PHYSICS DEPARTMENT

M.Tech. NANO- TECHNOLOGY

Course of Study & Scheme of Examination
2016-17

Maulana Azad National Institute of Technology
Bhopal

M.TECH. NANOTECHNOLOGY

First Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
NT511	Structure and Properties of Solids	3	-	-	3
NT512	Properties of Nano Materials	3	-	-	3
NT513	Processing and Fabrication of Nanostructures	3	-	-	3
NT531-NT534	Elective - 1	3	-	-	3
NT535-NT538	Elective - 2	3	-	-	3
NT551-NT554	Open elective-1	3	-	-	3
NT514	LAB-Practice-I	-	-	2	2
NT515	Seminar	-	2	-	2
					Total credit 22

Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
NT521	Nanostructure Characterization Techniques	3	-	-	3
NT522	Properties of Low-dimensional System	3	-	-	3
NT523	Instumentation	3	-	-	3
NT541-NT544	Elective - 3	3	-	-	3
NT545-NT548	Elective - 4	3	-	-	3
NT555-NT558	Open elective-2	3	-	-	3
NT524	LAB-Practice-II	-	-	2	2
NT525	Seminar	-	2	-	2
					Total credit 22

Third Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
NT-611	**Major Project Dissertation Phase-I**	-	-	30	16

Fourth Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
NT-621	**Major Project Dissertation Phase-II**	-	-	30	30

M.Tech. Nanotechnology

List of Elective (1)	
NT531 Optoelectronics	NT532 Nanoelectronics
List of Elective (2)	
NT535 Photonic Materials	NT536 Advanced Topics in Physics
List of Elective (3)	
NT 541 Molecular Structures	NT542 Computational Methods
List of Elective (4)	
NT545 Semiconductor devices	NT546 Amorphous Materials
List of Open elective –I	
NT551 Molecular Electronics & Biomolecules	NT552 Low Temperature Behavior of Materials
List of open elective II	
NT555 Laser Technology	NT556 Nano Fluids and Surfaces

SYLLABUS

M.Tech. NANOTECHNOLOGY

FIRST SEMESTER

NT-511 STRUCTURE AND PROPERTIES OF SOLIDS

Crystal Bonding and Structure, Crystalline, polycrystalline and Non-crystalline solid, Defects in solids; Transport properties: electrical, thermal; Interaction of X-ray with matter, Bragg's law; Free electron theory, Band theory of solids; Scattering theory-elastic and inelastic scattering, Types of scattering (Raman and Rayleigh); Dielectric, Magnetic properties of materials; Ferrites and Nanomagnets; Polymers and Composites.

REFERENCES:

1.Introduction to solid state Physics: C. Kittel
2. Elements of X-ray diffraction: B. D. Culity
3. Material Science and Engineering: W. Callister
4. Nanocomposite Science & Technology: Ajayan, Schalder and Barun
5. Solid State Physics: S. O. Pillai

NT-512 PROPERTIES OF NANO MATERIALS

Introduction to Nanotechnology: Characteristic scale for quantum phenomena-Quantum Confinement. Drexler-Smalley debate and historical and environmental evidences. Electronic structures- Quantum well, quantum dots, quantum wires. Nano-clusters. Structure and bonding. The Jellium Model. Discovery of C_{60}.Fullerene. Carbon Nano Tubes- types, structures, synthesis of CNTs. Transport, Optical, Thermal and Mechanical Properties of Nano tubes. Application of Nano Materials. Micro & Nano Electromechanical Systems.

REFRENCES :

1. D.Bimberg, M.Grundman, N.N. Ledenstov : Quantum Dot Heterostructures
2. Sharma Ashutosh, Jayesh : Adv. In Nano Science & Tech.
3. Dresselhaus M.S. & Avouris : CNT Synthesis, Structure

NT-513 PROCESSING AND FABRICATION OF NANOSTRUCTURES

Si processing methods: Cleaning /etching, oxidation-oxides, Gettering, doping, epitaxy. Top-down techniques: Photolithography, other optical lithography , Particle beam lithography, Processing of III-V semiconductors including nitrides. Molecular-Beam Epitaxy, Chemical Beam epitaxy, Metal-Organic CVD. Bottom-up techniques: self-assembly, self-assembled monolayer, directed assembly, layer-by-layer assembly. Combinations of top-down and bottom-up techniques: current state of the art

REFRENCES :

1. Hand Book of Semiconductor Cleaning Technology : Werner Kern
2. Principles of Lithography : Harry J. Lavinson
3. Introduction to Nano Science and Nanotechnology : Chris Binns

NT-514 LAB PRACTICE-I

List of Experiments:

1. Study of Hall effect
2. Band gap of semiconductor by Four Probe Method
3. LASER Characteristics : Measurement of spot size, Power & Beam diversion
4. I/V characteristics
5. Synthesis of Nano Materials
6. Thin Film Deposition

NT-515 SEMINAR

Seminar on Current Trends in Nanotechnology covering Synthesis Processes and applications.

SECOND SEMESTER

NT-521 NANOSTRUCTURE CHARACHTERIZATION TECHNIQUES

Compositional surface analysis: Ultraviolet (UV) and X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectrometry (SIMS), Contact angles

Microscopies: Optical microscopy, Fluorescence & Confocal microscopy, Cathodoluminescence (CL) and photoluminescence (PL) ,TEM, SEM.

Probe techniques: Atomic force microscopy (AFM), scanning tunneling microscopy (STM), scanning near field optical microscopy (SNOM), Deep level transient spectroscopy (DLTS), Kelvin-probe measurements. Nano scale current-voltage (I-V), capacitance-voltage (C-V) relationships .

REFRENCES

1. Fundamentals of Nano Scale Film Analysis : Alford, Feldman, Mayer (Springer)
2. Nano Structured Materials : Carl C. Koch
3. Nanostructures & Nano Materials : Ghuzang Cao
4. Hand Book of Nanophase & Nanomaterials (Vol. I&II) :Zhong Lin Wang (Springer)

NT-522 PROPERTIES OF LOW DIMENSIONAL SYSTEM

Transport properties: quantization of conductance, density of states, Coulomb blockade, Kondo effect. Hall, quantum Hall, fractional quantum hall effects

Vibrational and thermal properties: phonons, quantization of phonon modes, heat capacity and thermal transport

Optical properties: Collective oscillation (Gustav-Mie explanation), surface plasmon resonance, interactions between Nanoparticles, coupled-dipole approximation, Linear and Nonlinear optical properties.

REFRENCES :

1. Handbook of Nanotechnology : Bhushan
2. Nano optoelectronics :M.Grundman
3. Nanophotonics :Paras N.Prasad

NT-523 INSTRUMENTATION

Resistivity probing, Conductivity, Hall Mobility, Electrometer; X-ray Diffraction technique-powder & Single crystal diffraction; Spectroscopic techniques: UV-Vis, NMR, ESR, Raman Spectroscopy, FTIR; Compositional analysis: Electron probe micro analysis (EPMA), Auger electron spectroscopy (AES), ESCA; Magnetic properties measurement: VSM, SQUIDS, MFM, Susceptibility, Ferroelectric and dielectric measurements; Thermoelectric properties; Thermal analysis: TGA- DTA, DSC; Vacuum pumps (Turbo and ultra high vacuum), Measurement of Low pressure- penning and pirani gauge, Film thickness measurement

REFRENCES :

1. Elements of X-ray diffraction: B. D. Culity
2. Handbook of thin film technology: Leon I. Maissel, R. Glang
3. Handbook of analytical instruments: R. S. Khandpur
4. Introduction to magnetic materials: B. D. Culity and C. D. Graham
5. Thermal methods of analysis: W. W. Wendlant

NT-524 Lab Practice - II

List of Experiments:

1. Study of Nanomaterials using AFM
2. Photoluminescence studies of Nanomaterials
3. To take Debye Scherrer pattern of a given poly-crystalline material and determination of third “d” values from powder lines (XRD).
4. To determine the response of silicon solar cells and the effect of prolonged irradiations, and to calculate the efficiency and fill factors of a variety of solar cells.
5. Demonstration of SEM
6. Hysteresis Properties of Ferroelectric materials using P-E Loop Tracer
7. Dielectric Measurements using Impedance Spectroscopy

NT- 525 SEMINAR

Seminar on Current Trends in Nanotechnology covering Synthesis Process, Fabrication and Characterization of Nano materials and their applications in devices.

I & II SEMESTER ELECTIVES

NT-531 OPTO ELECTRONICS

Principle of light guidance in optical wave guides. Fabrication and types of Optical fibres, rays and modes, losses in optical fibres and applications. Optical fibre interconnectors, concept of optical waveguides. Nonlinear optics. Second harmonic generation. Birefringence. Electro-optics (Kerr effect, Pockels effect, Faraday effect), Magneto-optics. Optical Integrated Circuits, Light Emitting Diode, Solar Cells.

REFRENCES :

1. Optical Electronics :A. Ghatak & K. Thyagarajan
2. Quantum Electronics :A. Yariv
3. An Introduction to Optical Fibers :A.H. Cherin

NT-532 NANO ELECTRONICS

Spintronic: Spin Injection, GMR & TMR, Spin valve effect, spin valves and MRAM devices

Solid state devices: quantum dots, quantum wires, , Photonic bandgap materials, nanoscale photonic devices, Special phenomena in 2D and 3D nano structures.

The basic properties of liquid crystals and their display and non-display applications at the nanoscale

REFERENCES

1. Nano Electronics and Information Technology : Rainer Waser

NT-535 PHOTONIC MATERIALS

Atomic scale structure of materials. Magnetism: moments, environments and interactions, order and magnetic structure. Scattering theory: Excitations of crystalline materials, magnetic excitations, sources of X-rays and neutrons. Interaction of light with photon: L.A.S.E.R. Chaotic light and coherence. Laser spectroscopy. Multiphoton processes. Light scattering by atoms. Electron scattering by atoms. Coherence and cavity effects in atoms. Trapping and cooling.

REFRENCES :

1. Light & Matter : Yehuda Band
2. NanoPhotonics : Paras N. Prasad
3. Nanostructured Films & Coatings : Gang Moog Chow

NT-536 ADVANCED TOPICS IN PHYSICS

Electrets physics: various types of electrets, methods of preparation, various studies on electrets, uses of electrets. Luminescence: various kinds of luminescence, theory of luminescence, paramagnetic behavior, activators and co-activators, Clustering, color centers. Preparation techniques and application. Amorphous semiconductor materials. Preparation techniques in bulk form & in thin form. Rocking and quenching of materials. Characterization of amorphous materials.

REFRENCES :

1. Amorphous Materials : S.R. Elliot
2. Physics of Amorphous Solids : Richard Xylen

NT-541 MOLECULAR STRUCTURES

Molecular structure: Born-Oppenheimer approximation; Electronic structure ionic and covalent bonding, H_2, H_2^+; Vibrational and rotational structure.

Molecular spectra: Microwave, infrared and optical spectra of molecules; selection rules, experimental set-ups and examples; Raman spectroscopy. ortho-para states.

Molecular processes: Collisions with electrons and heavy particles; Experimental techniques.

REFERENCES

1. Physics of Molecules : Wolf Gang Demtroder
2. Hand Book of Molecular Physics & Quantum Chemistry :Stephen Wilson

NT-542 COMPUTAIONAL METHODS

Differential equation, special functions Bessel's, Hermite's. Laguerre polynomials. Eigen value , Eigen functions. Perturbation theory. Numerical analysis. Idea of visual basic, c++ and c-sharp.

REFERENCES

1. Matehmatical Physics : S.S. Rajput
2. Visual Basic & C ++ : Shyaum Series

NT-545 SEMICONDUCTOR DEVICES

Semi conducting materials, p-n junction, space charge and electric field distribution at junctions, forward & reversed biased condition, minority & majority carrier currents, Zener and avalanche break downs, Schottky barrier, Shockley diode & silicon control rectifier, Zener diodes, tunnel diodes, photo diodes. Two port network analysis, H,Y & Z parameters, BJT in CE configuration, Constants of CB & CE amplifier, FET, MOSFET, Equivalent circuit of FET. Source amplifier. Idea of transistor biasing and amplifiers.

REFRENCES :

1. Electronic Devices & Circuits :Millman & Halkins
2. Solid State Electronic Devices :Ben G Streetman
3. Microwave Principle :W.J. Reich
4. Electronics :S. Bhadran

NT-546 AMORPHOUS MATERIALS

Physics of Amorphous Material: preparation of amorphous materials, metallic glass, thermal evaporation techniques such as sputtering, CVD Techniques, quenching. Glasses, theory for glass transition, glass transition temperature. Chalcogenide glasses. Structure of disordered materials. Experimental techniques, electronic density of states. Localization phenomenon, transport , optical and dielectric properties.

REFRENCES :

1. Amorphous Materials : S.R. Elliot
2. Physics of Amorphous Solids : Richard Xylen
3. Electronic process in Non-Crystalline Materials : Davis & Mott.

   Disordered Material an Introduction : Paolo M. Ossi

OPEN ELECTIVE-I

NT-551 MOLECULAR ELECTRONICS AND BIOMOLECULES

Organic semiconductors, Organic molecules as switches, motor-molecules and biomimetic components .conducting polymers, light emitting polymers, The self-assembly of complex organic molecules, Molecular connections and the integration of molecular components into functional devices**,** Contact issues, Structure of biomolecules; Biotechnology, recombinant DNA technology, molecular biology. Structural and functional principles of bionanomachines, Interfacing bio with non-bio materials, Porous silicon

REFRENCES

1. Molecular Electronics : T. Helgakar
2. Semiconductor Quantum Dots : Masumota Takaga

NT-552 LOW TEMPERATURE BEHAVIOR OF MATERIALS

Thermodynamics & liquefaction of gases, Cryostat design , Transport Phenomenon, Fermi surface, Magnetism. Conductivity of solids, Technique of measurement, Paramagnetic & Nuclear adiabatic demagnetization. Superconductivity. fundamental phenomena of super conductivity, Meissner effect, London equation, Type I and Type II superconductors, qualitative idea of Cooper pairing and BCS theory. Ginsburg-Landau theory, coherence length, Green's functions of electrons and phonons, isotope effect, The BCS Hamiltonian, the gap parameter, Superconductor in a field, flux quantization effect, SQUIDS, High-Tc materials.

REFRENCES

1. Superconductivity :Werner Buckel & Reinhold
2. Thermodynamics :M.S.Yadav
3. Treatise on Heat :V.K. Shrivastava

Open elective-II

NT-555 LASER TECHNOLOGY

Interaction of radiation with matter, absorption and stimulated emission, absorption and gain coefficient, spontaneous emission, homogeneous and inhomogeneous broadening, Doppler width. basic principles of lasers , properties of laser beams, population inversion in three and four level lasers, resonance frequencies, modifications of the laser output, single mode operation, Q- switching. laser materials and types of lasers, solid state lasers, characteristics of dye lasers, semiconductor lasers. Laser applications. Material processing metrology and Remote sensing. Laser induced controlled thermonuclear fusion. Laser applications in spectroscopy.

REFRENCES :

1. Introduction to Laser Physics : K. Shimoda
2. Laser Spectroscopy A Basic Concepts and Instrumentation : W. Demtr der
3. Atomic and Laser Spectroscopy : A. Corney

NT-556 NANO FLUIDS AND SURFACES

Nanofluidics and surfaces: liquid structure near solid-liquid interfaces (simple liquids; layering electrolytes: Poisson-Boltzmann equation; Debye Hückel approx.) Hydrodynamic boundary condition: slip vs. non-slip, electro kinetic effects (electrophoresis, electro osmotic effect, electro viscous effect), surface reconstruction, dangling bonds and surface states

REFRENCES :

1. Nano- The Next Revolution : Mohan Sunder Rajan (NBTI)
2. Introduction To Nano Technology : Charles P. Pode (Springer)
3. Quantum Dot Heterostructures : D.Bimberg, M.Grundman

THIRD SEMESTER

NT-611 Major Project Dissertation Phase-I

Dissertation on Current Trends in Nanotechnology covering Synthesis Process, Fabrication and Characterization of nanomaterials and their applications in devices.

Note: Topic is to be selected / finalized in consultation with the concerned guide of the candidate. Accordingly the candidate shall carry out the project work.

FOURTH SEMESTER

NT-621 Major Project Dissertation Phase-II

Dissertation on Current Trends in Nanotechnology covering Synthesis Process, Fabrication and Characterization of nanomaterials and their applications in devices.

Note: Dissertation work is to be carried out and submitted within the stipulated time in consultation with the concerned guide of the candidate. Before submission of Dissertation the student must have one publication in Journal of repute.