DELHI TECHNOLOGICAL UNIVERSITY

SCHEME OF TEACHING & EVALUATION

MASTER OF TECHNOLOGY IN NANOSCIENCE AND TECHNOLOGY (NST)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN

XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	NST501	Physics of Nanomaterials	Core	4	3	0	2	15	25	20	40	-	17
	2	NST503	Chemistry of Nanomaterials	Core	4	3	0	2	15	25	20	40	-	
Group B	3	NST5401/5403/……	Elective 1	Elective	4	4	0	0	20	0	30	50	-	
	4	NST5301/5303/……	Elective 2	Elective	3	3	0	0	20	0	30	50	-	
	5	NST5201/5203/……/ UEC5201/5203/……	Elective 3/University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	NST502	Analytical Techniques	Core	4	3	0	2	15	25	20	40	-	
	2	NST504	Design and Synthesis of Nanostructures	Core	4	3	0	2	15	25	20	40	-	

Group D	3	NST5402/5404/……	Elective 4	Elective	4	4	0	0	20	0	30	50	-	**17**
	4	NST5302/5304/……	Elective 5	Elective	3	3	0	0	20	0	30	50	-	
	5	NST5202/5204/……/ UEC5202/5204/……	Elective 6/University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	NST651	Research Project	Core	12						40	60		**12**
	Track 2													
	1	NST601	Major Project I	Core	3						40	60		
	2	NST6401/6403/……	Elective 7	Elective	4	4	0	0	20	0	30	50	-	
	3	NST6301/6303/……	Elective 8	Elective	3	3	0	0	20	0	30	50	-	
	4	NST6201/6203/……	Elective 9	Elective	2	2	0	0	20	0	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	**Track 1**													
	1	NST652	Research Project	Core	12						40	60		**12**
	Track 2													
	1	NST602	Major Project II	Core	12						40	60		

LIST OF ELECTIVES :													
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 1	1	NST5401	Computational Physics and Programming	Elective	4	4	0	0	20	0	30	50	-
	2	NST5403	Nanoscale Modeling and Simulation		4	4	0	0	20	0	30	50	-
	3	NST5405	Environmental Nanotechnology		4	4	0	0	20	0	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 2	1	NST5301	Thin Film Technology	Elective	3	3	0	0	15	25	20	40	-
	2	NST5303	Functional Materials and Devices		3	3	0	0	15	25	20	40	-
	3	NST5305	Material Science at Nanoscale		3	3	0	0	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 3	1	NST5201	Seminar	Elective	2	0	0	2	-	100	-	-	-
	2	NST5203	Research Methodology		2	2	0	0	10	15	25	50	-
	3	NST5205	Micro Economics		2	2	0	0	10	15	25	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 4	1	NST5402	Nanophotonics	Elective	4	4	0	0	20	0	30	50	-
	2	NST5404	Spectroscopic Techniques for Nanomaterials		4	4	0	0	20	0	30	50	-

	3	NST5406	Molecular Spectroscopy		4	4	0	0	20	0	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 5	1	NST5302	Minor project	Elective	3	0	0	-	-	40	-	-	60
	2	NST5304	Renewable Energy Technology		3	3	0	0	20	0	30	50	-
	3	NST5306	Structural Analysis of Nanomaterials		3	3	0	0	20	0	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 6	1	NST5202	Nano-Electronics and Devices	Elective	2	2	0	0	20	0	30	50	-
	2	NST5204	Nanocomposites		2	2	0	0	20	0	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 7	1	NST6401	Nanobiotechnology	Elective	4	4	0	0	20	0	30	50	-
	2	NST6403	Nanosensors and Devices		4	4	0	0	20	0	30	50	-
	3	NST6405	Microelectromechanical Systems (MEMS)		4	4	0	0	20	0	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 8	1	NST6301	Nanolithography and Device Fabrication	Elective	3	3	0	0	20	0	30	50	-
	2	NST6303	Plasma Technology		3	3	0	0	20	0	30	50	-
	3	NST6305	Nanotechnology for Medical Diagnostic and Therapy		3	3	0	0	20	0	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 9	1	NST6201	Spintronic	Elective	2	2	0	0	20	0	30	50	-
	2	NST6203	Biophotonics		2	2	0	0	20	0	30	50	-

SEMESTER I

Courses

NST501 Physics of Nanomaterials

Introduction to the nanoscience, nanotechnology and significance of nanoscale, surface area and quantum confinement, different type of nanomaterials. An overview of quantum mechanical concepts related to low–dimensional systems- Wave-particle, de Broglie wavelength, time- dependent and time independent Schrodinger equation, Particle in box.

Excitons classification of quantum confined systems, Density of electronic states, Local density of states, Excitons in molecular crystals and in nanostructures, Direct and indirect band gap semiconductors; Lattice matching, Effective mass, Heterojunctions, Type I and Type II hetero structures. Optical properties of nanomaterials and Photoconductivity. Crystal structure, crystallographic planes, Miller indices, Bragg's law and X-ray Diffraction.

Statistical Mechanics, Microcanonical, canonical- and grand canonical ensembles and their connections, Classical Statistical systems, Boltzmann statistics and quantum statistical systems, Fermi-Dirac and Bose-Einstein Statistics and their applications.

Suggested Books:

[1] T. Pradeep, Nano: The essentials, Tata Mc Graw Hills, 2007.
[2] B.G. Streetman and Banerjee, Solid State Electronic Devices, Prentice Hall of India, 2001.
[3] G.L. Hornyak, J. Dutta, H.F. Tibbals and A. Rao, Introduction to Nanoscience, CRC Press, 2008.
[4] C.P. Poole, Jr. and F.J. Owens, Introduction to Nanotechnology, Wiley-Interscience, New York, 2003.

NST503 Chemistry of Nanomaterials

Chemical Bonding: Bonding Forces and Energies- Types of bonding- Ionic, Covalent, Metallic, van der Waals, π- π-stacking, Hydrogen bonding. Surface adsorption, Freudlich and Langmiur Adsorption Isotherm, Gibb's Isotherm, Their fundamental approach to Nanomaterials. Colloidal chemistry: Colloidal properties, origin of charge on colloidal properties. Determination of colloidal particle size. Synthesis of Nano materials/Nano systems employing chemical, precipitation, coprecipitation, microemulsion, thermolysis, Electrochemical and photochemical methods.

Nano polymers/Nanocomposites: Synthesis, Characterization, Properties and applications of Nano polymers/Nanocomposites, Polymers, metal oxide glass and ceramic-based nano composites and their use in catalysis. Preparation and Stabalization of Metal/Alloy nanoparticles**.** Separation and purification of Nano particles by Membrane Technology: Ion Exchange Membranes, Electrodialysis, Reverse Osmosis, Ultrafiltration Microfiltration and Nanofiltration Techniques.

Suggested Books:

[1] P.M. Ajayan and L.S. Schodler, Nanocomposites Science and Technology, Wiley, New York, 2003.
[2] C. N. R. Rao, Chemistry of Nanomaterials: Synthesis properties and applications, Wiley, New York, 2004.
[3] G. A. Ozin and A. C. Arsenault, Nanochemistry: A chemical approach to nanomaterials, Royal Society of Chemistry, Cambridge U.K., 2005

[4] K Holmberg, B jonsson and B Kromberg, Surfactants and Polymers In Aqueous, Wiley England,2004
[5] C. Brechignac, P. Houdy and M. Lahmani, Nanomaterials and Nanochemistry, Springer publication, 2007.

NST5401 Computational Physics and Programming

Roots of equations, Direct method and iteration method, Bisection method, Regula Falsi Method or Method of False position, Secant method, Newton-Raphson method, Finite differences, InterpolPation with equally spaced data points: Newton's forward and backward formulae for interpolation, Central difference: Gauss forward, Gauss Backward, Stirling, Bessels, Everett's formula for interpolation, Interpolation with unequally data points: Lagrange's interpolation formula, Divided differences and their property, Newton Divided differences formula.
Numerical integration, Newton-cotes integration formulae, trapezoidal method, Simpson's 1/3-rule, Simpson's 3/8-rule, Boole's and Weddle's Rule, Romberg integration, , Euler-Maclaurin formula, Numerical double integration, Numerical solution of ordinary differential equations by Taylor's series, Picard's method of successive approximation methods, Euler's method, modified Euler's method, Runge-Kutta method, solution of second order and simultaneous differential equations
Introduction to Matlab, Array & matrix operation, basic plotting's, loops and controlled loops, arithmetic, relational & logical operators, script and function files, inbuilt function for numerical methods: root findings, interpolation, curve fitting, integration, differentiation and solution of first and second order differential equations.

Suggested Books:
[1] S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw-Hill International Editions, 1998.
[2] T. Pang, An Introduction to Computational Physics, Cambridge University Press, 2010.
[3] A. Gilat, Numerical Methods for Engineers and Scientists, John Wiley & Sons, 2008.
[4] C. F. Gerald and P. O. Wheatle, Applied Numerical Analysis, Pearson, 2003.
[5] S. C. Chapra, MATLAB Programming for Engineers, Cengage, 2012.

NST5403 Nanoscale Modeling and Simulation

Introduction to the modeling in materials science; Simulation vs. modelling; Simulation techniques for nano, micro, meso and continuum scales; Nanoscale and microscale – molecular dynamics and Monte Carlo techniques.
Microstate, Macrostate, Distribution Laws, Indistinguishable particles, statistical mechanics and thermodynamics laws; Maxwell Botzmann statistics.
Monte Caro Simulation: Principles of equilibrium; Monte Carlo simulation-estimator; Importance of sampling, acceptance ratio, continuous time MC, Ising model and Metropolis algorithm; Simulation of Interfaces; Analysis of MC data; Out of equilibrium simulation; MC simulation in surface science; Implementation of MC algorithms.
Molecular Dynamics: Introduction, Interatomic potentials, Equations of motion, integration, Pair Distribution, constraints and free energy; Time correlation functions and spherical densities; Velocity autocorrelation functions; Time correlation function and relaxation times; Applications in nanomaterials.
Overview of Modelling, Simulation and Visualization Software -Gaussian, Comsol Multiphysics and Octave.

Suggested Books:
[1] M.E.J. Newman, and, G.T. Barkema, Monte Carlo Methods in Statistical Physics, Oxford University Press, 1999.
[2] J. G. Lee, Computational Materials Science: An Introduction, CRC Press, 2016.
[3] M.M. Wolfson, and G. J. Pert, An Introduction to Computer Simulation, Oxford Press, 1999.
[4] D. Raabe, Computational Materials Science: The Simulation of Materials Microstructures and Properties, Wiley-VCH, 1998.
[5] D.P. Landau and K. Binder, A Guide to Monte Carlo Simulation in Statistical Physics, Cambridge University Press, 2005.

NST5405 Environmental Nanotechnology

Overview of physical, chemical and biological processes concerning the environment; types, transport and transformation processes of contaminants in air, water and soil; effects of contaminants on environment. Environmental impacts of nanomaterials - Exposure and risk assessment, Dose-response, mechanisms of toxicity; ecotoxicological impacts of nanomaterials - bioavailability and uptake; assessment of life cycle risk of nanomaterials.
Nanoparticle transport, aggregation and deposition – physicochemical interaction, aggregation, eposition, nanoparticle behavior in heterogeneous systems, airborne nanoparticles. Reactive oxygen species (ROS) generation – semiconductor nanoparticles and ROS generation, metal sulphide surface chemistry and free radical generation, fullerene photochemistry and ROS generation potential, Environmental applications of nanomaterials.
Analytical methodologies for studying impact of nanomaterials in environment – atomic absorption spectrometry, inductively coupled plasma spectrometry, chromatography, thermal methods, hyphenated techniques.
.
Suggested Books:
[1] M.R. Wiesner and J.Y. Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill, New York, 2007.
[2] M. Diallo, J. Duncan, N. Savage, A. Street and R. Sustich, Nanotechnology Applications for Clean Water, William Andrew, 2008.
[3] J. R. Lead, and E. Smith, Environmental and Human Health Impacts of Nanotechnology, John Wiley & Sons, 2009.
[4] D.A. Skoog, F.J. Holler and S.R. Crouch, Instrumental Analysis, Cengage Learning India Private Limited, New Delhi, 2006.
[5] G.M. Masters, and W.P. Ela, Introduction to Environmental Engineering and Science, Pearson, 2007.

NST5301 Thin Film Technology

Introduction to the thin film deposition techniques – Kinetic theory of gases – Physical vapour deposition techniques – Physics and Chemistry of Evaporation – Thermal evaporation – Pulsed laser deposition – Molecular beam epitaxy – Sputtering deposition, Chemical methods – Thermal Chemical Vapour Deposition – Plasma enhanced Chemical Vapour Deposition – Spray Pyrolysis – Sol Gel method – Spin and Dip coating – Electrophoretic and electrochemical deposition. Self –assembled monolayers.
Nucleation, growth and epitaxy: Substrate surface, Adsorption, Surface energy, film growth modes, nucleation model, manifestation of epitaxy, lattice misfit and defect formation, morphology, grain growth, texture, microstructural control.
Fundamentals of diffusion –Grain Boundary Diffusion, metal-semiconductor reactions, film growth modes, Transformations-Origin of Thin film stress – Classifications of stress – Stress in epitaxial films – Growth Stress in polycrystalline films – Correlation between film stress and grain structure – Mechanisms of stress evolution – film stress and substrate curvature.

Suggested Books:
[1] R. F. Bunshah, Hand Book of Deposition technologies for Thin Films and coatings Second Edition, Noyes Publications, 1994.
[2] M. Ohring, Materials Science of Thin Films, Academics Press Limited, 1991.
[3] H. Luth, Solid surfaces, Interfaces and Thin Films 4th edition, Springer Publishers, 2010.
[4] H. Ibach, Physics of surfaces and Interfaces, Springer Publishers, 2006.
[5] K.L. Chopra, Thin Film Phenomena, Mc Graw-Hill Book, 1969.

NST5303 Functional Materials and Devices

Concept of functional materials. Challenges in the science and technology of advanced materials, Classification of materials, bonding in materials. Characterization of materials. Structural, morphological, optical, electrical, magnetic, dielectric, physical and thermal properties of materials and other various properties of materials.
Symmetry analysis of solids and the Landau theory of phase transitions; piezoelectric sensors, actuators and transducers; ferromagnetic and ferroelectric memories and flexoelectricity; phase change memories; liquid crystal displays; skyrmions and vortex structures. Electro and magnetocaloric cooling; epitaxial engineering of heterointerface properties and domain wall properties; mixed ionic and electronic conductivity, memristive memories, artificial synapses and neuromorphic circuitry.
Potential applications of selected functional materials from various areas of inorganic, organic and hybrid materials, Process and materials optimization, Optoelectronic materials and devices, Enhancement of device performance, Recent trends in Functional materials and devices and Future perspectives of advanced functional materials.

Suggested Books:
[1] W. D. Callister and Jr., Fundamentals of Materials Science and Engineering, John Wiley & Sons, 2012.
[2] B.D. Cullity, Elements of X-Ray diffraction, Addison Wesley, 1956.
[3] G. Sridhar, S. G. Choudhary and N. G. Goswami, Materials characterization techniques, NML, Jamshedpur.
[4] A.K. Tyagi and S. Banerjee, Functional materials: preparation, processing and applications, Elsevier, 2011.
[5] B. Sanyal and O. Eriksson, Advanced functional materials: a perspective from theory and experiment, Elsevier, 2012.

NST5305 Material Science at Nanoscale

Single crystalline, polycrystalline and amorphous structures, classification of crystals, imperfection in solids, grain boundaries and its effect on mechanical properties, Phase transitions in nanosystems-comparison to large systems. Carbon molecules, nature of carbon bonds, new carbon structures, Buckyballs, Carbon Nanotubes-fabrication, structure, electrical and mechanical properties. Applications in field emission, shielding, computers, fuel cells, sensors, catalysis, mechanical reinforcement
Bulk nanostructured materials, synthesis, mechanical and electrical properties, metal nanocluster composite glasses, porous silicon, natural nanocrystals, nanoparticles in zeolites, crystals of metal naoparticles, nanoparticle lattices in suspensions, photonic crystals, nanocopmposites, nanoceramics, ceramic matrix composites. Nanostructured ferromagnetism, effect of nanostructuring, nanomagnets, nano carbon ferromagnets, giant and colossal magnetoresistance, Ferro fluids, Nanocmposites of dielectric, piezoelectric and ferroelectric materials. Polarization types, frequency dependence, other relevant current topics.
Fundamental Magnetic Properties; Nanocomposite soft magnetic materials, hard magnetic materials; Effects of particle size and Surface chemistry on magnetic properties.

Suggested Books:
[1] C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 2012.
[2] N. W. Aschroft and N. D. Mermin, Solid State Physics, Holt, Rinehart and Winston, 1976.
[3] P. M. Ajayan, L. S. Schadler and P. V. Braun, Nanocomposite: Science and Technology, Wiley, 2003.
[4] G. A. Mansoori, Principles of Nanotechnology, World Scientific, 2005.
[5] M. F. Ashby, Nanomaterials, Nano-tech & Design by, Butterworth-Heinemann, 2009.

NST5201 Seminar

NST5203 Research Methodology

Knowledge of research methods- The role of research in academia/industry- needs of research- understanding the modern research methods and its trends/goals- critical thinking and its evaluation parameters-developing and designing questionnaires- implementations– challenges /obstacles.
Identifying the key resources: - Online/offline data, database search tools/algorithms, accessing the review articles, theses/dissertations, catalogs, citations– evaluation of quality Impact factor (QIF) of such resources– modeling using para- and meta-analysis– parenting the records and documentation/compilation.
Motivational research– Types of research: - Descriptive vs. Analytical, Applied Vs Fundamental, Qualitative Vs Quantitative, Conceptual Vs Empirical: laboratory/simulation research, clinical/diagnostic research, historical/contemporary research,
Types of research techniques: - library research, field research, laboratory/simulation research– Research Process: - Extensive literature survey, Formulating the research problem, development of working hypotheses, preparing the research design, determining the sample design– Art of scientific writing. Brief overview of ethics and science.

Suggested Books:
[1] A. Briggle and C. Mitcham, Ethics and Science: An introduction, Cambridge University press, 2012.
[2] G. Comstock, Research Ethics: A philosophical guide to the responsible conduct of Research, Cambridge University Press, 2013.
[3] A. Lahthorp and K. Foss, Student cheating and plagiarism in the internet era: A wake up call, Greenwood publishing group Inc, 2000.
[4] E. B. Wilson, An introduction to scientific research, Dover publication, 1990.
[5] A. Robert, Day and B. Gastel, How to write and publish a scientific paper, Cambridge University press, 2012.

NST5205 Micro Economics

Theory of consumer behavior- Law of demand and supply, elasticity, Budget constraint, concept of utility, diminishing marginal utility, Diamond-water paradox, income and substitution effects; indifference curves.
Theory of cost and production - Production: behavior of profit maximizing firms, production process, production functions, law of variable proportions, isoquant and isocost lines, cost minimizing equilibrium condition. Costs: costs in the short run, costs in the long run, revenue and profit maximizations, minimizing losses, short run industry supply curve, economies and diseconomies of scale.
Theory of firms and market structure- Equilibrium in short run and long run under-Perfect competition, Monopoly and Imperfect Competition: Monopolistic competition, oligopoly.

Suggested Books:
[1] K. E. Case and R. C. Fair, Principles of Economics, Pearson Education, 2007.
[2] A. Koutsoyiannis, Modern Microeconomics, Palgrave Macmillan, 2003.
[3] J.M. Henderson and R. E. Quandt, Microeconomic Theory: A Mathematical Approach, McGraw-Hill, New York, 1958.

SEMESTER II

Courses

NST502 Analytical Techniques

X-Ray diffraction. Dynamic light scattering, Light microscopy, Scanning Electron Microscopy based techniques (Secondary electron imaging, backscattered electron imaging, Electron backscattered diffraction (EBSD). TEM based techniques (diffraction contrast imaging, Electron diffraction, High resolution imaging). Scanning probe microscopies (Atomic Force Microscopy (AFM), Piezeo Force Microscopy, Scanning Tunneling Microscopy).
Ultraviolet-visible-infrared, Fourier Transform Infrared Spectroscopy. Raman. X-ray photoelectron spectroscopy. Auger spectroscopy. Energy Dispersive X-ray Spectroscopy, Wavelength Dispersive X-ray Spectroscopy, Electron Energy Loss Spectroscopy, scanning tunneling spectroscopy. Differential Thermal analysis (DTA) - Differential Scanning Calorimetry (DSC) – Thermo-gravimetric analysis (TGA). Electrical measurement techniques: Resistivity, Polarization, Dielectric properties, electrochemical techniques (Cyclic voltametry). Magneto-Resistance, Vibrating Sample Magnetometer, Superconducting Quantum Interference Device, Magneto Optical Kerr Effect.

Suggested Books:
[1] C. N. R. Rao, A. Mueller and A. K. Cheetham, Chemistry of nanomaterials: Synthesis, properties and applications, Wiley, 2004.
[2] C.N.R. Rao, P. J. Thomas and G. U. Kulkarni, Nanocrystals: Synthesis, properties and applications, Springer, 2007.
[3] B. D. Cullity and R. W. Stock, Elements of X-Ray Diffraction, Pearson, 2014.
[4] P. J. Goodhew, J. Humphreys and R. Beanland, Electron Microscopy and Analysis, Taylor & Francis, 2000.
[5] D. B. Williams and C. B. Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Springer, 2009.

NST504 Design and Synthesis of Nanostructures

Physical Methods: Growth and properties of nanostructures using top-down and bottom-up approaches and their applications. Self-assembly and self-organization, formation of nanostructure by mechanical milling (Ball milling). Overview of thin film technology for various nanotechnology applications, Miniaturization of electrical and electronic devices. Arc discharge, Ion sputtering, Laser ablation, pulsed laser deposition (PLD), Laser pyrolysis, Molecular beam epitaxy, Chemical vapour deposition method and other variants, electrodeposition. Microwave synthesis of NPs.
Chemical Methods: Sol-gel techniques, Colloidal particle synthesis. Synthesis of nanocomposites and nanostructures, fabrication of quantum dots, nanowires, nanorods Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sono-chemical routes, Hybrid methods, Solvated metal atom dispersion, Micelles and microemulsions.
Biological Methods: Synthesis process and application of Biological Methods. Electro-spinning synthesis of nanofibers, Microfluidic Synthesis of NPs, Green Synthesis of NPs using plants/bacteria/fungi.; Biological material based metallic nanowires.

Suggested Books:
[1] C. P. Poole, Jr. and F. J. Qwens, Introduction to Nanotechnology, Wiley, 2003.
[2] C. N. R. Rao, A. Mueller and A. K. Cheetham, Chemistry of nanomaterials: Synthesis, properties and applications, Wiley, 2004.
[3] J. Arbiol and Q. Xiong, Semiconductor Nanowires: Materials, Synthesis, Characterization and Applications, Woodhead Publishing, 2015.
[4] A. Alves and C. P. Bergmann, Novel Synthesis and Characterization of Nanostructured Materials, Springer Berlin Heidelberg, 2013.
[5] W.A. Goddard III and Donald Brenner Handbook of Nanoscience, Engineering, and Technology, CRC Press, 2002.

NST5402 Nanophotonics

Photons and electrons- similarities and differences, confinement of photons and electrons, Nanoscale optical interactions-axial and lateral nanoscopic localization, quantum confinement effects, cooperative transitions and emission.

Introduction to photonics, Electromagnetic properties of nanostructures–Wavelength and Dispersion laws, Maxwell and Helmholtz equations, Photonic band-structure and photonic band gap, Propagation of light in periodic media. Band structure in periodic media– 1D and 2D cases. Fabrication of photonic crystals: Photonic crystals by self-assembly - Photonic Crystals by Microfabrication, Photonic Crystals with Tunable Properties. Photonic crystal fibers, optical communication and sensors.
Harmonic generation in photonic nanostructures: Metal nanoparticles, Nanoparticles in monolayer– planar photonics structures- photonic crystals.

Suggested Books:
[1] P. N. Prasad, Nanophotonics, Wiley-Interscience, 2004.
[2] M. Ventra, S. Evoy and J. R. Heflin, Introduction to Nanoscale Science & Technolog, Springer, 2004.
[3] K. Sakoda, Optical properties of photonic crystals, Springer, 2004.
[4] R. H. Kingston and D.L. Mac Adam, Detection of optical and infrared radiation, Springer, 1978.
[5] C. P. Poole, Jr. and F. J. Qwens, Introduction to Nanotechnology, Wiley, 2003.

NST5404 Spectroscopic Techniques for Nanomaterials

Basic concepts-Spontaneous Emission- Classical Bound- Radiating Electron-Quantum Mechanical Radiative Decay-Absorption and Emission - Absorption Coefficient and Absorption Cross-Section, Absorption and Induced Emission-Nano-optics and local spectroscopy, Fluorescence spectroscopy -Scanning plasmon near-field optical spectroscopy (SPNM)-near-field optical spectroscopy- nearfield nonlinear optics.
Simplified model for vibrational interactions-Characteristic bands for organic compounds- Attenuated-total reflection (ATR) and grazing incidence angle techniques-Reflection-absorption IR spectroscopy (RAIRS)-The Raman Effect- Lateral and in-depth Resolution of Conventional μRS- Resonant Raman Spectroscopy (RRS)- Nano-specific Modes- Surface-Enhanced Raman Spectroscopy (SERS)- Nano-Raman- Phase Identification and Phase Transitions in Nanoparticles- Characterizing Carbon Materials with Raman Spectroscopy.
Absorption saturation and harmonic generation, Second-harmonic generation (SHG) and sum frequency spectroscopy (SFG) - Luminescence up conversion. Optical properties of assembled nanostructures-interaction between nanoparticles-Direct and indirect gap transitions-, -Single molecule and single nanoparticles spectroscopy-Dynamic light scattering spectroscopy Fluorimetry and chemiluminescence - X-ray fluorescence spectrometry-
X-Ray Beam Effects, Spectral Analysis -Core Level Splitting Linewidths- Elemental Analysis: Qualitative and Quantitative -Secondary Structure, XPS Imaging -Angle-Resolved.

Suggested Books:
[1] G. B. Vladimir and H. G. Rubahn, Optics and Spectroscopy at Surfaces and Interfaces, John-Wiley and Sons, 2005.
[2] W. William and Parson, “Modern Optical Spectroscopy”, Springer, 2007.
[3] R. Joseph and Lakowicz, Principles of fluorescence spectroscopy, Springer, 2010.
[4] J. J. Jhang, Optical properties and spectroscopies of Nanomaterials, World Scientific Publishing, 2009.
[5] J.R. Lakowicz, Principles of fluorescence spectroscopy, springer, 1983.

NST5406 Molecular Spectroscopy

Overview of Bohr-Somerfield theory of Hydrogen Atom, Quantum mechanics of Hydrogen atom: Angular momentum & Parity, Magnetic dipole moments, Electron spin and Vector atom model, Spin orbit Interaction. The Zeeman Effect, Paschen-Back effect, The Stark effect, Hyperfine structure of spectral lines.

Rotational spectroscopy: Rigid rotor, Rotational spectra of diatomic molecules, Intensities of spectral lines, Isotope effects, Non-Rigid Rotator, Rotation levels of polyatomic molecules: spherical, symmetric, and Asymmetric top molecules. Vibrational spectroscopy: Vibration of diatomic molecules, Harmonic oscillator and Anharmonic oscillator, Vibrational-rotational couplings, Vibration of polyatomic molecules.
Electronic spectroscopy: Electronic spectra of diatomic molecules, vibrational coarse structure, Franck-Condon Principle, Dissociation energy and dissociation products, Rotational fine structure of Electronic-Vibration transition, Production of excited state, Radiative processes, Kasha's Rule, Jablonbski diagram, Luminescence, Photoluminescence, kinetics, Quantum yield and Lifetime.

Suggested Books:
[1] H. E. White, Introduction to Atomic Spectra, McGraw Hill, 1934.
[2] R. B. Leighton, Principles of Modern Physics, McGraw Hill, 1959.
[3] G. Herzberg, Molecular spectra and molecular structure I, II and III. Spectra of diatomic molecules, Prentice-Hall, 1939.
[4] C. N. Banwell and E. M. McCash, Fundamentals of molecular spectroscopy, McGraw Hill, 1994.
[5] J.R. Lakowicz, Principles of fluorescence spectroscopy, springer, 1983.

NST5302 Minor Project

NST5304 Renewable Energy Technology

Energy challenges, development and implementation of renewable energy technologies- nanotechnology enabled renewable energy technologies -Energy transport, conversion and storage- Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.
PV modules: Module and Circuit Design - Identical and Non-Identical Cells– Module Structuring and assembly - Environmental Protection - Thermal Considerations – Electrical Considerations and output conditioning - assembly materials– interconnects– crystalline and thin film modules - issues with solar PV modules, bypass diode and blocking diode– module testing and analysis.
Nanomaterials in Energy Storage Devices: multiwall carbon nanotubes for Li-Ion Batteries, Nanomaterials in Electrodes, Hybrid Nanotubes: Anode Material, Supercapacitor, Battery Electrodes.
Energy from waste- Bio-chemical Conversion: Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestion biogas production, landfill gas generation and utilization, present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages. Device isolation & analysis.

Suggested Books:
[1] J. Twidell. and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, 1986.
[2] H. J. Moller, Semiconductor for solar cells, Artech House Inc, 1993.
[3] D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor & Francis, 1998
[4] K L Chopra, Suhit Ranjan Das, Thin Film Solar Cells, Springer Science, 1983.
[5] D. Linden and T. B. Reddy, Handbook of batteries 3rd Edition, Mcgraw Hill, 2002.

NST5306 Structural Analysis of Nanomaterials

Phase, Phase rules of Gibbs; Phase diagram: unary, and ternary systems, lever rule; microstructure during cooling, Crystal formation (energy vs. distance between atoms); Structural Magic number rule to show the number of atoms in nanoparticles; X-ray diffraction by the crystalline phase. Basic principles; Hanawalt method; Examples of phase analysis single phase and phase mixture; Analysis of unknown phase mixtures; practical difficulties. Quantitative Analysis: Atom fraction and weight fraction; Factors that control absolute and relative x-ray intensities. Single Phase-chemical analysis by parameter measurement, principle and application of this method. Multiphase: Basic principles, Methods like external standard method; Direct comparison method and internal standard method; precautions for precise measurements; Practical difficulties.
Need for orientation identification, methods for determining crystal orientation; Laue method (the back- reflection and the Transmission Laue method). The diffractometer method; Zone, pole and trace, Stereographic projection, Wulff net, Angle between poles and traces, rotation of the poles around axes, Stereographic projection diffraction spots of transmission Laue methods, Greninger chart for the orientation of back- reflection Laue patterns, Stress Measurement.

Suggested Books:
[1] B. D. Cullity, S. R. Stock, Elements of X-Ray diffraction, Prentice Hall, 3rd Edition, New Jersey, 2001.
[2] R. Phillips, Crystal defects and Microstructures, Cambridge University Press, Cambridge, U.K., 2001.
[3] Z. L. Wang, Characterization of Nanophase Materials, Wiley-VCH, Weinheim, Germany, 2000.
[4] M. D. Graef and M. E. McHenry, An Introduction to crystallography, diffraction and symmetry, Cambridge University Press U.K., 2007.
[5] S. M. Allen and E. L. Thomas, The structure of Materials (MIT Series in materials science and engineering), John Wiley & Sons, US, 1999.

NST5202 Nano-Electronics and devices

Enhancement mode & Depletion mode MOSFETs, Drain current and Transfer Characteristics Analysis-Linear Regime, and Saturation Regime, Parameter Evaluation: Transconductance, Drain Conductance, Cut-off Frequency, Pass Transistors, Pull-up and Pull Down Transistor. Alternative forms of Pull-Up. Basic MOS inverter design, transfer characteristics, logic threshold, NAND\ NOR logic implementation based on MOSFETs, Transit time and inverter time delay, CMOS inverter. Inverting and non-inverting type super buffers, noise margins.
MOS design rules: Lambda based design rules and MOS layers. Stick diagrams, NMOS and CMOS design layout diagrams, Scaling of MOS Circuits. Functional limitations to scaling. Tunneling Diode and Resonating tunneling diodes: Structure and operation. Concept of double quantum well and its role in the Resonance Tunneling Diodes; Single electron tunneling Transistor; Current versus energy characteristics of SET; Derivation of the resistance offered by SET for electron tunneling. Applications of SET. Solar Cells: Thin Film Solar Cells, Multi-junction Solar Cells and Pervoskite Solar Cells; Basics of Direct and Indirect Semiconductors w.r.t. Light Emitting Diodes (LEDs); Types of LEDs and Materials for LED Fabrication.

Suggested Books:
[1] N. H. E. Weste, Principles of CMOS VLSI Design (2nd edition), Addison Wesley, 1994.
[2] D. A. Pucknell and K. Eshraghian, Basic VLSI Systems and Circuits, Prentice Hall, 1995
[3] W. C. Lin, Handbook of Digital System Design, CRC Press, 1990.
[4] S. M. Sze, Physics of Semiconductor Devices (2^{nd} edition), Wiley, 2008.
[5] S. E. Lyshevski, Nano and Micro - electromechanical Systems, CRC Press, 2005.

NST5204 Nanocomposites

Advantage of composite materials, mechanical properties, Thermal, electrical and electronic and optical properties. Super hard nanocomposites-designing and mechanical properties - stress-strain relationship, toughness, strength, and plasticity. Ceramic metal nanocomposites: Ceramic based nano-porous composites, metal matrix nanocomposites, natural nano-bio-composites, thin film nanocomposites, synthesis of various nanocomposites materials.
Introduction to polymer composites, Processing of nanoparticles, binding mechanisms in nanoparticles, dispersion of nanoparticles, and stabilization of nanoparticles. Processing and fabrication of polymer nanocomposites, Melt blending, solvent casting, In-situ polymerization, solution polymerization, template synthesis, high shear mixing. Natural nanocomposite systems: Spider silk, bones, shells; organic –inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; use of synthetic nanocomposites for bone teeth replacement. Bioactive nanocomposites in bone grafting and tissue engineering, inorganic/polymer nanocomposites for dental restoration and bone replacement applications.

Suggested Books:
[1] P. M. Ajayan, L. S. Schadler and P. V. Braun, Nanocomposite science and technology, Wiley-VCH, 2003.
[2] H .S. Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers, 2003.
[3] A. D. Pomogailo and V. N. Kestelman, Metalopolymer nanocomposites, Springer-Verlag, 2005.
[4] K. E. Gonsalves, C. R. Halberstadt, C. T. Laurencin and L. S. Nair, Biomedical nanostructures, John-Wiley & Sons, 2008.
[5] C. A. Mirkin and C. M. Niemeyer, Nanobiotechnology II, Wiley- VCH, 2006.

SEMESTER III

Courses

NST651 Research Project

NST601 Major Project I

NST6401 Nanobiotechnology

Historical perspective of integration of biology, chemistry and material science opportunities and promises of nanobiotechnology. Complexity and size of biological molecules– DNA, RNA proteins and carbohydrates; Techniques: Biological analysis electrophoretic and chromatographic analysis– basic principles and applications. Fluorescent probes for analysis of proteins and nucleic acids. Labeling of proteins and nucleic acids by acids by various fluorescent dyes. Bacteria viruses: Prokaryotic complexity and size distribution; Bacterial cell-to-cell communication, quorum sensing, chemotaxis; Microbial production of inorganic nanoparticles; Gold nanoparticles for imaging and therapy. Nanoparticles, quantum dots, carbon nanotubes, nanofibers, and buckyballs interface with biological macromolecules; Impact of Nanomaterials in biological process; tolerance by immune systems and toxicity; Nucleic acid Engineering: Modifications of DNA for nanotechnological applications, Semiconductor (metal) nanoparticles, nucleic acid, and protein based recognition groups– Application in optical detection methods – Nanoparticles as carrier for genetic material– Nanotechnology in agriculture. Drug delivery, DNA computing, Molecular design using biological selection, Hybrid materials, Future directions.

Suggested Books:
[1] J. M. Berg, Tymoczko, J. L. and L. Stryer, Biochemistry 6thEd, W. H. Freeman and Company, NewYork. 2006.
[2] C. M. Niemeyer and C. A. Mirkin, Nanotechnology: Concepts, Applications and perspectives, Wiley Press. 2004.
[3] D. S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley Press. 2004.
[4] V. Labhasehwar and D. L. Pelecky, Biomedical Applications of Nanotechnology, Wiley Press, 2007.
[5] R .L. P. Adams, L. Knwler and D. P. Leader, The Biochemistry of the Nucleic Acids, Springer, 2007.

NST6403 Nanosensors and Devices

Introduction to sensors, static characteristics and dynamic characteristics, Physical effects: - Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect, Chemiluminescence Effect, Doppler Effect, Hall Effect, thermoelectric effect, magneto-optical phenomena. Types of sensors- Mechanical, optical, spintronic, bioelectronics and biomagnetic sensors, surface modification, surface materials and interactions and its examples.
Taxonomy of Nano-and Microsystems-Synthesis and Design. Classification and considerations, Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS. Introduction to modeling, analysis and simulation, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS.
Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Nanosensors and Devices-Interfacing with the Brain, towards molecular medicine, Lab-on-BioChips- Guided evolution for challenges and the solutions in Nano Manufacturing technology.

Suggested Books:
[1] S. E. Lyshevski, Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering – 2nd Ed., CRC Press, 2005.
[2] N. P. Mahalik, Micro manufacturing and Nanotechnology, Springer, Berlin Heidelberg New York, 2006.
[3] M. J. Jackson, Micro and Nanomanufacturing, Springer, 2007.
[4] Z. Cui, Nanofabrication, Principles, Capabilities and Limits, Springer, 2008.
[5] K. Kalantar–Zadeh and B. Fry, Nanotechnology Enabled Sensors, Springer, 2008.

NST6405 Microelectromechanical Systems (MEMS)

Overview of MEMS and Microsystems – Thin film growth and models –Mechanical, Electrical, Thermal properties for Thin Films/MEMS– Measurement techniques– Materials for MEMS- Semiconductors, Metals and Metal alloys, Ceramics, Polymers – Silicon and other substrate materials. MEMS Fabrication – Doping process - Bulk micromachining - Wet & Dry Etching- Isotropic and anisotropic etching and mechanism - Etch stop techniques – DRIE and other processes- Surface Micromachining – LIGA and laser assisted processing – Nanomechanical system fabrication - Fundamentals of Design and Simulation.
Microsystem design – Static bending of thin films –Mechanical vibration–thermomechanics–fracture mechanics – Thermofluidics. Scaling laws in miniaturization – Design considerations – Process and Mechanical design – Finite element method (FEM), Computer aided design CAD – Mircosensors and Microactuators– Optical, chemical, thermal, gas, pressure, bio and mechanical sensors – Nanosensors–Applications in automobile, aerospace, health care, industrial, consumer and telecommunications, Capacitive Accelerometer.

Suggested Books:
[1] Tai-Ran Hsu, MEMS and Microsystems – Design, Manufacture, and Nanoscale Engineering Second Edition, John Wiley & Sons, New Jersey, 2008.
[2] R. Ghodssi and P. Lin, MEMS Materials and Processes Handbook, Springer, New York, 2011.
[3] N. Maluf and K. Williams, An introduction to Micro electro mechanical systems Engineering Second Edition, Artech House, Boston, 2004.
[4] J. A. Francisco, Sensors based on nanostructured materials First Edition, Springer-Verlag, New York, 2008
[5] H. Baltes, O. Brand, G. K. Fedder, C. Hierold, J. G. Korvink and O. Tabata, Enabling Technology for MEMS and Nanodevices, Wiley-VCH, Weinheim, 2004.

NST6301 Nanolithography and Device Fabrication

State of the art (including principles, capabilities, limits, applications) of Optical lithography, Mask Making, Electron lithography, X-ray lithography, Ion lithography, Neutral atomic beam lithography, Plasma-Aided Nanofabrication, Soft Lithography, Nanosphere Lithography, Nano-imprint, Dip-pen nanolithography, key consequences of adopted techniques.
Definition of Technology node, Basic CMOS Process flow. MOS Scaling theory, Issues in scaling MOS transistors: Short channel effects, Description of a typical 65 nm CMOS technology. Requirements for Non-classical MOS transistors. MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2 vs High-k gate dielectrics. Integration issue of high-k. Interface states, bulk charge, band offset, stability, reliability – Qbd high field, possible candidates, CV and IV techniques.
Suggested Books:

[1] Z. Cui, Nanofabrication, Principles, Capabilities and Limits, Springer, NewYork (2008).
[2] H. Howard, Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106), Springer Series in Materials Science, Springer-Verlag Berlin, 2009.
[3] M. J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization 2nd Edition, CRC Press, California, USA, 2002.
[4] G. F. Cerofolini, Nanoscale Devices, Springer, 2009.
[5] R. Gross, A. Sidorenko and L. Tagirov, Nanoscale Devices – Fundamentals and Applications, Springer, 2006.

NST6303 Plasma Technology

Introduction to plasmas, plasma discharge (dc & rf), microwave discharge, photo-ionization, surface ionization (Q-Machine), and laser-produced plasma, plasma measurements (densities and temperatures), plasma frequency and plasma Debye length, Langmuir probe, the formation of plasma sheath, plasma sheath width (expression).
Synthesis of carbon nanotubes (CNTs) and carbon nanofibers (CNFs), Graphene, g - CNT Composites using plasma enhanced CVD (dc and rf) and microwave plasma enhanced CVD, growth mechanism (tip growth mode, base growth mode and vertically aligned CNTs/CNFs), plasma etching, Plasma Electronics (Field Emission properties) and aspect ratio.
Role of Plasma in High Power Microwave Devices, Free Electron Laser (FEL) growth rate, Gain and Efficiency, Cerenkov Free Electron Laser (CFEL) (growth rate, Gain and Efficiency), and Gyrotron. Role of plasma dust grains in Fusion devices- Tokamak and International Thermonuclear Experimental Reactor (ITER). Laser-Driven Accelerators: Laser -Beat Wave Accelerator (LBWA) and Laser Wake Field Accelerator (LWFA).

Suggested Books:
[1] K. Ostrikov and S. Xu, Plasma-Aided Nanofabrication: from plasma sources to Nanoassembly, Wiley-VCH, Weinheim, Germany, 2007
[2] M. A. Lieberman and A. J. Lichtenberg, Principles of Plasma Discharges and Material Processing, Wiley Interscience Publications, USA, 1995.
[3] C. S. Liu and V.K. Tripathi, Interaction of Electromagnetic Waves with Electron Beams and Plasmas, World Scientific, Singapore, 1994.
[4] C.W. Roberson and P. Sprangle, A Review of free electron lasers, Physics of Plasmas, 1(1), P. 3, AIP Publishing, 1989.

NST6305 Nanotechnology for Medical Diagnostic and Therapy

Nanotechnology for Disease Diagnostics: Quantum dot conjugation strategies with DNA-aptamer, Protein and Antibody and FRET/BRET based assays for Cancer, AIDS, tuberculosis and other disease diagnostics; Nanoparticle assisted multiplexed diagnostic assays (Bio barcode amplification assay, Sandwich DNA assay, Eliza) and point-of care diagnostics (Lateral flow assay).

Nanotechnology for Drug delivery**:** Lipid, polymeric, Hyaluronic acid and heparin functionalized core shell nanoparticle as drug delivery vehicles; Carbon nanotube-based vectors for delivering immunotherapeutics and drugs, Hydrogels for drug delivery, nanoparticle induced Gene delivery for gene therapy.
Nanotechnology for therapy: Nanodrugs for treatment of cancer (abraxane and other drugs); concept of nanodrugencapsulation, self-assembly, controlled release (targeted and triggered release), nanoparticle recovery; modified Ag-nanoparticle for Photodynamic Therapy of cancer; nanoparticle assisted vaccine development; nanoshells for surgical procedures.

Suggested Books:
[1] C. Kumar, Nanomaterials for Medical Diagnostics and Therapy, Wiley-VCH, 2007.
[2] H. F. Tibbals, Medical Nanotechnology and Nanomedicine, CRC Press, 2010.
[3] K. K. Jain, The handbook of Nanomedicine, Humana Press, 2008.

NST6201 Spintronics

History and overview of spin electronics; Classes of magnetic materials; The early history of spin; Quantum Mechanics of spin; The Bloch sphere; Spin-Orbit interactions and Hall effect; Anomalous Hall Effect, Spin Hall Effect, Inverse Spin Hall Effect Exchange interaction.
Spin relaxation mechanisms; Basic electron transport; Anisotropic magnetoresistance, Spin-dependent transport; Giant Magneto Resistance (GMR) effect, Tunnel Magnetoresistance (TMR) Spin dependent tunneling; Andreev Reflection at ferromagnet and Superconductor interfaces; Spin transfer torques; Spin-transfer drive magnetic dynamics.
Current-driven switching of magnetization and domain wall motion; Domain wall scattering and Current-Induced switching in ferromagnetic wires; Spin injection, spin accumulation, and spin current.
Silicon based spin electronic devices, Spin LEDs: Fundamental and applications, Electron spin filtering, Materials for spin electronics: Heusler Alloys and DMS, Spin-Valve and spin-tunneling devices: Read Heads, MRAMS, Field Sensors, Spin transistors, Quantum Computing with spins.

Suggested Books:
[1] S. Bandyopadhyay and M. Cahay, Introduction to Spintronics, CRC Press, 2008.
[2] M. Johnson, Magnetoelectronics, Academic Press, 2004.
[3] D. J. Sellmyer and R. Skomski, Advanced Magnetic Nanostructures, Springer, 2006.
[4] S. Maekawa, Concepts in Spin Electronics, Oxford University Press, 2006.
[5] D. D. Awschalom, R. A. Buhrman, J. M. Daughton, S. V. Molnar, and M. L. Roukes, Spin Electronics, Kluwer Academic Publishers, 2004.

NST6203 Biophotonics

Electromagnetic properties of nanostructures – Wavelength and Dispersion laws– Density of states – Maxwell and Helmholtz equations – Photonic band-structure and photonic band gap- Propagation of light in periodic media. Band structure in periodic media– 1D and 2D cases. Light absorption in cells– Light induced cellular processes– photochemistry induced by exogenous photosensitizers– Interaction of light with tissues: Nature of Optical interactions– Measurement of optical properties of a tissue Light-induced Processes in Tissues–Autofluorescence, photochemical processes, thermal effects, photoablation, plasma induced ablation and photodisruption.
Nanotechnology for Biophotonics: interface of bioscience, nanotechnology and photonics- Semiconductor quantum dots for bioimaging– Metallic nanoparticles and nanorods for Biosensing– Up-converting nanophores- Inorganic nanoparticles– Pebble nanosensors for Invitro Bioanalysis- Nanoclinics for optical diagnostics and Targeted therapy.

Biomaterials for Photonics: Photonics and Biomaterials– Bioderived materials (Baceriorhodopsin, Green Fluorescent Protein, DNA, Bio-objects and biocolloids) Bioinspired materials– Biotemplates (DNA and Viruses as templates)– Bacteria as synthesizers for photonic polymers. Suggested Books: [1] S. V. Gaponenko, Introduction to Nanophotonics, Cambridge University Press, New York, 2010. [2] J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals (2nd edition), Princeton University Press, 2008. [3] P. N. Prasad, Introduction to Biophotonics, John Wiley and Sons, New Jersey, 2003. [4] B. C. Wilson, V. V. Tuchin and S. Tanev, Advances in Biophotonics, IOS Press, 2005. [5] H. Masuhara, S. Kawata and F. Tokunaga, Nano Biophotonics: Science and Technology, Elsevier, 2007.

SEMESTER IV	
Courses	
NST652	**Research Project**
NST602	**Major Project II**