOS Circuits & Physical Design	4	0
6.	12D86106 9D06101 12D86107	Elective – I a. Quantum Electronics b. Digital System Design c. Measurements and Characterization	4	0
7.	12D68105	Simulation and Synthesis Lab		3
		Contact periods/week	24	3
		Total	27	

II YEAR II Semester

S. No	Course code	Subject	Theory	Lab.
1.	12D86201	MEMS/NEMS Design	4	
2.	12D86202	Carbon Nanotubes and Applications	4	
3.	12D86203	Nano BioTechnology	4	
4.	12D86204	Nanosensors	4	
5.	12D86205	Nano Fabrication Techniques	4	
6.	12D86206 12D86207 12D86208	Elective – II a. Nano Medicine b. Packing Technology c. Industrial Nanotechnology	4	
7.	12D86209	Nanosensors Lab		3
		Contact periods/week	24	3
		Total	27	

II YEAR (III & IV Semesters)

S. No	Course code	Subject
1	12D86401	Seminar
2	12D86402	Project work

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(12D86101) ADVANCED COMPUTING METHODS

UNIT I

Complex Variables - I: Elements of set theory, Set notations, Applications of set theory, Open & Closed Sets. Review of Complex variables, Conformal mapping and transformations.

UNIT II

Complex Variables - II: Functions of complex variables, Integration with respect to complex argument, Residues and basic theorems on residues.

UNIT III

Numerical Analysis - I: Introduction, Interpolation formulae, Difference equations, Roots of equations, Solutions of simultaneous linear and non-linear equations,

UNIT IV

Numerical Analysis - II: Solution techniques for ODE and PDE, Introduction to stability, Matrix Eigen value and Eigen vector problems.

UNIT - V

Optimization Technique - I: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization.

UNIT - VI

Optimization Technique - II: Elements of calculus of variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.

UNIT - VII

Probability and Statistics - I: Definition and postulates of probability, Field of probability, Mutually exclusive events, Bayes' Theorem, Independence, Bernoulli trial.

UNIT - VIII

Probability and Statistics - II: Discrete Distributions, Continuous distributions, Probable errors, Linear regression, Introduction to non-linear regression, Correlation, Analysis of variance.

TEXT BOOK :

1. Sen, M. K. and Malik, D. Fundamentals of Abstract Algebra- , Mc. Graw Hill
2. Khanna, V. K. and Ghamdri, S. K.- Course of Abstract Algebra, Vikash Pub.
3. Halmos, T. R.-Naive Set Theory, Van Nostrand
4. Scarborough, J. B.-Numerical Mathematical Analysis, Oxford University Press
5. Cone, S. D.-Elementary Numerical Analysis, Mc. Graw Hill.
6. Mukhopadhyay, P.-Mathematical Statistics ,New Central Book Agency
7. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.

8. Uspensky, J. V.-Introduction to Mathematical Probability, Tata Mc. Graw Hill
9. Dreyfus, S. E.-The Art and Theory of Dynamic Programming –Theory and Applications, Academic Press.
10. Rao, S. S.-Optimisation Theory and Application, Wiley Eastern Ltd., New Delhi

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(12D86102) MICRO ELECTRONIC TECHNOLOGY & IC FABRICATION

UNIT I (MINIATURIZATION TECHNOLOGY)

INTODUCTION TO MEMS

Introduction, Why Use Miniaturization Technology? From Perception to Realization, Overall MEMS Market Size, MEMS Market Character, MEMS Based on Si, Non-Silicon MEMS,MEMS versus Traditional Precision Engineering The Times are a 'Changing

UNIT II (INTRODUCTION TO LITHOGRAPHY)

LITHOGRAPHY

Introduction , Historical Note: Lithography's Origins, Photolithography Overview Critical Dimension, Overall Resolution, Line-Width , Lithographic Sensitivity and Intrinsic Resist Sensitivity (Photochemical Quantum Efficiency), Resist Profiles, Contrast and Experimental Determination of Lithographic Sensitivity Resolution in Photolithography Photolithography Resolution Enhancement Technology Beyond Moore's Law Next Generation Lithographies Emerging Lithography Technologies

UNIT III (DRY TECHNOLOGY)

PATTERN TRANSFER WITH DRY ETCHING TECHNIQUES

Introduction, Dry Etching: Definitions and Jargon, Plasmas or Discharges Physical Etching: Ion Etching or Sputtering and Ion-Beam Milling, Plasma Etching (Radical Etching) Physical/Chemical Etching

UNIT IV (ADDITIVE TECHNOLOGY)

PATTERN TRANSFER WITH ADDITIVE TECHNIQUES

Introduction , Silicon Growth, Doping of Si , Oxidation of Silicon, Physical Vapor Deposition , Chemical Vapor Deposition, Silk-Screening or Screen-Printing , Sol-Gel Deposition Technique ,

Doctors' Blade or Tape Casting, Plasma Spraying, Deposition and Arraying Methods of Organic Layers in BIOMEMS, Thin versus Thick Film Deposition , Selection Criteria for Deposition Method

UNIT V (SUBTRACTIVE TECHNOLOGY)

WET BULK MICROMACHINING

Introduction, Historical Note, Silicon Crystallography , Silicon As Substrate Silicon As A Mechanical Element In MEMS , Wet Isotropic And Anisotropic Etching Alignment Patterns , Chemical Etching Models, Etching With Bias And/Or Illumination Of The Semiconductor, Etch-Stop Techniques, Problems With Wet Bulk Micromachining

UNIT VI (PROCESS TECHNOLOGIES)

SURFACE MICROMACHINING

Introduction, Historical Note, Mechanical Properties of Thin Films, Surface Micromachining Processes , Poly-Si Surface Micromachining Modifications, Non-Poly-Si Surface Micromachining Modifications , Materials Case Studies

LIGA AND MICROMOLDING

Introduction, LIGA-Background, LIGA and LIGA-Like Process Steps

UNIT VII (MINIATURIZATION TECHNIQUES)

A COMPARISON OF MINIATURIZATION TECHNIQUES: TOP-DOWN AND BOTTOM-UP MANUFACTURING

Introduction, Absolute and Relative Tolerance in Manufacturing , Historical Note: Human Manufacturing, Section I: Top-Down Manufacturing Methods,Section II: Bottom-Up Approaches

MODELING, BRAINS, PACKAGING, SAMPLE PREPARATION AND NEW MEMS MATERIALS

Introduction, Modeling, Brains In Miniaturization, Packaging, Substrate Choice

UNIT VIII (MINIATURIZATION APPLICATIONS)

SCALING, ACTUATORS, AND POWER IN MINIATURIZED SYSTEMS

Introduction , Scaling, Actuators, Fluidics, Scaling In Analytical Separation Equipment, Other Actuators , Integrated Power

MINIATURIZATION APPLICATIONS: Introduction, Definitions and Classification Method, Decision Three

Text book:

1.Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition: The Science of Miniturization, Marc J. Madou, 2nd Edition

References:

1.process engineering analysis in semiconductor device fabrication by Stanley Middleman and Arthur k.kochberg,McGraw Hill 1993

2.Itching in Microsystem technology by Michael Kohler,1999

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(12D86103) MATERIALS FOR NANOTECHNOLOGY

UNIT I

Introduction to nanomaterials, Properties of materials & nanomaterials, role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state

UNIT II

Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and coprecipitation;

UNIT-III

Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis;

UNIT IV

Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids

UNIT V

Self Assembly and catalysis: Process of self assembly, semiconductors islands, monolayers, nature of catalysis, porous materials, pillared clays, colloids, biometrics.

UNIT VI

Fabrication of Nanomaterials by Physical Methods: -Inert gas condensation, Arc discharge, Plasma arc technique, RF plasma, MW plasma, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition.

UNIT VII

M based nanolithography and nanomanipulation, E beam lithography and SEM

basednanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography.

UNIT VIII

Nanocomposites: An Introduction: Types of Nanocomposite (i.e. metal oxide, ceramic,glass and polymer based); Core-Shell structured nanocomposites.applications and milestones.

REFERENCES:

1. Nanochemistry: A chemical approach to nanomaterials by G. A. Ozin, A. C. Aresnault, L. Cadematriri, RSC Publishing

2. Microfabrication and Nanomanufacturing- Mark James Jackson

3. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.

4. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.

5. Fabrication of fine pitch gratings by holography, electron beam lithography and nano- imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim;

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(12D86104) MICRO SENSORS & ACTUATORS

UNIT I

Introduction - Sensing and Actuation: Case Studies of Real Devices.

UNIT II

Sensing mechanism: piezoresistive, piezoelectric, capacitive and others (tunneling, optical), Actuation mechanism: piezoelectric, Electrostatic, Magnetic, and Thermal.

UNIT III

Physical Sensors - Pressure sensors and microphones, Accelerometers, Gyroscopes, Force sensors

UNIT IV & UNIT V

Optofluidics - Optical forces, Electro-kinetics, Biosensors, MEMS devices for DNA analysis and medical applications.

UNIT VI

Sensors and actuators for turbulent flows: Introduction, MEMS fabrication, turbulent flows, Sensors for turbulence measurement and control, micro-actuators for flow control.

UNIT VII

RF MEMS Elements and modeling: Capacitors, Varactors, Inductors, Resonators, and Switches.

UNIT VIII

RF MEMS applications: RF MEMS filters, oscillators, phase shifters.

TEXT BOOKS:

1. Kovacs, G.T.A., Micromachined Transducers Sourcebook, McGraw-Hill, 1998
2. Maluf, N. An Introduction to Microelectromechanical Systems Engineering, Artech House Mems Library, 2000

3. Beeby, S., Ensell, G., Kraft, W. and White, N., MEMS Mechancial Sensors, Artech House 2004
4. Senturia, S.D Microsystem Design, Kluwer, 2001.

REFERENCE BOOKS:

1. IEEE/ASME Journal of Microelectromechanical Systems, Sensors and Actuators: A, IOP Journal of Micromechanics and Microengineering
2. Héctor J. De Los Santos, RF MEMS Circuit Design for Wireless Communications, Artech House, London, 2002.
3. Mohamed Gad-el-Hak, The MEMS Handbook, CRC Press, New York, 2002.

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(12D86105) NANO – CMOS CIRCUIT AND PHYSICAL DESIGN

UNIT I

NANO-CMOS SCALING PROBLEMS AND IMPLICATIONS

Design Methodology in the Nano-CMOS Era, Scaling, Overview of Sub-100-nm Scaling Challenges and Subwavelength Optical Lithography, Back-End-of-Line Challenges (Metallization), Front-End-of-Line Challenges (Transistors), Process Control and Reliability Lithographic Issues and Mask Data Explosion, New Breed of Circuit and Physical Design, Modeling Challenges, Need for Design Methodology Changes.

UNIT II

THEORY AND PRACTICALITIES OFSUBWAVELENGTH OPTICAL LITHOGRAPH

Introduction and Simple Imaging Theory, Challenges for the 100-nm Node, ê-Factor for the 100-nm Node, Significant Process Variations, Impact of Low-ê Imaging on Process-Sensitivities, Low-ê Imaging and Impact on Depth of Focus, Low-ê Imaging and Exposure Tolerance, Low-ê Imaging and Impact on Mask Error, Enhancement Factor, Low-ê Imaging and Sensitivity to Aberrations ,Low-ê Imaging and CD Variation as a Function of Pitch, Low-ê Imaging and Corner Rounding Radius.

UNIT III

RESOLUTION ENHANCEMENT TECHNIQUES

Physics, Specialized Illumination Patterns, Optical Proximity Corrections, Subresolution Assist Features, Alternating Phase-Shift Masks, Physical Design Style Impact on RET and OPC Complexity, Specialized Illumination Conditions- Two-Dimensional Layouts, Alternating Phase-Shift Masks, Mask Costs.

UNIT IV

PROCESS SCALING IMPACT ON DESIGN

Introduction - Design Considerations, Device Modeling, Passive Components, Design Methodology – Benchmark Circuits.

UNIT V

MIXED-SIGNAL CIRCUIT DESIGN

Design Using Thin Oxide Devices - Design Using Thick Oxide Devices, Low-Voltage Techniques, Current Mirrors, Input Stages, Output Stages, Band gap References, Design Procedures, Electrostatic Discharge Protection, Multiple-Supply Concerns, Noise Isolation, Guard Ring Structures, Isolated NMOS

Devices, Epitaxial Material versus Bulk Silicon, Decoupling, Power Busing, Integration Problems, Corner Regions, Neighboring Circuitry.

UNIT VI

ELECTROSTATIC DISCHARGE PROTECTION

Introduction - ESD Standards and Models, ESD Protection Design, ESD Protection Scheme, Turn-on Uniformity of ESD Protection Devices, ESD Implantation and Silicide Blocking, ESD Protection Guidelines, Low-C ESD Protection Design for High-Speed I/O, ESD Protection for High-Speed I/O or Analog Pins, Low-C ESD Protection Design, Input Capacitance Calculations, ESD Robustness, Turn-on Verification, ESD Protection Design for Mixed-Voltage I/O, Mixed-Voltage I/O Interfaces, ESD Concerns for Mixed-Voltage I/O Interfaces, ESD Protection Device for a Mixed-Voltage I/O Interface.

UNIT VII

ESD PROTECTION DESIGN

ESD Protection Circuit Design for a Mixed-Voltage/O Interface, ESD Robustness, Turn-on Verification, SCR Devices for ESD Protection, Turn-on Mechanism of SCR Devices, SCR-Based Devices for CMOS On-Chip ESD Protection.

UNIT VIII

SIGNAL INTEGRITY PROBLEMS IN ON-CHIP INTERCONNECTS

Introduction - Interconnect Figures of Merit, Interconnect Parasitics Extraction, Circuit Representation of Interconnects, RC Extraction, Inductance Extraction, Signal Integrity Analysis, Interconnect Driver Models, RC Interconnect Analysis, RLC Interconnect Analysis, Noise-Aware Timing Analysis, Design Solutions for Signal Integrity, Physical Design Techniques, Circuit Techniques.

TEXT BOOKS:

1. Ban P. Wong, Anurag Mittal, Yu CaoGreg Starr, "NANO-CMOS CIRCUITAND PHYSICAL DESIGN", John Wiley & Sons, Inc., Hoboken, New Jersey. 2000.
2. Charles chiang, Jamil Kawa, "Design for manufacturability and yield for Nano - Scale CMOS", Springer, 2007.

Oleg Semenov, Hossein Sarbishael, ManojSachdev, "ESD Protection Device and Circuit Design for Advanced CMOS Technologies", Springer, 2008.

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4 **4**

(12D86106) QUATUM ELECTRONICS

ELECTIVE-I

UNIT-I

CRYSTAL STRUCTURE: Crystalline and amorphous solids- Crystal lattice and crystal structure- Translational symmetry-space lattice-unit cell and primitive cell-symmetry elements in crystal-the seven crystal systems.

UNIT-II

IMPERFECTIONS IN CRYSTALS: Wigner-seitz cells-Miller indices-Miller-bravais indices-Indices of a lattice direction-The spacing of a set of crystal planes, Importance of lattice imperfections- types of imperfection-Point defects-dislocations.

UNIT-III

RECIPROCAL LATTICE: Bragg law- Reciprocal lattice – Properties of Reciprocal lattice- Reciprocal lattice of simple cube- Reciprocal lattice of bcc- Reciprocal lattice of fcc- diffraction conditions- Brillouion zones.

UNIT-IV

Introduction-Why quantum mechanics - matter waves-length scales - De-Broglie hypothesis – wave particle duality.

UNIT-V

Heisenberg's uncertainty principle-Schrodinger wave equation – General postulates of Quantum mechanics- particle in one dimensional box.

UNIT-VI

QUANTUM MECHANICS OF ELECTRONICS: Electron as particle and electron as wave-

UNIT-VII

Analogies between quantum mechanics and classical electromagnetic-Probabilistic current density-multiple particle systems.

UNIT-VIII

FREE AND CONFINED ELECTRONS: Free electrons-the free electron gas theory of metals-electrons confined to abounded region of space and quantum numbers-electrons confined to atom-the hydrogen atom and the periodic table-quantum dots-wires-wells.

TEXTBOOKS:

1. An introduction to solid states electronic devices by Ajay kumar saxena Macmillan India Ltd {Unit-I, II}
2. Solid state Physics by Kittle {Unit-I,II}
3. P.M.Mathews and K.Venkatesan, "A textbook of Quantum Mechanics", Tata McGraw Hill Publishing Company Ltd {Unit-III}
4. Quantum Mechanics – Schiff {Unit-III}
5. Quantum Mechanics by B.k.Agarwal and Hariprakash, PHI {Unit-III}
6. Fundamentals of nanoelectronics by George W.Hanson Pearson education {Unit-IV,V}

REFERENCE BOOKS:

1. Introduction to Nanotechnology by Charles P.Poole Jr & Frank J. Owens;Wiley India Pvt. Ltd
2. The Feynman lectures on Physics; Vol I to III
3. Quantum mechanics by Brandsen & Joachem
4. J.J.Sakurari, "Modern Quantum Mechanics Mc.Graw Hill, Addison Wesley Longman Inc., USA, 1999
5. Nano Terchnology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer
6. Nano Technology – science, innovation and opportunity by Lynn E Foster;Prentice Hall - Pearson education.
7. Hand book of Nano structured materials; Vol I to V Bio Ethics Readings and cases by Branch A.Brody & H.Tristram Engelhardt.Jr; Pearson Education
8. Quantum mechanics: - Pawling & Wilson
9. Quantum physics by A.Ghatak

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(9D06101) DIGITAL SYSTEM DESIGN

ELECTIVE-I

UNIT I

DESIGN OF DIGITAL SYSTEMS: ASM charts, Hardware description language and control sequence method, Reduction of state tables, state assignments.

UNIT II

SEQUENTIAL CIRCUIT DESIGN: design of Iterative circuits, design of sequential circuits using ROMs and PLAs, sequential circuit design using CPLD, FPGAs.

UNIT III

FAULT MODELING: Fault classes and models – Stuck at faults, bridging faults, transition and intermittent faults. **TEST GENERATION:** Fault diagnosis of Combinational circuits by conventional methods – Path Sensitization technique, Boolean difference method, Kohavi algorithm.

UNIT IV

TEST PATTERN GENERATION: D – algorithm, PODEM, Random testing, transition count testing, Signature Analysis and testing for bridging faults.

UNIT V

FAULT DIAGNOSIS IN SEQUENTIAL CIRCUITS: State identification and fault detection experiment. Machine identification, Design of fault detection experiment.

UNIT VI

PROGRAMMING LOGIC ARRAYS: Design using PLA's, PLA minimization and PLA folding.

UNIT VII

PLA TESTING: Fault models, Test generation and Testable PLA design.

UNIT VIII

ASYNCHRONOUS SEQUENTIAL MACHINE: fundamental mode model, flow table, state reduction, minimal closed covers, races, cycles and hazards.

TEXTBOOKS:

1. Z. Kohavi – "Switching & finite Automata Theory" (TMH)
2. N. N. Biswas – "Logic Design Theory" (PHI)
3. Nolman Balabanian, Bradley Calson – "Digital Logic Design Principles" – Wily Student Edition 2004.

REFRENCES:

1. M. Abramovici, M. A. Breues, A. D. Friedman – "Digital System Testing and Testable Design", Jaico Publications
2. Charles H. Roth Jr. – "Fundamentals of Logic Design".
3. Frederick. J. Hill & Peterson – "Computer Aided Logic Design" – Wiley 4^{th} Edition.
4. R Goswami and K Chattopadhyay, Acta Mater. 52, 5503 (2004)
5. V. Germain et al., J. Phys. Chem. B, Vol. 107, No. 34, 2003

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4 **4**

(12D86107) MEASUREMENTS & CHARACTERIZATION OF NANOMATERIALS

ELECTIVE-I

UNIT – I

STRUCTURAL CHARACTERIZATION - I

X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM)

UNIT – II

STRUCTURAL CHARACTERIZATION - II

Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).

UNIT – III

SPECTROSCOPIC CHARACTERIZATIONS:

Basic concepts of spectroscopy, operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurement, Raman spectroscopy

UNIT – IV

SURFACE CHARACTERIZATION:

X-ray Photoelectron Spectroscopy (XPS), Auger electron spectroscopy, Low Energy Ion Scattering Spectroscopy (LEISS), Secondary Ion Mass Spectroscopy (SIMS), Rutherford Backscattering Spectroscopy (RBS).

UNIT-V

RESONANCE METHODS

Electron Spin Resonance (ESR), Ferromagnetic Resonance (FMR), Nuclear Magnetic Resonance (NMR), Mossbauer Spectroscopy

UNIT-VI

THERMAL CHARACTERIZATION OF MATERIALS:

DTA, TGA, DSC (Principle and Applications), Determination of thermo physical parameters.

UNIT-VII

MULTI-WALLED CARBON NANOTUBES:

Synthesis, Characterization, MWNT Purity Assessment

UNIT-VIII

NANO MATERIALS FOR ORGANIC PHOTOVOLTAICS

Material Characterization, Semiconducting Quantum dots, Fullerene Derivatives, Polymers, Composites

TEXT BOOKS:

1. Elements of X –ray Diffraction, B. D. Cullity

2. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton

1. Thermal Analysis of Materials, Robert F Speyer, New York.

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3 **2**

(12D68105) SIMULATION AND SYNTHESIS LAB

1. Introduction to MATLAB Programming
2. Program assembly, Execution, Data processing and graphic analysis
3. Application of FFT for signal processing
4. Signal processing – Signal generation, filter design and analysis
5. MATLAB program to plot the one-dimensional rectangular potential well with infinite potential barrier
6. Numerical solution of the Schrodinger wave equation for rectangular potential well with infinite potential barrier using MATLAB program.
7. Design and simulation of (i) Combinational logic circuits, (ii) Sequential logic circuits, (iii) Analog circuits and (iv) A/D mixed circuits
8. Synthesis of Digital Circuit.
9. Place and Router Techniques for FPGAs.
10. Implementation of Design using FPGA and CPLD Devices.

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(12D86201) MEMS /NEMS Design and Applications

Unit I

Introduction to MEMS and NEMS: MEMS and NEMS – multidisciplinary nature of MEMS/NEMS – working principles: as micro sensors - acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor, pressure sensor and thermal sensor.

Unit II

Micro devices: micro actuation - thermal actuation, piezoelectric actuation and electrostatic actuation, micro gripers – micro motors – micro valves – micro pumps – accelerometers – micro fluidics and capillary electrophoresis, active and passive micro fluidic devices.

Unit III

Materials for MEMS/NEMS: Silicon – Compatible material systems, Silicon, Silicon oxide and nitride, Thin metal films, Polymers, Other materials and substrates, Glass and fused quartz substrates, Silicon carbide and diamond, Gallium Arsenide and other group III-V compound semi conductors, Shape - memory alloys transduction.

Unit IV

Material properties: Important material properties and physical effects, Pizoresistivity, Pizoelectricity and thermoelectricity, Inter atomic bonds, Material structures.

Unit V

MEMS/NEMS design, processing and Technologies: Basic process tools, Epitaxy, Oxidation, Sputter deposition, Evaporation, Chemical vapor deposition, spin on methods, Lithography, Lift off process, Bulk Micro machining, Etching processes – Wet etching, Plasma etching, Ion milling.

Unit VI

Wafer bonding – Silicon fusion bonding, Anodic bonding, Silicon direct bonding, sol gel deposition methods, Self assembled mono layers, EFAB. LIGA electromagnetic micro drive, DRIE.

Unit VII

MEMS/NEMS Scaling issues and Packaging: Introduction – Scaling of physical systems – Geometric scaling, Mechanical system scaling, Thermal system scaling, Fluidic system scaling, Electrical system scaling, Packaging-package design considerations, Process steps, Wafer thickness and dicing issues, Thermal management, Hermetic packaging, Electrical//Micro fluidic/and optical interconnects, Quality control-reliability and failure modes and analysis, Signal mapping transduction.

Unit VIII

MEMS/NEMS applications: Applications in automotive industry – health care – aerospace – industrial product consumer products – lab on chip – molecular machines – data storage devices – micro reactor – telecommunications, Servo systems.

Text Books:

1. Nadim Malut and Kirt Williams, "An introduction to Micro electro mechanical systems Engineering," Artech House, Inc, Boston, Second Edition.

2. James J Allen, “Micro electro mechanical systems Design,” CRC Press – Taylor and Francis Group.
3. Nicolae Lobontiu & Ephrahim Garcia, “Mechanics of micro electro mechanical systems,” Kluwer. Academic Publishers – Boston.

References Books:

1. Bharath Bhushan, “Springer Hand Book of Nano Technology “ Springer publications.
2. Sergey Edward Lysherski, “ Nano and Micro electro Mechanical systems,” CRC Press.

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(12D86202) Carbon Nano Tubes and Applications

Unit I
Diamond, nanodiamond particles, nanodiamond particles synthesis: high pressure high temperature technique, chemical methods using energetic particles and beam, Applications of nanodiamond particles.

Unit II
Diamond-like Carbon films (DLC), classification of DLC, properties and applications of DLCs: internal stress and adhesion, coating morphology, porosity and diffusional property, DLC/graphite transformation.

Unit III
DLC properties continued: Optical properties, electrical properties, mechanical properties, chemical resistance, tribological properties; deposition techniques of DLC films.

Unit IV
Nanocrystalline diamond (NCD) films, pretreatment processes to enhance the nucleation of NCD films, propertiesand applications of NCD films: tribology, electron emission, electrochemical electrodes, conformal coatings, deposition of NCD films.

Unit V
Carbon nanotube (CNT), structure of CNT, synthesis of CNT, electronic, vibrational, mechanical and optical properties of CNT; applications of CNT. fabrication of Fullerene (C60).

Unit VI
Functionalization of Carbon Nanotubes: covalent functionalization of CNTs, non covalent functionalization of CNTs, modification of CNTs via mechnochemical reactions, electrochemical deposition, electroless deposition; plasma activation of CNTs.

Unit VII
Lithium & Hydrogen adsorption & storages, Fuel cell applications and energy storage, Chemical Sensors applications of CNTs.

Unit – VIII
Computer applications (Nano chip), optical and telecommunication applications. Nano composites, silicon Nanowires.

Text books:

1. Charles P. Poole Jr and Frank J.Owens, "Introduction to Nanotechnology," Wiley India Pvt Ltd.
2. W. R Fahrner, "Nanotechnology and Nano Electronics – Materials, devices and measurement techniques," Springer publications.
3. Michael J. O'Connell, "Carbon Nanotubes: Properties and Applications."

Reference books:

1. J. Robertson, "Diamond-like Amorphous Carbon, Materials Science and Engineering," R 37 (2002) 129-281.
2. Olga A. Shenderova, Dieter M. Gruen William, " Ultrananocrystalline Diamond: Synthesis, Properties, and Applications," Andrew Publishing Norwich, New York, U.S.A.
3. R Satio, "Physical properties of Carbon Nanotube."
4. C. N. R. Rao & A. Govindaraj, " Nanotubes and Nanowires," RCS Publishing.
5. M.Balakrishna rao and K.Krishna Reddy, "Encyclopaedia of Nanotechnology," Vol I to X Campus books.
6. Lynn E. Foster, "Nanotechnology – science, innovation and opportunity," Prentice Hall Pearson education.
7. T. Pradeep, "Nano: The Essentials – Understanding Nano Science and Nanotechnology," Tata Mc.Graw Hill.

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(12D86203) Nano Bio-Technology

Unit I

Functional Principles of Nanobiotechnology: From Biotechnology to Nanobiotechnology, Information-Driven Nano assembly, Energetics, Topdown and bottom up approach for building nanomaterials, Chemical Transformation Biomaterials, Machine-Phase Nanobiotechnology.

Unit II

Structural Principles of Nano-biotechnology Construction of Nano-machines, The Raw Materials: Biomolecular Structure and Stability, Protein Folding, Self-Assembly, Self-Organization, Molecular Recognition, Atomicity limits the tolerance of combining sites, Flexibility, Flexibility poses great challenges for the design of , nanobiomachines.

Unit - III

Nano biometrics – Introduction – lipids as nanobricks and mortar: self assembled nanolayersthe bits that do think – proteins- three dimensional structures using a 20 aminoacid-biological computing – a protein based 3D optical memory using DNA to build nano cubes and hinges – DNA as smart glue – DNA as wire template – DNA computers.

Unit IV

Nanobio machines: The Unfamiliar World of Nanobiomachines, Modern nano biomachine using different molecular motors, Biomaterials created by nano particle, Biomaterial supplementing important human body part, Guided Tour of Natural Nanobiomachinery.

Unit V

Biosensors as Precursors of Bioelectronics, Functionalization of Sensing Substrates, Biochip, Nanosensors-Miniaturization of Biosensors, Nanomaterial Based Biosensors. Electron Transfer of Biomolecules, Nanoparticle Biomaterial Hybrid Systems for Sensing and Electronic Devices, Effect of Biosensor in biological and physicochemical techniques.

Unit VI

DNATemplated Electronics, Sequence –specific molecular lithography, Single Biomolecule Manipulation for Bioelectronics, DNA as a semiconductor.

Unit VII

Applications of nanobiotechnology in early medical diagnostics, drug targeting, drug delivery, nanosurgery and other biomedical field.

Unit VIII

The Future of Nanobiotechnology: A Timetable for Nanobiotechnology, Lessons for Molecular Nanotechnology, Case Studies: Nanotube synthesis; A general nanoscale assembler, Nanosurveillance. Ethical Considerations. Respect for life, Potential dangers.

Books:

M. Niemeyer and Chad. A. Mirkin (eds.), " Nano biotechnology: concepts, applications & perspectives," Wiley VCH Weinheim (2004).

Jain, K. K, "Nanobiotechnology in molecular diagnostics: current techniques and applications,"

Reference Books

1. David.S.Goodsell, "Bionanotechnology: concepts, Lessons from Nature," Wiley-Liss 2004
2. Sandra J Rosethal, David W Wright, " Nanobiotechnology Protocols," Series Methods in Molecular Biology, 2005.
3. R.S. Greco, F.B.Prinz and R.L.Smith, "Nanoscale Technology in Biological Systems," CRC press, 2005.

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M. Tech. II SEM (M & NE) **Th** **C**

4 **4**

(12D86204) Nanosensors

Unit I

Transducers: Conductometric and capacitive transducers, optical waveguide based transducers, optical fiber based transducers, Interferometric optical transducers, surface Plasmon resonance transducers, electrochemical transducers, solid state transducers, PN diodes or bipolar junction based transducers, schottky diode based transducers.

Unit II

MOS capacitor based transducers, FET based transducers, Acoustic wave transducers, Quartz crystal Microbalance, Film Bulk acoustic wave resonator (BAW transducer), Interdigitally launched surface acoustic wave transducer (SAW transducer), Cantilever based transducers.

Unit III

Sensor Characteristics: Active and Passive sensors – Static characteristics, Accuracy, offset and linearity, Dynamic characteristics, First and second order sensors.

Unit IV

Physical effects: Physical effects involved in signal Transduction, Photoelectric effect, photodielectric effect, Photoluminescence effect, electroluminescence effect, chemiluminescence effect, Doppler effect, Barkhausen effect, Hall 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.

Unit V

Nano based Inorganic sensors: Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials, 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 tunnelling junctions.

Unit VI

Organic / Biosensors: Structure of Protein, role of protein in nanotechnology, using protein in nano devices antibodies in sensing, antibody in nano particle conjugates, enzymes in sensing, enzymenanoparticle hybrid sensors, Motor proteins in sensing, transmembrane sensors.

Unit VII

Nanosensors based on Nucleotides and DNA, Structure of DNA – DNA decoders andmicroarrays, DNA protein conjugate based sensors, Bioelectronic sensors, DNAsequencing with nanopores, sensors based on molecules with dendritic architectures, biomagnetic sensors.

Unit VIII

Signal conditioning and data acquisition: Earthing and grounding – series and common mode noise, errors due to common mode interference, specification of common mode rejection ratio, instrumentation amplifiers, isolation amplifiers, charge amplifiers, filters, integrators and differentiators, phase sensitive

detectors (PSD), Linear switching PSD, Multiplying PSD, Digital PSD, Edge triggered PSD, Phase locked loop.

Text Books:

1. Kouroush Kalantar – Zadeh, Benjamin Fry, "Nanotechnology enabled sensors," Springer Verlog New York, 2007.
2. H. Rosemary Taylor Chapman and Hall, " Data acquisition for sensor systems," Sensor physics and technology 5, London, 1997.

Reference Books:

1. Ramon Pallas-Areny, John G. Webster, "Sensors and signal conditioning," John Wiley & Sons 2nd edition, 2001.
2. Jerome Schultz, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins, " Biosensing: International Research and Development," Springer 2006.

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M. Tech. II SEM (M & NE) **Th** **C**

4 **4**

(12D86205) Nano Fabrication Techniques

Unit I

Introduction: Introduction to microelectronics fabrication and Moore`s empirical law - Limitations – Si processing methods: Cleaning/etching, oxidation, Gettering, doping, epitaxy- semiconductor device road map –gate dielectrics, poly Si, high k dielectrics.

Unit II

Top-down Lithography techniques Necessity of clean a room, different types of clean rooms, maintenance, Importance of Lithography techniques. Photolithography, Electron Beam lithography, Extreme UV lithography, X-ray Lithography, Focused ion beam Lithography (FIB).

Unit III

Etching Techniques Types of etching - Reactive ion etching (RIE), Wet chemical etching, Isotropic etching, Anisotropic etching, electrochemical etching.

Unit IV

Bottom - up approach - I Self-assembly and Lithography: self-assembly, self-assembled mono layers, directed assembly, layer-by layer assembly, patterned growth, control of position and diameter.

Unit V

Combinations of top-down and bottom-up techniques: current state of the art - DNA self-assembly Chemical vapour deposition of Nanostructures: Nanocrystals - Nanowires by catalytic (Au, Ni and Ag) and non-catalytic VLS approach.

Unit VI

Bottom - up approach II: Patterned growth Nanoimprint lithography (NIL), soft polymer photoresistive, moulding /replica, printing with stamp pads, RIE etching, patterned growth, control of position, size and density. Dip-pen lithography, setup, working principle.

Unit VII

M based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation.

Unit – VIII

Ion beam lithography, oxidation and metallization, Mask and its application, Deep UV lithography, X-ray based lithography.

Text Books:

1. M. Madou, “Fundamentals of microfabrication,” CRC press, 1997.
2. G. Timp, “Nanotechnology,” AIP press, Springer Verlag, New York , 1999.
3. M.J.Jackson, “Micro fabrication and Nanomanufacturing,” CRC press, 2005.
4. G.Cao, “Naostructures and Nanomaterials: Synthesis, properties and applications,” Imperical College Press, 2004.

Reference Books:

1. R.D. Piner, "Dip-pen lithography Science," 1999.
2. W.T.S Huck, "Nanoscale assembly: Chemical Techniques (Nanostructure Science and Technology)," Springer, 2005.
3. H. Schift et al, "Fabrication of polymer photonic crystals using nano imprint lithography, Nanotechnology," 2005.
4. E. L Principe, P. Gnauck and P. Hoffrogge, "Microscopy and Microanalysis," Cambridge University Press, 2005.
5. Leon L. Shaw (editor), "Processing & properties of structural naonmaterials."
6. Mark James Jackson, "Microfabrication and Nanomanufacturing,"

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M. Tech. II SEM (M & NE) **Th** **C**

4 **4**

(12D86206) Nano Medicine
ELECTIVES – II

Unit I

NANOMOLECULAR DIAGNOSTICS - ARRAY AND CHIPS:
Introduction -Nanodiagnostics -Rationale of Nanotechnology for Molecular Diagnostics -Nanoarrays for Molecular Diagnostics . NanoProTM System -Nanofluidic/Nanoarray Devices to Detect a Single Molecule of DNA-Self-Assembling ProteinNanoarrays -Fullerene Photodetectors for Chemiluminescence DetectiononMicrofluidicChips -Protein Microarray for Detection of Molecules with Nanoparticles Protein Nanobiochip.

Unit II
Nanoparticles for Molecular Diagnostics -Gold Nanoparticles -Quantum Dots for Molecular Diagnostics Magnetic Nanoparticles -Use of Nanocrystals in Immunohistochemistry -Imaging Applications of Nanoparticles Study ofChromosomes byAtomic ForceMicroscopy-Applications of Nanopore Technology for Molecular Diagnostics DNA–Protein and DNA–Nanoparticle Conjugates.

Unit III
NANOMACHINES AND NANOBARCODES, NANOBIOSENSORS:
DNA Nanomachines for Molecular Diagnostics -Nanobarcodes Technology -Nanobarcode Particle Technology for SNP Genotyping -Qdot Nanobarcode for Multiplexed Gene Expression Profiling -BiobarcodeAssay for ProteinsSingle-Molecule Barcoding System for DNA Analysis Nanoparticle-Based Colorimetric DNA Detection Method.

Unit IV
Cantilevers as Biosensors for Molecular Diagnostics –CarbonNanotube Biosensors -FRET-BasedDNANanosensors. Ion Channel Switch Biosensor Technology -Electronic Nanobiosensors -Electrochemical Nanobiosensors -Quartz Nanobalance Biosensors -Viral Nanosensors -PEBBLENanosensors -Microneedle-Mounted Biosensors OpticalBiosensors- Nanowire (NW) Biosensors -Nanoscale ErasableBiodetectors.

Unit V
NANOPHARMACEUTICALS:
Introduction -Nanobiotechnology for Drug Discovery -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules -Role of AFM for Study of Biomolecular Interactions for Drug Discovery Nanoscale Devices for Drug Discovery -Nanotechnology Enables Drug Design at Cellular Level Nanobiotechnology-Based Drug Development -Dendrimers asDrugs- Fullerenes as Drug Candidates – Nanobodies.

Unit VI
Nanobiotechnology in Drug Delivery -NanoscaleDelivery of Therapeutics -Nanosuspension Formulations Viruses as Nanomaterials for Drug Delivery -Nanoparticle-Based Drug Delivery -Trojan Nanoparticles -Self-Assembling Nanoparticles for Intracellular Drug Delivery -Nanoparticle Combinations for Drug

Delivery Liposomes -Liposome–Nanoparticle Hybrids-Nanospheres-Nanotubes -Nanocochleates.-Nanomolecular Valves for Controlled Drug Release -Nanomotors forDrugDelivery.

Unit VII

ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES:

Introduction - Development of nano medicines – Nano Shells – Nano pores – Tectodendrimers – Nanoparticle drug system for oral administration – Drug system for nasal administration – Drug system for ocular administration – Nanotechnology in diagnostic application. Preformulation Studies: on various dosage forms such as tablets, capsules, suspension, creams, emulsion, injectables, ophthalmic and aerosols etc. Biomedical nanoparticles – Liposome's – Dentrimers – Different types of drug loading – Drug release – Biodegradable polymers – Applications Nanobiotechnologies for Single-Molecule Detection -Protease-Activated QuantumDot Probes -Nanotechnology for Point-of-Care Diagnostics -Nanodiagnostics for the Battle Field -Nanodiagnostics for Integrating Diagnostics with Therapeutics.

Unit VIII

APPLICATION IN CANCER THERAPY & NANOMEDICINE:

Introduction and Rationale for Nanotechnologyin Cancer Therapy -- Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications -Pharmacokinetics of Nanocarrier-Mediated Drug and Gene Delivery - Multifunctional Nanoparticles for Cancer Therapy-Neutron Capture Therapy of Cancer: Nanoparticlesand High Molecular Weight Boron Delivery Agents. Nano-Oncology- Nanoneurology- Nanocardiology- Nano-Orthopedics- Nano-Ophthalmology.

Text Books:

1. Zhang, "Nanomedicine: A Systems Engineering Approach," 1st Ed., Pan Stanford Publishing, 2005.
2. Robert A. Freitas Jr., "Nanomedicine Volume IIA: Biocompatibility," Landes Bioscience Publishers, 2003.

Reference Book:

1. Kewal K. Jain, "The Handbook of Nanomedicine," Humana Press, 2008.

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M. Tech. II SEM (M & NE) **Th** **C**

4 **4**

(12D86207) **Packing Technology**
ELECTIVES – II

Unit I
Packaging and its importance in retail industry, Types of Packaging.

Unit II
Evolution of Packaging, Purpose of packaging like Physical protection, Barrier protection, Containment, Information transmission, Marketing, Security, Convenience, Portion control.

Unit III
Packaging requirements, regulations and standards.

Unit IV
Understanding the Packaging Design Process: Packaging dynamics, Packaging for various sectors electronics, manufacturing, automotive, textiles, pharmaceuticals, agro.

Unit V
Package development considerations. Structural Design for Packaging, Measuring packaging design success.

Unit VI
Elements of Packaging design: color, symbols, icons, illustration, surface graphics, typography, photography, material.

Unit VII
Understand the packaging manufacturing process, Packaging machining process like printing, stamping, cartons, case and tray forming.

Unit VIII
Packing, sealing, labeling, wrapping, vacuum packaging.

Text Books:
Akabane. N, "Package Form and Design: Encyclopedia of Paper-Folding Design," *PIE* Books, 2011.
Burke W, Baer L and Pietruszynski. J, "The Big Book of Packaging," Harper Design, 2011.
Denison E. and Cawthra .R, "The Big Book of Packaging Prototypes," Rotovision, 2011.

Reference Books:
DuPuis S. and Silva. J, "Package Design Workbook: The Art and Science of Successful Packaging," Rockport Publishers, 2008.
Coles R, McDowell D and Kirwan M. J, "Food Packaging Technology," Blackwell, 2003.
Capsule, "*Packaging 01:* An Essential Primer for Today's Competitive Market," Rockport Publishers, 2008.
Ambrose .*G*, "This End Up: Original Approaches to Packaging Design," Rotovision, 2002.

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M. Tech. II SEM (M & NE) **Th** **C**

4 **4**

(12D86208) Industrial Nano Technology
ELECTIVES – II

Unit I

NANOTECHNOLOGY IN ELECTRICAL AND ELECTRONICS INDUSTRY:

Advantages of nano electrical and electronic devices –Electronic circuit chips – Lasers - Micro and Nano-Electromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors - Data memory –Lighting and Displays – Filters (IR blocking) – Quantum optical devices – Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products.

Unit II

NANOTECHNOLOGY IN BIOMEDICAL AND PHARMACEUTICAL INDUSTRY:

Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces – Protein Engineering – Drug delivery – Therapeutic applications.

Unit III

NANOTECHNOLOGY IN CHEMICAL INDUSTRY:

Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays.

Unit IV

NANOTECHNOLOGY IN AGRICULTURE AND FOOD TECHNOLOGY:

Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in Food industry - Packaging, Food processing - Food safety and bio-security – Contaminant detection – Smart packaging.

Unit V

NANOTECHNOLOGY IN TEXTILES AND COSMETICS

Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – **Polymer nanofibers** - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers.

Unit VI

Bionics: Swim-suits with shark-skin-effect,Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes).

Unit VII

Modern textiles: Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear.

Unit VIII

Cosmetics: Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics.

Text Books:

1. Mark A. Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson, 2003.
2. Bharat Bhushan, "Springer Handbook of Nanotechnology," Barnes & Noble, 2004.
3. Neelina H. Malsch (Ed.), "Biomedical Nanotechnology," CRC Press, 2005.

Reference Books:

1. Udo H. Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems," Wiley Publishers 2010.
2. Jennifer Kuzma and Peter VerHage, "Nanotechnology in agriculture and food production," Woodrow Wilson International Center, 2006.
3. Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, "Nanotechnology in the Agri-food sector," Wiley-VCH Verlag, 2011.
4. P. J. Brown and K. Stevens, "Nanofibers and Nanotechnology in Textiles," Woodhead Publishing Limited, Cambridge, 2007.
5. Y-W. Mai, "Polymer Nano composites," Woodhead publishing, 2006.
6. W.N. Chang, "Nanofibres fabrication, performance and applications," Nova Science Publishers Inc, 2009.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

M. Tech. II SEM (M & NE) **L** **C**

3 **2**

(12D86209) Nano Sensors Laboratory

List of Experiments:

1. Energy density, power density and cyclability of a rechargeable Li-ion battery and capacitor.
2. Fuel cell performance evaluation.
3. Solar cell performance evaluation.
4. Thin film deposition using coating (spin and dip) and deposition (Langmuir-Blodgett and electro-deposition) for gas sensor application.
5. Synthesis of colloidal nanoparticles by appropriate techniques (precipitation, sol-gel, microemulsion, solvothermal, sonochemical, etc).
6. Spectroscopic characterization of metallic, semiconducting and insulating nanoparticles.
7. Ball milling route for making nanoparticles and particle size distribution estimation.
8. Particle size and lifetime analysis using dynamic light scattering.
9. Physical vapor deposition and chemical vapor deposition techniques for thin film deposition.
10. Fabrication of suitable structures on thin films for device applications.