MASTER OF TECHNOLOGY
in
SCHOOL OF MATERIAL SCIENCE & NANOTECHNOLOGY
Scheme & Syllabi

w. e. f. 2013-14

School of Material Science & Nanotechnology
National Institute of Technology, Kurukshetra

SCHOOL OF MATERIAL SCIENCE & NANOTECHNOLOGY
NATIONAL INSTITUTE OF TECHNOLOGY, KURUKSHETRA

MASTER OF TECHNOLOGY (MATERIAL SCIENCE & NANOTECHNOLOGY**)**
(W.E.F. 2013-14)

FIRST SEMESTER

Course No.	Title	Schedule of Teaching		Credit Point
		L-T-P	Total	
MNT501T	Nanomaterials and their properties	3-0-0	3	3
MNT503T	Condensed Matter Physics	3-0-0	3	3
MNT505T	Synthesis of Nanomaterials	3-0-0	3	3
MNT507T	Material Characterization Techniques	3-0-0	3	3
MNT509T	Polymers and Ceramic Materials	3-0-0	3	3
MNT 511P	Lab.-I	0-0-4	4	2
MNT 513S	Seminar-I	0-0-2	2	2
	Total	15-0-6	21	18

Weightage for Theory Courses:
During Semester Evaluation Weightage – 50%
End Semester Examination Weightage – 50%

Weightage for Lab. Courses:
During Semester Evaluation Weightage – 60%
End Semester Examination Weightage – 40%

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
Nanomaterials and their properties

Course No. MNT **501T** **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Introduction, Properties of materials & nanomaterials, effects of dimensions in nanomaterials,
Electrical Properties: Classification of materials: Metal, Semiconductor, Insulator, Band structures, Mobility, Resistivity, Relaxation time, Recombination centers, Confinement and transport behavior in nanomaterials.
Dielectric and magnetic Properties: Dielectric constant and loss, Ferroelectric behavior, Fundamentals of magnetism, Different kind of magnetism in nature: Dia, Para, Ferro, Antiferro, Ferri, Superpara, Important properties in relation to nanomagnetism.
Optical Properties: Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence.
Thermal Properties: Concept of phonon, Thermal conductivity, Specific heat, Exothermic & endothermic processes.
Mechanical Properties: Young's modulus, Bulk Modulus, Modulus of rigidity. Tensile testing and tensile Strength, Yield Strength, Breaking Strength.

Reference Books

• Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
• Nanomaterials Handbook- Yury Gogotsi
• Encyclopedia of Nanotechnology- Hari Singh Nalwa
• Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
• Microwave Properties of Magnetic Films - Carmine Vittoria.
• Physics of Magnetism - S. Chikazumi and S.H. Charap
• Physical Theory of Magnetic Domains - C. Kittel
• Magnetostriction and Magnetomechanical Effects - E.W. Lee
• Springer Handbook of Nanotechnology - Bharat Bhusan
• Electronic transport in mesoscopic systems, Supriyo Datta

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
Condensed Matter Physics

Course No. MNT **503T** **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Crystal Physics:
Periodic array of atoms, translation vectors, unit cell, space lattice, Miller indices, simple crystal structures, bonds in solids. nanocrystalline solids, physical properties of nanomaterials, melting points and lattice phonons, constants, mechanical properties, reciprocal lattice
Free electron theory: Elements of classical free electron theory and its limitations, quantum theory of free electrons, Fermi level, Density of states, Fermi-Dirac distribution function.
Band Theory of Solids:
Origin of bands, band theory of solids, motion of electron in periodic field of crystal, Kronig-Penny model, Brillouin zones, concept of holes, distinction between metal, insulator and semi- conductor, size effect on energy gap- quantum confinement.
Thermal Properties of Solids:
Concept of lattice vibrations and thermal heat capacity, classical, Einstein and Debye theories of molar heat capacity and their limitations, concept of phonons.
Dielectric Properties: Basic equations , Dielectric polarization, Concept of Lorentz and Maxwell's fields, Clausius-Mosotti Equation, Effect of temperature and frequency on dielectric constants and dielectric loss behavior.

Reference Books:

1. **Introduction to Solid State Physics**
   C. Kittel
2. **Solid State Physics**
   A.J. Dekker
3. **Solid State Physics**
   S.O. Pillai

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)

Synthesis of Nanomaterials

Course No. MNT **505T** **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Physical Methods- Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and other variants, Electrodeposition, Template Synthesis.

Chemical Methods- Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, Post-synthetic size-selective processing. Sol- gel, Micelles and microemulsions, Cluster compounds.

Biological Methods - Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

Lithographic Techniques- SPM based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography, Dip pen nanolithography.

Reference Books:

• Hari Singh Nalwa - Encyclopedia of Nanotechnology.
• Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
• Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
• Nanomaterials Handbook- Yury Gogotsi
• Springer Handbook of Nanotechnology - Bharat Bhusan
• Processing & properties of structural naonmaterials by Leon L. Shaw (editor)
• Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.
• Synthesis of Nanostructured Materials –Cao
• Handbook of Nanoscience, Engineering- Goddard et al

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)

Material Characterization Techniques

Course No. MNT **507T** **Credits: 3**

L	**T**	**P**	**Total**	**Sessional-50 Theory-50**
3	**0**	**0**	**3**	**Duration of Exam- Three hours**

X-ray diffraction technique, Small Angle X-Ray Scattering (SAXS), XPS, SEM & TEM, EDAX, Scanning Probe Microscopy, Optical microscope, operational principle, Instrumentations and application for analysis of nanomaterials,
UV-Vis-NIR Spectrophotometers, Principle of operation and application for band gap, measurements, FTIR, Photoluminescence, Raman spectroscopy,
Ellipsometry, Vibrating Sample Magnetometer, Squid magnetometer, Four probe method, P-E loop tracer.
Scanning Electron Microscopy; Scanning Probe Microscopy; Optical Spectroscopy; Raman Spectrometery.
Thermal techniques for characterization: Gravimetric analysis, Differential thermal analysis.

Reference Books:

1. Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology)- Roland Wiesendanger
2. Advanced X-ray Techniques in Research and Industries - A. K. Singh (Editor)
3. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander
4. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter
5. Introduction of X-ray Crystallography- M.M. Woolfson
6. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton
7. Fabrication of fine pitch gratings by holography, electron beam lithography and nano-imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim; Frank Shepherd
8. Microfabrication and Nanomanufacturing- Mark James Jackson
9. Instrumental Methods of Analysis, 7th edition- Willard, Merritt, Dean, Settle
10. Transmission Eletron Micoscopy of Materials – Gareth Thomas

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
Polymers and Ceramic Materials

Course No. MNT **509T** **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Polymers and chemical bonding: Polymerization mechanism. Addition and Condensation polymerization. Molecular weights and their distribution. Simple and hindered rotation. Crystallinity and melting. Glass transition. Physical states and mode of motions of polymer chains, radiation effects on polymers.
Conducting polymers: Types of conducting polymers. Chemical and electrochemical routes of synthesis. Doping and dedoping of conjugated polymers. Solatron and polaron formation in conducting polymers.
Bio and natural polymers: Proteins, nucleic acids, lipids, cellulose and polysaccharides.Medicinal and biomedical applications of polymers. Inorganic Polymers, Biodegradable polymers, Nanocomposites, polymer electrets.
Advanced Polymeric Materials: High Temperature polymers, Piezo and Pyro electric polymers, Polymer liquid crystal.
Ceramics: Bonding and crystal structure of ceramics. Effect of bonding, crystal structure and microstructure on physical properties of ceramics. Electronic properties of ceramic materials. Synthesis of ceramic powder and nanoparticles and their consolidation. Sintering and grain growth mechanisms. Creep and fatigue in ceramics materials, Polymer composites.

Reference Books:

1. Polymer Science, V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, Halsted Press, John Wiley & Sons, New York.
2. Principles of Polymerization, George Odian, John Wiley & Sons. 4th Ed.
3. Polymer Chemistry, B. Vollmert, Springer-Verlag, Berlin.
4. Fundamentals of Ceramics, M.W. Barsoum.
5. Modern Ceramic Engineering, D. W. Richerson.
6. Introduction to Ceramics, W.D. Kingery, H.K. Bowen and D.R. Uhlmann.
7. Ceramic fabrication process, W.D. Kingery.
8. Fundamentals of ceramics, W.M. Barsoum.
9. Liquid Crystalline Polymers (Cambridge Solid State Science Series) A. M. Donald, A. H. Windle), S. Hanna
10. Liquid Crystal Polymers: Synthesis, Properties and Applications By D. Coates**,** Rapra Publishing

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MASTER OF TECHNOLOGY (MATERIAL SCIENCE & NANOTECHNOLOGY**)**
(W.E.F. 2013-14)

SECOND SEMESTER

Course No.	Title	Schedule of Teaching		Credit Point
		L-T-P	Total	
MNT502T	Carbon Nanotubes and Nanowires	3-0-0	3	3
MNT504T	Transducers &Actuators	3-0-0	3	3
MNT506T	Nano Electronics (Elective)	3-0-0	3	3
MNT508T	MEMS & NEMS	3-0-0	3	3
MNT510T	Bio nanotechnology (Elective)	3-0-0	3	3
MNT 512P	Lab.-II	0-0-4	4	2
MNT 514S	Seminar-II	0-0-2	2	2
	Total	15-0-6	21	18

Weightage for Theory Courses:
During Semester Evaluation Weightage – 50%
End Semester Examination Weightage – 50%

Weightage for Lab. Courses:
During Semester Evaluation Weightage – 60%
End Semester Examination Weightage – 40%

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)

Carbon Nanotubes and Nanowires

Course No. MNT502T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Carbon Nanotubes: Structures, Single and Multiwalled CNTs, Vertically aligned CNTs, Chemically modified nanotubes, CNTs composites, Dispersible carbon nanotubes, Carbon nanotube array based smart materials, Graphene, Electrical, Mechanical, Optical and Thermal properties of CNTs, Spectroscopic analysis, Applications of CNTs, Inorganic nanotubes.

Nanowires: Vapor phase and solution based growth of nanowires, Growth control and integration, Elemental nanowires, Metal oxide nanowires, Metal Nitride nanowire, Metal carbide nanowire, semiconductors nanowires, Useful properties and potential applications.

Reference Books

1. Physical properties of Carbon Nanotube-R Satio
2. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins
3. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell
4. Carbon Nanotechnology- Liming Dai
5. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
Transducers & Nanosensors

Course No. MNT504T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

General concepts & terminology, Transducers, Fundamentals of nano sensors, sensors and actuators, Static and dynamic characteristic of measurement systems.

Sensor Classification: Primary sensors, interference, internal Perturbations and compensation techniques.

Resistive sensors: Strain gauges, Resistive temperature detectors, Thermistors, Magneto resistors, Light dependent resistors, resistive hygrometers, Applications of resistive-sensors.

Reactance and electromagnetic sensors: Capacitive sensors, inductive sensors, reluctance-variation sensors, eddy current sensors, linear variable differential transformers, magneto elastic sensors, Hall effect sensors, e.m. induction sensors tachometers. Applications of reactance and e.m. sensors.

Generating sensors: Thermoelectric sensors, Piezoelectric sensors, Pyroelectric sensors, Photovoltaic sensors, electrochemical sensors. Applications of generating sensors.

Nanotransducers: Design of nanotransducers, nano-mechanical, Chemical and magnetic transducers, Nanoactuaters, Biosensor, micro fluids, Integration of sensor with actuators and electronic circuitry, Polymer based sensor, DNA Biosensors, optical sensors. Carbon Nanotube Sensors

Nanoactuaters: Cantilever sensors, Nano structured optical actuators, Multiferroic materials and their applications as sensors and actuators.

Reference Books:

1. Sensors and Signal Conditioning (Raman Pallas-Arency & J.G. Webster: John Wiley & Sons.
2. Process Instruments and Controls Handbook(Considine DM (ed): McGraw-Hill
3. Instrument Science & Technology (Jones B.E: Adam Hilger)
4. Instrument Transducers: An introduction to their performance and design (Neubert H.K.P: Oxford)
5. Sensors and Analyzer Handbook (Norton H.N Prentice Hall)
6. Sensors and Transducers (Usher M.J: Macmillan)
7. Measurement Systems Application and design (Doebelin E.O: McGraw-Hill
8. Principles of Measurement and Instrumentation (Marris A.S: Prentice Hall)
9. Nanotechnology (Wiley-VCH Verlag GmbH & Co. KGaA) by M. Kohler and W. Frtzsche

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
Nano Electronics

Course No. MNT506T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

High Electron Mobility Transistors; Quantum Interference Transistors; Carbon Nanotube Transistors;Quantum Corrals in Electronics, Electrical contacts and nanowires.
Quantum Dot Devices; Electron Wavefunction Effect Devices;Single Electron Effect Devices;Nanotransistors-Vertical Transport Nanotransistor Designs; Lateral Transport Nanotransistor Designs; and devices, Superlattices, Wavefunctions and Density of States for superlattices,Nano Motors.
Molecular electronics, molecular switching, Schottky devices. Quantum Structures and Devices. Quantum layers, wells, dots and wires, Mesoscopic Devices, Nanoscale Transistors, Single Electron Transistors, MOSFET and NanoFET, Resonant Tunneling Devices, optical devices, Connection with quantum dots, quantum wires, and quantum wells.
Spin tunneling devices - Magnetic tunnel junctions- Tunneling spin polarization, Tunnel-based spin injectors - Spin injection and spin transport in hybrid nanostructures.

Reference Books:

1. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by H. Meixner.
2. Between Technology & Science : Exploring an emerging field knowledge flows & networking on the nanoscale by Martin S. Meyer.
3. Nanoscience & Technology: Novel structure and phenomea by Ping Sheng (Editor)
4. Nano Engineering in Science & Technology : An introduction to the world of nano design by Michael Rieth.
5. Enabling Technology for MEMS and nano devices -Balles, Brand, Fedder, Hierold.
6. Optimal Synthesis Methods for MEMS- G. K. Ananthasuresh
7. MEMS & MOEMS Technology and Applications- P. Rai Choudhury
8. Processing Technologies- Gandhi
9. From Atom to Transistor- Supriyo Datta
10. Nanotechnology-Basic Science and Emerging Technologies, Mick Wilson et al,Overseas Press,
11. Carbon Nanotubes:Science and Applications, Laurie Kelly, Meyyappan Meyyappen,CRC Press
12. Nanomaterials:Synthesis,Properties and Applications , A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics
13. Molecular Electronic Devices: F.L.Carter et al(Ed);New York:North Holland

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
MICRO-ELECTRO MECHANICAL SYSTEM (MEMS) & NANO-ELECTRO MECHANICAL SYSTEMS

Course No. MNT508T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Nano-and Microscience, Engineering and Technology: Introduction and overview, MEMS and NEMS definitions, Taxonamy of Nano-and Microsystems-Synthesis and Design.
Nano-and Micro Systems: Classification and considerations, Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures, Biomimetics and nervous systems.
Modeling of Micro-and Nanoscale Electromechanical Systems: Introduction to modeling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modeling developments of micro-and nanoactuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS.
Synthesis, Design and Fabrication of MEMS: Introduction, Microfabrication of microcoils/windings through copper, nickel and aluminium electro deposition, micromachined polymer magnets, axial electromagnetic micromotors, micromachined polycrystalline SiC microimotors.

Reference Books:
1. Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano- and Micro-EngineeringSergey Edward Lyshevski, Lyshevski Edward Lyshevski,CRC Press
2. Nanomaterials:Synthesis,Properties and Applications
A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics
3. Micro-Electro Mechanical and Nano-Electro Mechanical Systems
Sergy Edward Lyshevski,CRC Press

MASTER OF TECHNOLOGY
MATERIAL SCIENCE & NANOTECHNOLOGY (W.E.F. 2013-14)
Bio Nanotechnology

Course No. MNT510T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Nano-and Micro Bio Systems: Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures, Biomimetics and nervous systems, Nanorobots and their application, Bioelectromagnetism.

Nanomedicine: Medical use of Nanomaterials, Drug delivery systems. Cancer treatment by nanomaterials, Drug tracking systems, Targeted drug delivery systems, Hyperthermia, Applications of Nanomaterials in Medical imaging.

Bio Sensors: Nano-Bio sensors, Nanoparticles for gene delivery systems, Optical biosensors and their application, Spintronic Biosensors.

Reference Books:

1.Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano- and Micro-Engineering. Sergey Edward Lyshevski, Lyshevski Edward Lyshevski,CRC Press

2.Nanomaterials:Synthesis,Properties and Applications, A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics

3.Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Sergy Edward Lyshevski,CRC Press

4. Lynn E. Foster, Foreword by George Allen, Foreword by Joe Lieberman, Nanotechnology: Science, Innovation, and Opportunity, Nanomedicine: Basic Capabilities, Vol. 1 by Robert A. Freitas Jr. 1999 Rev

5. Neelina Malsch , Biomedical nanotechnology by CRC press release, *Malsch TechnoValuation, Utrecht, The Netherlands*

THIRD SEMESTER

Course No.	Title	Schedule of Teaching		Credit Point
		L-T-P	Total	
MNT 514P	Industrial/Central Laboratories Training	0-0-8 week	8	4
EE 621P	Preparatory Work for Dissertation	0-0-12 weeks	12	6

NOTE: The Industrial/Central Laboratory training and preparatory work for dissertation shall be evaluated by a committee comprising the following {on the basis of one mid semester seminar and one end semester seminar presented and one end semester report submitted by the candidate}.

1. HOD or faculty nominee proposed by HOD.
2. Dissertation Supervisor (and co-supervisor).
3. Two senior most faculty members of the department.

FOURTH SEMESTER

Course No.	Title	Schedule of Teaching				Credit Point
		Lecturer	Tutorial	Practical	Total	
EE 622P	Dissertation	0	0	32	32	16
					32	16

NOTE:

I. The Dissertation shall be evaluated by a committee comprising the following through presentation cum viva-voce examination.
1..HOD or faculty nominee proposed by HOD.
2.. Dissertation Supervisor (and co-supervisor).
3.. One external expert appointed by the department.

II. For award of grade, following criteria to be used.

Grade	Conditions to be fulfilled
A+	One paper accepted/published in SCI Journal
A	One good quality paper accepted/published in non-paid journal or two good quality papers presented in International/National Conference.*
B	One good quality paper presented in International Conference
C/D	In other cases

* Conference organized by IIT/NIT/a premier R & D organization.

Non-Credit Based Dissertation Evaluation