M.TECH (NANO TECHNOLOGY) - w.e.f. 2016-2017

I SEMESTER

S. No.	Subject Code	Name of the Subject	L	T	P	C	I	E	Total
1	MTNT1T01	Structure, Bonding and Quantum mechanics of electronics	3	1	4	3	40	60	100
2	MTNT1T02	Synthesis of Nanomaterials	3	1	4	3	40	60	100
3	MTNT1T03	Science and technology of Thin-film	3	1	4.	3	40	60	100
4	MTNT1T04	Nano Biotechnology , materials and devices	3	1	4	3	40	60	100
5	MTNT1T05	Numerical methods and Advanced Computing Techniques	3	1	4	3	40	60	100
6		Elective - I	3	1	4	3	40	60	100
7	MTNT1L01	Simulation Lab			3	2	40	60	100
		Total Credits				**20**	**280**	**420**	**700**

II SEMESTER

S. No.	Subject Code	Name of the Subject	L	T	P	C	I	E	Total
1	MTNT2T01	Material characterization techniques	3	1	4	4	40	60	100
2	MTNT2T02	Properties of nano structures	3	1	4	4	40	60	100
3	MTNT2T03	Nano Electronics And Nano Photonics	3	1	4.	4	40	60	100
4	MTNT2T04	Carbon nanotubes and applications	3	1	4	4	40	60	100
5	MTNT2T05	Nano composites- Design and synthesis	3	1	4	4	40	60	100
6		Elective-II	3	1	4	4	40	60	100
7	MTNT2L01	syntheses and processing lab			3	2	40	60	100
		Total Credits				**20**	**280**	**420**	**700**

III SEMESTER

S. No.	Subject Code	Name of the Subject	L	T	P	C	I	E	Total
1	MTNT3S01	Seminar-1	-	-	-	2	-	-	-
2	MTNT3P01	Project Work Part-1	-	-	-	18	-	-	-
		Total Credits				**20**	**-**	-	-

IV SEMESTER

S. No.	Subject Code	Name of the Subject	L	T	P	C	I	E	Total
1	MTNT4S01	Seminar-2	-	-	-	2	-	-	-
2	MTNT4P01	Project Work Part-2	-	-	-	18	-	-	-
		Total Credits				**20**	-	-	-

Elective-I		
1	MTNT1TE1	Nanotechnology for energy systems
2	MTNT1TE2	Surface sciences and advanced catalysis
3	MTNT1TE3	Thermodynamics

Elective-II		
1	MTNT2TE4	MEMS/NEMS design and application
2	MTNT2TE5	Lithography techniques

M.TECH (NANO TECHNOLOGY)
I SEMESTER

Structure, bonding and quantum mechanics of electronics

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-some imperfections in crystals-Wigner-seitz cells-Miller indices-Miller-bravais indices-Indices of a lattice direction-The spacing of a set of crystal planes.

Unit-II Reciprocal lattice and crystal imperfections: 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. Importance of lattice imperfections- types of imperfection-Point defects-dislocations.

Unit-III Introduction-Why quantum mechanics - matter waves-length scales - De-Broglie hypothesis – wave particle duality- Heisenberg's uncertainty principle-Schrodinger wave equation – General postulates of Quantum mechanics- particle in one dimensional box.

Unit-IV Quantum mechanics of electronics: Electron as particle and electron as wave-Time independent Schrodinger equation and boundary contestation on the wave function-Analogies between quantum mechanics and classical electromagnetic-Probabilistic current density-multiple particle systems.

Unit-V 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

M.TECH (NANO TECHNOLOGY)
I SEMESTER

SYNTHESES OF NANOMATERIALS

Unit-I Introduction to synthesis of nanostructure materials, Bottom-up approach and Top-down approach with examples.

Unit-II Physical methods: Inert gas condensation, Arc discharge, RF-plasma, plasma arc technique, electric explosion of wires, ball milling, Quartz crystal monitor for measurement of thickness.

Unit III Chemical methods: Nanocrystals by chemical reduction, photochemical synthesis, electrochemical synthesis, nanocrystals of semiconductors and other materials by arrested precipitation, emulsion synthesis, sonochemical routes.

Unit – IV Thermolysis route - spray pyrolysis and solvated metal atom dispersion, sol-gel method, solvothermal and hydrothermal routes, solution combustion synthesis, Chemical vapor synthesis.

Unit – V Biological methods – use of bacteria, fungi, actinomycetes for nano-particle sythesis-magnetotatic bacteria for natural synthesis of magnetic nano-particle.

Textbooks:

1. Inorganic Materials Synthesis and Fabrication by J.N. Lalena, D.A. Cleary, E.E. Carpenter, N.F. Dean, John Wiley & Sons Inc.
2. Introduction to Nano Technology by Charles P. Poole Jr and Frank J. Owens. Wiley India Pvt Ltd.
3. The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I by C.N.R. Rao, A. Muller and A.K. Cheetham

Reference books:

1. Encyclopedia of Nanotechnology by M.Balakrishna Rao and K.Krishna Reddy, Vol I to X, Campus books.
2. Encyclopedia of Nanotechnology by H.S. Nalwa
3. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology – by T.Pradeep; Tata Mc.Graw Hill

M.TECH (NANO TECHNOLOGY)
I SEMESTER

SCIENCE AND TECHNOLOGY OF THIN FILMS

Unit – I Vacuum technology: principles of vacuum pumps in range of 10^{-2} torr to 10^{-11} torr, principle of different vacuum pumps: roots pump, rotary, diffusion, turbo molecular pump, cryogenic-pump, ion pump, Ti-sublimation pump, importance of measurement of vacuum, Concept of different gauges: Bayet- Albert gauge, Pirani, Penning and pressure control.

Unit – II Conditions for the formation of thin films: Environment for thin film deposition, deposition parameters and their effects on film growth, formation of thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), capillarity theory, microstructure in thin films, adhesion, properties of thin films: Mechanical, electrical, and optical properties of thin films, few applications of thin films in various fields.

Unit-III Physical Vapor Depostion techniques: Thermal evaporation, resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition

Unit -IV Electrical discharges used in thin film deposition: Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion beam sputtering, Ion plating, difference between thin films and coating.

Unit –V Electro deposition, molecular beam epitaxy and laser pyrolysis. Chemical vapor deposition techniques: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, boundaries and flow, Different kinds of CVD techniques: Metallorganic CVD (MOCVD), Thermally activated CVD, CVD, Spray pyrolysis, etc.

Text Books & References

1. Thin Film Phenomenon by K.L. Chopra, McGraw-Hill
2. Methods of Experimental Physics (Vol 14) by G.L.Weissler and R.W. Carlson “Vacuum Physics
and Technology”
3. A User’s Guide to vacuum Technology by J.F.O’Hanlon, John Wiley and Sons
4. Vacuum Physics and Techniques by T.A. Delchar, Chapman and Hall
5. Evaporation: Nucleation and Growth Kinetics” by J.P. Hirth and G.M.Pound, Pergamon Press

M.TECH (NANO TECHNOLOGY)
I SEMESTER

NANO BIO-TECHNOLOGY-MATERIALS AND DEVICES

Unit–I Fundamentals terms in biotechnology, Biological building blocks: Sizes of building blocks and Nanostructures, Polypeptide nanowire and protein nanoparticles

Unit – II Nucleic Acids – DNA Double Nano wire, Genetic code and protein synthesis

Unit-III Biological Nanostructures: Bio-mimitics with examples, Bio compatible Bio sensors, Examples of proteins, vesicles, bilayers, and Multilayer films, application of bio-nanotechnology: bio nano machines, molecular modeling.

Unit – IV Applications to NEMS and Nano devices: Nano bio-sensors and biomedical applications nano materials in drug delivery, organic semiconductors, biological neurons and their functions, bio-chemical and quantum mechanical computers: DNA computers, parallel processing, Bit and 'Q' bit, Quantum parallelism.

Unit –V Nanoscale processes in the environment, Nano technology for Immune system, clinical imaging, nano robots, Nano Fibres for Tissue Engineering.

Text books:

1. Bio Nano Technology by Good Sell, Wiley Liss
2. Introduction to Nanotechnology by Charles. P.Poole Jr and Frank J. Owens, Wiley India Pvt Ltd.
3.Nano Technology, A gentle introduction to the next big idea by Mark Ranter and Daniel Ranter,
Pearson education
4 Nanotechnology – science, innovation and opportunity by Lynn E Foster, Prentice Hall – Pearson education.

Reference books:

1. Encyclopedia of Nanotechnology by H.S.Nalwa
2. Encyclopaedia of Nanotechnology by M.Balakrishna Rao and K.Krishna Reddy (Vol I to X), Campus books.

M.TECH (NANO TECHNOLOGY)
I SEMESTER

NUMERICAL METHODS AND ADVANCED COMPUTING TECHNIQUES

Unit – I Numerics in general: Interpolation, Gauss elimination, Solution by iteration, Least square method.

Unit - II Numeric Linear Algebra and differential equations: Matrix Eigen value problems: Introduction, Inclusion of Matrix Eigenvalues, Tridiognalization and RQ factorization. Methods for first order ODEs, Multi step methods, Higher order ODES

Unit-III Introduction to probability: Probability, Sample space and events- Probability- the axioms of probability, some elementary theorems-conditional probability Baye's theorem Random Variables- Discrete and continuous – distribution- distribution function Distribution Binomial and poison distributions and normal distribution – related properties.

Unit- IV Systems, Models, Simulations and the Monte Carlo Methods:Systems,Models,Simulation and the Monte Carlo Methods, Random number generation, Introduction, Congruential Generators, Statistical Tests of Pseudorandom Numbers, Random variate generation, inverse Transform Method, Composition Method, Acceptance-Rejection Method,

Unit-V Monte Carlo integration and Variance reduction techniques: Introduction, Monte Carlo Integration, The Hit or Miss Monte Carlo Method, The Sample-Mean Monte Carlo Method, Efficiency of Monte Carlo Method, Integration in Presence of Noise,

Text books:

1. Advanced engineering mathematics, by Erwin Kreyszig, wiley publications
2. Probability and statistics, scham series, Arnold o. allen, academic press
3. Probability and statistics, Arnold o. allen, academic press
4. Probability and statistics for engineers, miller and john e. freund, prentice hall of india
5. A primer for the monte carlo method, llya M. Sobol' CRC Press
6. Simulation and monte carlo method by reuven y. rubisten
7. The monte carlo method, popular lectures in mathematics by sobol.i.m

ELECTIVE –I

M.TECH (NANO TECHNOLOGY)
I SEMESTER

NANO TECHNOLOGY FOR ENERGY SYSTEMS (Elective - I)

Unit–I Battery materials and batteries: Lithium Ion based batteries.

Unit–II Renewable energy Technology: Energy challenges, nanomaterials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies, solar cell structures: quantum well and quantum dot solar cells, photo- thermal cells for solar energy harvesting, Thin film solar cells, CIGS solar cells, Die sensitized solar cells.

Unit–III Hydrogen storage Technology: Hydrogen production methods, purification, hydrogen storage methods and materials: metal hydrides and metal-organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalphy formations and thermal management during hydriding reaction, multiple catalytic – degradation of sorption properties, automotive applications.

Unit–IV Fuel cell Technology: Fuel cell Principles, types of fuel cells (Alkaline Electrolyte, Phosphoric acid, Molten Carbonate, solid oxide and direct methanol and Proton exchange fuel cells), Principle and operation of Proton Exchange Membrane (PEM) fuel cell, Materials and fabrication methods for fuel cell technology, micro fuel cell power sources – Biofuels
.

Unit–V Microfluidic Technology: MEMS & NEMS technology for microfluidic devices: micro and nano engines and driving mechanism, power generation, microchannel battery pump (TCP), piezoelectric membrane and their applications.

Text Books & References

1. Renewable Energy Resources by J. Twidell and T.Weir, E&FN Spon Ltd.
2. Hydrogen from Renewable Energy Source by D.Infield
3.Fundamentals of Industrial Catalytic Process by C.H. Bartholomew and Robert J. Farraoto, John
Wiley & Sons Inc.
4. Fuel storage on Board Hydrogen storage in Carbon Nanostructures by R.A. Shatwell
5. Fuel cell Technology Handbook by Hoogers, CRC Press
6. Hand book of fuel cells: Fuel cell technology and applications by Vielstich, Wiley:CRC Press

M.TECH (NANO TECHNOLOGY)
I SEMESTER
SURFACE SCIENCES AND ADVANCED CATALYSIS (Elective - I)

Unit–I Adsorption phenomenon: Chemisorption & Physisorption, adsorption isotherms and methods of determination of pore size and surface area of materials using the adsorption isotherms,
Catalysis – Definition, types of catalysis with suitable examples, characteristics of a catalyst, selectivity or specificity of the catalyst, activation and deactivation of catalysts, catalytic poisoning

Unit–II Necessity for the alternate energy sources and the role of catalytic technology in the energy sector – Fuel cells, Solar cells, Biomass and Biofuels,New trends in heterogenous catalysis – catalytic sensors, membrane and monolithic reactors

Unit–III Catalysis in environmental protection & green process- Industrial catalytic wet air oxidation processes, water purification, synthesis of speciality, commodity and fine chemicals, catalysis in automobiles : catalytic converter applications

Unit–IV Important catalytic materials – Nanostructured metals like Pt, Pd and Fe, nanostructured ceramics like silica, silicate and alumina, pillared clays, colloids and porous materials (viz. mesoporous materials)

Unit–V Mesoporous materials – Introduction, synthesis & characterization, properties and applications (with suitable examples), unipore size, bimodal pore size, graphs., supramolecular chemistry, synthesis (micelar rods).

Text Books & References

1. Basic principles in applied catalysis – Manfredlaerns
2. Nanotechnology in Catalysis – Pinzhan
3. Introduction to Nanotechnology – Charles P Poole Jr & Frank J Owens
4. Nanoscale Materials –LM Liz Marzan & Prashant V. Kamat
5. Nanostructured catalysts – SL Scott, CM Crudden & CW Jones
6. Concepts of Modern Catalysis & kinetics - I. Chorkendorff, J.W. Niemantsverdriet
7.Chemistry of Nanomaterials: Synthesis, properties & applications, Volume-I – CNR Rao, A Muller & AK Cheetham

M.TECH (NANO TECHNOLOGY)
I SEMESTER

THERMODYNAMICS. (Elective - I)

Unit-I Introduction: The scope of thermodynamics, defined quantities; temperature, volume, pressure, work, energy, heat, Joules Experiments, SI units**.**

Unit- II The first law and other basic concepts: The first law of thermodynamics, thermodynamic state and state functions, enthalpy, the steady-state steady-flow process, equilibrium, the reversible process, constant-V and constant-P processes, heat capacity.

Unit –III The second law of thermodynamics: Statements of the second law, heat engines, thermodynamic temperature scales, thermodynamic temperature and the ideal-gas scale, Entropy, Entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics

Unit – IV Phase rule and its application to multicomponent multiphase system. Thermodynamic stability diagrams

Unit- V Solution thermodynamics: Fundamental property relation, chemical potential as a criterion for phase equilibrium, partial properties, ideal gas mixtures.

Text Books & References

1.Introduction to chemical engineering thermodynamics by J.M. Smith, H.C. Van Ness and M.M.
Abbott, 5th ed. Mc Graw Hill 1996.
2.YVC Rao, Chemical Engineering Thermodynamics, University Publications

M.TECH (NANO TECHNOLOGY)
I SEMESTER

SIMULATION LAB

I. ARGUS LAB:

1. Construction of fullerene & its energy calculations
2. Construction of bucky balls (C20, C40, C60, C80, C100, C120)
3. Construction of Carbon nanotubes
4. Energy minimization of lysozyme and its mutant
5. Energy minimization of chymotrypsin and its mutant
6. Energy minimization of enzymes involved in Neurological science

II. MOSES 1.2

1. Study single electron transistor using MOSES 1.2 simulator
2. Simulation of I – V characteristics for a single junction circuit with a single quantum dot using MOSES 1.2 simulator

III. MATHEMATIC SIMULATION

M.TECH (NANO TECHNOLOGY)
II SEMESTER

MATERIAL CHARACTERIZATION TECHNIQUES

Unit – I Compositional and structural Characterization techniques: X-ray Photoelectron Spectroscopy (XPS), Energy Dispersive X-ray analysis (EDAX), Principles and applications of X-ray diffraction; electron diffraction, Electron probe microanalysis (EPMA), Ion beam techniques: SIMS & RBS.

Unit – II Surface characterization Techniques- High resolution microscopy; Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), scanning tunneling microscopy (STM).

Unit – III Spectroscopic techniques: Fourier Transform infrared (FTIR) spectroscopy, Raman spectroscopy techniques: micro Raman and laser Raman.

Unit – IV Electrical characterization techniques: Measurement of resistivity by 4-prob method, Hall measurement, Seebeck coefficient measurements, nano indentation techniques, electron beam induced current measurement (EBIC).

Unit-V Thermal and Magnetic characterization: VSM, Thermal analysis, impedance and ferroelectric measurements

Text books:

1. Nano: The Essentials -Understanding Nano Scinece and Nanotechnology by T.Pradeep,TataMc.Graw Hill
2. Introduction to Nano Technology by Charles. P. Poole Jr and Frank J. Owens, Wiley India Pvt Ltd.
3. A practical approach to X-Ray diffraction analysis by C.Suryanarayana
4. Electron Microscopy and analysis by P.J. Goodhew and F.J. Humpreys
5. Scanning electron microscopy and x-ray microanalysis by J.I. Goldstein
6. Characterization of nanostructured materials by Z.L. Wang
7. Modern Raman Spectroscopy: A practical approach by E. Smith and G.Dent
8. Principles of Instrumental analysis by D.A. Skoog, F.J. Hollen and T.A. Niemann

Reference Books:

1. Nanotechnology: Principles and Practices – Sulabha K. Kulkarni – Capital Publishing Company.
2. Specimen preparation for Transmission Electron microscopy by John & Bravmno et al, published by MRS
3. Photoelectron spectroscopy by JHD Eland, Butterworth & Co. publishers, 2nd education.
4. Encyclopedia of Nanotechnology by H.S. Nalwa

M.TECH (NANO TECHNOLOGY)
II SEMESTER

PROPERTIES OF NANOSTRUCTURES

Unit – I Electronic properties, Energy bands and gaps in semiconductors, Fermi surfaces ,localized particle, donors, acceptors, deep traps,excitons,mobility,size dependent effects, conduction electrons and dimensionality Fermi gas and density of states, semiconducting nanoparticles.

Unit – II Optical properties , Photonic crystals, optical properties of semiconductors, band edge energy, band gap, dependence on nanocrystallins size, Quantum dots, optical transitions, absorptions, interband transitions, quantum confinements.

Unit – III Fluorescence/luminescence, photoluminescence/fluorescence, optically excited emission, electroluminescence, Laser emission of quantum dot, Photo fragmentation and columbic explosion, phonons in nanostructures, luminescent quantum dots for biological labeling.

Unit – IV Magnetic properties, Introduction of magnetic materials, basics of ferromagnetism – ferro magnetic resonance and relaxation, magnetic properties of bulk nanostructures, magnetic clusters, dynamics of nanomagnets, nanopore containment of magnetic particles, nanocarbon ferromagnets, ferrofluids, electron transport in magnetic multilayers.

Unit – V Thermomechanical behavior of thin film nanostructures – a general framework for the thermo mechanics of multi layer films, surface stress-scaling from macro to nano structures.

Text books:

1. Introduction to Nano Technology by Charles. P. Poole Jr & Frank J. Owens. Wiley India Pvt. Ltd.
2. Solid State physics by Pillai,Wiley Eastern Ltd.
3. Introduction to solid state physics 7th edition by Kittel.; John Wiley & sons (Asia) Pvt Ltd.

Reference books:

1. Nano Terchnology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer
3. Encyclopaedia of Nano Technology by M.Balakrishna rao and K.Krishna Reddy,Vol I to X Campus books.
4. Nano Technology - Science, innovation and opportunity by Lynn E. Foster. Prentice Hall Pearson education.
5. Hand book of Nano structured materials Vol I & V
6. Encyclopedia of Nano Technology by H.S.Nalwa

Journal references:

1.K K Nanda, Pramana J. Phys., Vol. 72, No. 4, April 2009
2.A.A.Shavtsburg & M.F.Gerald, Chemical Physics Letters 317 2000. 615–618
3.V P Skripov, V P Koverda and V N Skokov, Phys. Status Solidi A66, 109 (1981)
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

M.TECH (NANO TECHNOLOGY)
II SEMESTER

NANO ELECTRONICS AND NANO PHOTONICS

Unit-I: Single-electron and few-electron phenomena and devices: Tunnel junction and applications of tunneling, Tunneling Through a Potential Barrier, Potential Energy Profiles for Material Interfaces, Metal—Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions,
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Unit-II: Applications of Tunneling; Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in MOSFETs, Theory of Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode.

Unit-III: Coulomb Blockade: Coulomb Blockade, Coulomb Blockade in a Nanocapacitor, Tunnel Junctions, Tunnel Junction Excited by a Current Source, Coulomb Blockade in a Quantum Dot Circuit.

Unit-IV: The Single-Electron Transistor: The Single-Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs, Molecular SETs and Molecular Electronics.

Unit –V: Spintronics: Spintronics and Foundations of nano-photonics.

Text books:

1. Fundmentlas of nano electronics by George W Hanson Pearson publications, India 2008.{Unit-I- IV)
2. Introduction to photoelectron Spectroscopy (Chemical Analysis Vol. 67) by P.K. Ghosh; Wilel Interscience.
3. Nanophotonics by P.N.Prasad – Springer Education series.
4. Nanotechnology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer
5. Nanomaterials: Synthesis, properties and applications\edited by A S Edelstein and R Cammarata (Institute of Physics, UK Series in Micro and Nanoscience and Technology)

Reference books:

1. Encyclopaedia of Nano Technology by M.Balakrishna Rao and K.Krishna Reddy (Vol I to X) Campus books.
2. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology by T.Pradeep; Tata Mc.Graw Hill.
3. Spin Electronics by M. Ziese and M.J. Thornton.
4. Nanoelectronics and Nanosystems – From Transistor to Molecular and Quantum Devices by Karl Goser, Peter Glosekotter, Jan Dienstuhl.
5. Silicon Nanoelectronics by Shunri Odo & David Feny, CRC Press, Taylor & Francis.
6.Nanotubes and nanowires by C.N.R. Rao and A. Govindaraj, RSC Publishing.
7.Encylopedia of Nanotechnology by H.S. Nalwa, American Scientific Publishers.
8.Handbook of Nanoscience, Engineering &Technology by W. Goddard, D. Brenner, S. Lyshevski, G.J.Iafrate, CRC Press (2000).
9.Quantum-Based Electronic Devices and Systems by M. Dutta and M.A. Stroscio, WorldScientifi

M.TECH (NANO TECHNOLOGY)
II SEMESTER

CARBON NANO TUBES AND APPLICATIONS

Unit – I Carbon Nano structures and types of Carbon Nano tubes, growth mechanisms Mechanical reinforcements, Solid Disordered carbon Nanostructures, Nano structured crystals. Graphene,Carbon nanofibers.

Unit –II Electrical, Vibrational, Mechanical Properties of CNTs, optical properties & Raman
spectroscopy of CNTs

Unit –III Carbon clusters and Fullerenes, Synthesis of CNTs by Flame, CVD, Laser & Arc-discharge process.

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

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

Text books:

1. Introduction to Nanotechnology by Charles P. Poole Jr and Frank J.Owens Wiley India Pvt Ltd.
2. Nanotechnology and Nano Electronics – Materials, devices and measurement techniques by WR
Fahrner, Springer publications

Reference books:

1. Encyclopaedia of Nanotechnology by M.Balakrishna rao and K.Krishna Reddy, Vol I to X Campus books.
2. Encyclopedia of Nanotechnology by HS Nalwa
3. Nanotechnology – science, innovation and opportunity by Lynn E.Foster. Prentice Hall Pearson education.
4.Nano:The Essentials – Understanding Nano Scinece and Nanotechnology by T.Pradeep; Tata Mc.Graw Hill.

M.TECH (NANO TECHNOLOGY)
II SEMESTER

NANOCOMPOSITES - DESIGN AND SYNTHESIS

Unit – I Introduction to Nanocomposites, Composite material, Mechanical properties of Nano composite material: stress - strain relationship, toughness, strength, plasticity.

Unit – II Ceramic-Metal Nanocomposites, Ceramic based nanoporous composite, Metal matrix nanocomposites, Polymer-based nanocomposites Carbon nanotube based nanocomposites and Natural nanobiocomposites, Biomimetic nanocomposites and Biologically inspired nanocomposites.

Unit – III Synthesis methods for various nanocomposite materials: mechanical alloying, thermal spray synthesis etc. Nano composites for hard coatings; DLC coatings; Thin film nanocomposites; Modeling of nanocomposites.

Unit – IV Nano Indentation, Types of indentation: Oliver & Pharr, Joslin-Oliver, Vickers
Indentation process.

Unit – V processing of polymer nanocomposites, properties of nanocomposites, Salt infiltration, Powder mixing, Intrusion method, Exfoliation & interaction, Gel-casting impregnation techniques: Hot melt impregnation, solution impregnation.

Text books:

1. Nanocomposite Science & Technology by P.M. Ajayan, L.S. Schadler and P.V. Braun, Wiley-VCH GmbH Co.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens; Wiley India Pvt Ltd.
3. Nanotechnology, A gentle introduction to the next big idea by Mark Ratner, Daniel Ratner Pearson education.

Reference books:

1. Encyclopedia of Nanotechnology by H.S.Nalwa
2. Encyclopaedia of Nano Technology by M.Balakrishna rao and K.Krishna Reddy, Vol I to X Campus books.

M.TECH (NANO TECHNOLOGY)
II SEMESTER

Lithography Techniques (Elective-II)

Unit – I Introduction to lithography and Optical lithography: Introduction to lithography-Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists.

Unit – II Electron Lithography: Electron optics, Raster scan and Vector scan, Electron proximity / Projection Printing, Direct writing, Electron resists, Electron Beam Applications.

Unit –III X-ray Lithography: X-ray Proximity and projection printing X-ray masks, X-ray sources, X-ray resists.

Unit –IV Ion Lithography: Focussed ion beam – Point sources of Ion, Ion Column, Beam writing, Focused Ion Beam Lithography, Masked Ion Beam Lithography, Ion Projection Lithography.

Unit– V Lithography based on Surface Instabilities: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths of each of the above techniques

Reference books:

1.K.L. Chopra, "Thin Film Phenomenon", McGraw-Hill, 1968
2.John N.Helbert, "Handbook of VLSI Microlithography", Noyes Publication, USA, 2001.
3.James R Sheats and Bruce w.Smith, "Microlithography Science and Technology", Marcel Dekker Inc., New York, 1998.
4.S. Wolf "Silicon processing for the VLSI era", Vol-1 to 4, Lattice Press.
5.J.P. Hirth and G.M.Pound "Evaporation: Nucleation and Growth Kinetics" (Pergamon Press, Oxford, 1963

Journals references:

1.R.F.Bunshah and C.V.Deshpandey "Evaporation Processes" MRS Bulletin p.33, Dec.1988.
2.W.D.Westwood "Sputter Deposition Processes" MRS Bulletin p.46, Dec.1988.
3.P.Harris "Taking the Lead in Electron-bem Deposition"Vacuum & Thin Film, Feb.1999,p.26.
4.B.Heinz Sputter Target and Thin Film Defects" Vacuum & Thin Film, October 1999,p.22.
5.G.S.Bales et al., "Growth and Erosion of Thin Splid Films", Science, 249, 264 (1990).
6.C.R.M. Grovenor, H.T.G. Hentzell and D.A. Smith, "The Development of Grain Structure during Growth of Metallic Films" Acta Metallurgica 32, 773 (1984).
7.L.A.Stelmack, C.T.Thurman and G.R. Thompson "Review of Ion-assisted Deposition: Research to Production", Nuclear Instruments and Methods in Physics Research B, 37/38,787 (1989).
8.J.M.Bennett "when is a surface clean?" p.29 in Optics and Photonics News, June, 1990.
9. H.M.Layton "Ultrasonic Cleaning for Semiconductor Wafer Processing".

M.TECH (NANO TECHNOLOGY)
II SEMESTER

MEMS /NEMS Design and Applications (Elective–II)

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

Unit-III 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, 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-VI 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-V 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. “An introduction to Micro electro mechanical systems Engineering” by Nadim Malut and Kirt Williams – Second edition – Artech House, Inc, Boston
2. “Micro electro mechanical systems Design”./ by James J Allen- CRC Press – Taylor and Francis Group
3.“Mechanics of micro electro mechanical systems “ by Nicolae Lobontiu and Ephrahim Garcia Kluwer. Academic Publishers – Boston

References Books

1. “Springer Hand Book of Nano Technology “ by Bharath Bhushan – Springer

2 .“ Nano and Micro electro Mechanical systems” by Sergey Edward Lysherski – CRC Press.

M.TECH (NANO TECHNOLOGY)
II SEMESTER

SYNTHESES AND PROCESSING LAB

Unit I: Two methods for the synthesis of CNTs (CVD method and Flame Synthesis)

Unit II: Nano – Catalyst Preparation by Chemical methods

Unit III: Synthesis of oxide Nanostructures / nano composites by Sol-gel Process

Unit IV: Preparation of any two types of Ceramic Powders, $BaTiO_3$ (ball milling) & Al2O3 (flame)

Unit V: a) Composite preparation (Ball Milling) b) X-ray Diffraction measurements of Nano Crystallites

Unit VI: Nano Particle Size Analysis

Reference books

1. Advanced catalysis and Nano structured material by WR Moser.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens Wiley India Pvt Ltd.
3. Encyclopedia of Nanotechnology by H.S. Nalwa
4. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology – by T.Pradeep; Tata Mc.Graw Hill

NT– 301 Seminar.

NT– 302 Project work.