MNT 201 - Properties of Nanostructure

UNIT I :

Nanoscale I/V: Quantum wells, Q wires and dots, density of states, electrical transport properties in semiconductor nanostructures, quantization of conductance, coulomb blockade, Kondo effect, ballistic transport, non relativistic dirac fermions (massless electrons) & their conductance, Quantum Hall effect, fractional Q Hall effect.

UNIT II :

Vibrational and thermal properties of low-dimensional materials, phonons, quantization of phonon modes, 0D, 1D, 2D, and 3D phonons, heat capacity and thermal transport at nanoscale. Superconductivity phenomena, flux quantization, Josephson effects, proximity and anti proximity effects at nanoscale.

UNIT III :

Nanofluid mechanics; flow of nanofluid, electrophoresis dielectrophoresis: Size selective sepration of dielectric nano particles, nano and micro fluid channels, low reynold number fluid dynamics, optical tweezer.

Unit IV :

Linear and nonlinear optical properties, Size Quantization effect, Optical blueshift phenomenon, Effective mass approximation, Tight Binding Theory (TBT), Collective oscillation, surface plasmon resonance, interactions between Nanoparticles, coupled-dipole approximation, Light detection in nano-structures; scanning near-field microscopy, single-molecule detection.

UNIT V :

Negative refrective index metamaterials, Passive microwave devices and antenna transmission lines metamaterials, super resolving metamaterials, negative refractive index lenses. Plasmonic nanowire metamaterials.

References :

1. Hari Singh Nalwa : Encyclopedia of Nanotechnology
2. Introduction to Nanotechnology : Charles P. Poole Jr and Franks J. Qwens
3. Microwave Properties of Magnetic Films : Carmine Vittoria
4. Physics of Magnetism : S. Chikazumi and S. H. Charap
5. Physical theory of Magnetic Domains : C. Kittel
6. Magnetostriction and Magnetomechanical Effects : E.W.Lee
7. Nanostructures : Bastard
8. The Physics of Low-dimensional Semiconductors: An Introduction , John H. Davies
9. Transport in nano structure: Devid Ferry
10. Electronic transport in meso-scopic systems: Supriyo Datta
11. Nanofluids: Science and Technology by Sarit K. Das.
12. Surface-Enhanced Raman Scattering Physics and Applications Series: Topics in Applied Physics , Vol. 103 Kneipp,
13. Atomic Force Microscopy, Scanning Nearfield Optical Microscopy and anoscratching Application to Rough and Natural Surfaces Series: Nano Science and Technology Kaupp, G.
14. Quantum transport: Supriyo Datta

15. Negative refractive index metamaterials; Fundametals applications by GV Eleftheriadas and K Balmain.

16. Physics and applications of negative refractive index metamaterials by S Anantha Ramakrishna
17. Nanofluids: Science and Technology by Sarit K. Das, Stephen U. Choi, Wenhua Yu, and T. Pradeep
18. Fluid Properties at Nano/Meso Scale: A Numerical Treatment (Microsystem and Nanotechnology Series) by Peter Dyson, Rajesh Ransing, Paul H Williams, and Rhondri Williams

MNT 202 - Transduction and Measurements

Unit-I

Principles of transduction; some examples of transducers. Light sensing detectors (photo diodes and photo multiplier tubes) and their classification. Oscilloscopes, fast amplifiers, lockin amplifiers, Control systems, interfacing for data acquisition and processing.

Unit-II

Nanosensors: Gas sensors, Pollution sensor, Photo sensor, Temperature sensor, IR detector, Biosensor, nanomaterial gas discharge devices, CNT based fluid velocity sensor.
Turbo and ultra high vacuum, Clean room technology, class 1000,100,10 clean rooms.

Unit-III

Thermodynamics & liquefaction of gases, Cryostat design , Transport Phenomenon, Fermi surface,
Conductivity of solids, Technique of low temperature measurement, Physical properties measurement systems (Quantum design-PPMS), Magnetic properties measurement systems (MPMS), SQUIDS, Vibrational sample magnetometer (VSM), AC magnetic susceptibility measurement. Kelvin probe measurements, Ferroelectric and Ferromagnetic measurement, dielectric measurement.

Unit-IV

Interaction of radiation with matter, absorption, spontaneous emission and stimulated emission, population inversion, Semiconducting lasers, Quantum well lasers and quantum dot lasers. Chaotic light and coherence, Trapping and cooling.

Unit-V

Scattering theory, elastic and inelastic scattering, Types of scattering (Raman and Rayleigh scattering), Theory of luminescence, types of luminescence, Photoluminiscence, electroluminescence, and its applications, activators and co-activators, colour centres, Single and two photon laser induced fluorescence, excited state dynamics (lifetimes), fluorescence resonant energy transfer, single molecule dynamics.

References :

1. Instrumentation : Sawney
2. Light & Matter : Yehuda Band
3. Laser technology : A. Ghatak
4. NanoPhotonics : Paras N. Prasad
5. Manuals of Quantum design Instruments (ttp://www.qdusa.com/products/ppms.html)
6. Handbook of Thin Film Technology by Leon I. Maissel and Reinhard Glang

MNT 203 - Fuctional Nano Materials

UNIT I :

Nature of carbon bonds, Different allotropes of carbon, structure and properties of C_{60}, Graphene, Carbon nanotubes and its types, Laser vaporization techniques, arc discharge method and chemical vapor deposition techniques for CNT preparation, purification techniques.
Properties of Carbon Nanotubes and Graphene: Optical, Electrical and electronic properties, Mechanical, Thermal and vibrational properties.

UNIT II :

Shape memory alloys, Principle of one-way and two-way shape memory alloys. Important parameters in pseudo-elastic transformations. Shape memory alloy deformation, twinning & actuation. Thin film shape memory alloys for MEMS and transduction applications. Biomimetricy. Device integration of smart materials.

UNIT III :

Supramolecular structures, Introduction to secondary (non covalent) interactions and their role in organic solids, Insulated molecular wires, threded molecular wires, Discotic systems, hexabenzocorones, porphyrine and phthalocyanine, rylenes, perylenes, terrylenes and quaterrylenes,. Dendrimenrs, dendronised materials as a tool to control supramolecular architectures, potential applications of supramolecules.

UNIT IV :

Hybrid nanomaterials, Core shell and other encapsulated systems, magnetic particle ferrites, microorganisms for synthesis of nanoparticles, nanoparticle-enzyme hybrids, superhard nanocomposites, diblock copolymer based nanocomposites, assemply of polymer nanoparticle composites, Functionalization of carbon nano tubes, covalent functionalization, defect functionalization, nanotube-polymer composites.

UNIT V :

Applications of Carbon Nanotubes in field emission, fuel cells, CNT FETs, Light emitting displays and flat panel displays, hydrogen storage, solar panels, Application of functional nanomaterials in clean energy (Hydrogen Production from Biomass, Catalytic coal hydrogasification), in environmental technologies (clean water and air) and in health care (tissue and bone repairs, bio medical sensors)

References :

1. Nanocomposite Science and Technology, Ajayan, Schadler and Braun
2. Fullerene & Carbon nanotubes, Dressel Shaus
3. Carbon Nanotubes, Elizer
4. Physical properties of CNT: Saito
5. Carbon nanotechnology: Liming Dai
6. Nanotubes and nanowires: CNR Rao and Govindaraj RCS Publishing.
7. Electroceramics: Materials, Properties, Applications, by A.J. Moulson and J.M. Herbert.
8. Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers by G. Gautschi.
9. Smart Structures and Materials, by Artech B. Culshaw.
10. Functional and Smart Materials Structural Evolution and Structure Analysis, by Zhong Lin Wang and Z. C. Kang.
11. Block Copolymers in Nanoscience by Massimo Lazzari
12. Supramolecular Chemistry, Jonathan W. Steed, Jerry L. Atwood

MNT 204 - Nanoscale Devices

UNIT I :
Silicon technology, processing methods: cleaning/etching, oxidation, gettering, doping, epitaxy. Sputtering, Plasma enhanced CVD, reactive ion etching. Moores Law, design rules for CMOS at 90 nm, 45nm, 32 nm. Semiconductor device road map, Silicon on insulator technology.

UNIT II :
Gate dielectrics, poly-Si high-k dielectrics.Thermal matching, effect of lattice mismatch in device fabrication, challenges in MOSFETs for sub 15nm gate technology, 3D interconnects. Photoresist technologies for the nanoscale; metrology and defect inspection, Costing and yield, Assembly and packaging.

UNIT III :
Top down approach to nanolithography; Tools for nanolithography, immersion lithography, Electron and ultraviolet (EUV) photolithography, phase shifting masses, x ray lithography including plasma xray sources, Ebeam lithography, focused ion beams. Nanosphere lithography – Molecular self-assembly, soft lithography, Stereo-lithography, nanoscale 3D shapes – NEMS design, molecular manipulation by STM and AFM - LB flim resists - nanopattern synthesis – Nano scratching.

UNIT IV :
Processing III-V semiconductors including nitrides, molecular beam epitaxy, chemical beam epitaxy, metal organic CVD, quantum wells. Si-Ge, SiC, diamond: synthesis defects and properties at the nanoscale.

UNIT V:
Fundamentals of carrier transport in quantum structures, temperature effects, Resonant tunneling diodes, single electron transistor, modulation-doped field effect transistor MODFETs, and Heterojunction Bipolar Transistors (HBTs)

References:

1. VLSI Technology, S M Sze
2. VLSI fabrication, by S K Gandhi
3. ULSI Devices, Wiley New York, by C.Y. Chang and S.M. Sze.
4. Handbook of Semiconductor Manufacturing Tech by R. D. Doering and Y. Nishi.
5. Semiconductors, 2nd edition, Cambridge University Press, by R.A. Smith.
6. Fundamentals of Modern VLSI Devices, Y Taur, and T. H. Ning.
7. Nitride Semiconductors and Devices (Springer Series) by Hadis Morkoç
8. Physical Properties of III-V Semiconductor Compounds: InP, InAs, GaAs, GaP, InGaAs, and InGaAsP by Sadao Adachi
9. Handbook of Compound Semiconductors: Growth, Processing, Characterization, and Devices (Materials Science and Process Technology Series) by Paul H. Holloway and Gary E. McGuire

MNT 205 - Nano Biotechnology

UNIT I:

Physics of Biological sytems Interaction of biomolecules with surfaces, basic concepts of cell and molecular biology, Biomolecules and its structure, properties of DNA, Recombiant DNA technology.

UNIT II:

Organic nanomaterials: Dendrimers, micelles, liposomes, block coplymers,
Bionanomaterials: Biomimtric Systems, bioceremics & nanotherapeutics, microorganisms for synthesis of nanomaterials, biomembranes. Bio-functionalization of gold, magnetic and polymer nanoparticles and CNTs.

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UNIT III:

Role of nanoparticles and nanodevices in Blood clotting, Blood substitutes, Bionanomaterials: Metallic and ceramic implant materials: Bone regeneration, Nano crystalline structures of Bone and Calcium phosphate cements. Cobalt-based alloys; Titanium and its alloys, Nanoparticles relating to Aluminium oxides; Hydroxyapatite; Glass ceramics; ceramic implants; Carbon implants. Nano dental materials.

UNIT IV:

Nanobiodevices, Nanobio hybrid systems for bioelectronic devices , nanoparticle-enzyme devices, nanoparticle based protein recognition, biomaterial circuitry, lab on chip technology. Potentiometric sensors including chemically sensitive field effect transisitors, fabrication of planer waveguides immunosensors, surface plasmon resonance sensors and cantilever sensors.

UNIT V:

Drug designing and synthesis of nanodrugs–metal nanoparticles and drug delivery vechicles–Nanoshells–Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology. Fundamentals of synthetic chemistry and its pharmaceutical applications.

References:

1. SV Bhat, Biomaterials (2nd Edition), Narosa Publishing House, New Delhi-2005.
2. JB Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984 Challa S.S.R.Kumar, Joseph Hormes, Carola Leuschmal.
3. Nanofabrication towards biomedical applications wiley –VCHVerlag GmbH & CO, KGaA.
4. Introduction to Bioinformatics. Lesk L.A. (ed) 2003. Oxford University, Press
5. Encyclopedia of Nanoscience & Nanotechnology : Native, Hari Singh (Ed), American Scientific Publisher California (2004).
6. Springer Handbook of Nanotechnology Bhushan, Bharat (Ed.)
7. Nano biotechnology: Concepts, Applications and Perspectives by Christof M. Niemeyer and Chad A. Mirkin
8. Nanobiotechnology C M Niemeyer, C A Mirkin,
9. Biofunctionalization of Nanomaterials, Challa Kumar.
10. Bio inorganic Hybrid Nanostructures, Ruiz-Hitzkey and Yuri Lvov.
11. Biomedical Applications of nanotechnology, Leslie-Peleckey.
12 Targetted Drug & Delivery System : S.P. Vyas
13 Chemical sensors and biosensors, Brian R Eggins
14 Electrochemical methods : Fundamentals and applications by Allen J Bard and Larry Faulkner
15 Springer series on chemical sensors and bio sensors by Viladimir Mirsky

16 Exercises in Synthetic Organic Chemistry by Chiara Ghiron , Russell Thomas