AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATION 2009

M.TECH. NANOTECHNOLOGY

CURRICULUM II TO IV SEMESTERS – (FULL TIME)

SEMESTER – II

Code No.	Course Title	L	T	P	C
THEORY					
NO9321	Advanced Characterization Techniques	3	0	0	3
NO9322	Nanomaterials and Nanomedicine	3	0	0	3
NO9323	Industrial Nanotechnology	3	0	0	3
NO9324	Nanoelectronics	3	0	0	3
NO9325	Nanolithography	3	0	0	3
NO9326	Advanced Nanobiotechnology	3	0	0	3
PRACTICAL					
NO9327	Characterisation of Nanomaterials	0	0	4	2
	TOTAL	**18**	**0**	**4**	**20**

SEMESTER – III

CODE NO.	COURSE TITLE	L	T	P	C
THEORY					
NO9331	Nanodevices	3	0	0	3
NO9332	MEMS and NEMS	3	0	0	3
NO9333	Nano Biophysics	3	0	0	3
NO9334	Project Work (Phase I)	0	0	12	6
	TOTAL	**9**	**0**	**12**	**15**

SEMESTER – IV

CODE NO.	COURSE TITLE	L	T	P	C
NO9341	Project Work (Phase II)	0	0	24	12
	TOTAL	**0**	**0**	**24**	**12**

NO9321 ADVANCED CHARECTERIZATION TECHNIQUES L T P C
3 0 0 3

UNIT I **9**

Electron Microscopes: scanning electron Microscopy – Transmission electron microscopy – scanning tunneling electron microscopy (STEM) – Image collection in electron microscopes – environmental transmission electron microscopy – electron energy loss spectroscopy.

UNIT II **9**

Scanning Probe Microscopes – Atomic manipulations – Atomic force microscopy – Scanning probe lithography – optical microscopies – confocal microscopy – scanning near field optical microscopy – secondary ion mass (SIMS) spectrometry – matrix assisted laser desorption ionization mass spectrometry (MALDIMS).

UNIT III **9**

Spectroscopy – infrared surface spectroscopy (IR) – Raman Spectroscopy – Brillouin Spectroscopy – Dynamic Light Scattering (DLS) – NMR Spectroscopy – ESR Spectroscopy – (Inductively Coupled Plasma) Spectroscopy – Mossbauer Spectroscopy. Thermogravimetric Analysis (TGA) – Differential Scanning Calorimetry (DSC) – Thermomechanical Analysis(TMA).

UNIT IV **9**

Mechanical Characterization – modulus and load carrying capability of nano region/ compression micro hardness – fatigue – abrasion and wear resistance – superplasticity – nanoindentation. Nanotribology – Nanotribometre –Quartz Crystal microbalance – Friction force microscope.

UNIT V **9**

Neutron and X- ray diffraction – Debye Scherrer formula – dislocation density – microstrain macromolecular crystallography using synchrotron radiation – role for neutron scattering in nanoscience. Optical absorption and emission spectroscopy – photoluminescence – Thermoluminescence – X – ray absorption Fine Structure (XAFS) – extended X- ray absorption fine structure (EXAFS) – electron scattering for chemical Analysis (ESCA)

TOTAL : 45 PERIODS

REFERENCES:

1. Nano: The Essentials, T.Pradeep. Tata McGraw Hill, New Delhi (2007)
2. Introduction to Nanotechnology, Charles P Poole Jr and Frank J Ownes, John Wiley Sons, Inc(2003)
3. Nanocomposite Science and Technology, Pulickel m.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley – VCH Verlag, weiheim (2003)
4. Nanotechnology: Basic sciences and emerging technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkar Raguse, Overseas Press (2005).
5. Instrumental Methods of Analysis, Willard, 2000.
6. Instrumental Methods for Chemical Analysis, Ewing. Etal 2000.

NO9322 NANOMATERIALS AND NANOMEDICINE L T P C
3 0 0 3

UNIT I **9**

Structure, property of Biological Materials: tissues, bones and teeth, collagen rich tissues, elastic tissues, nanostructured collagen mimics in tissue Engineering. Biopolymers: Preparation of nanobiomaterials – Polymeric scaffolds collagen, Elastins: Mucopolysaccharides, proteoglycans, cellulose and derivates; Dextrans; Alginates; Pectins; Chitin.

UNIT II **9**

Cardiovascular implants: Role of nanoparticles and nanodevices in Blood clotting; Blood rhelogy; Blood vessels; Geometry of blood circulation; Vascular implants; Cardiac pacemakers; Blood substitutes; Biomembranes.

UNIT III **9**

Polymeric implant materials: Polyolefin; polyamides (nylon); Acrylic polymers (bone cement) and hydrogels; Fluorocarbon polymers; Natural and synthetic rubbers, silicone rubbers; High strength thermoplastics; Deterioration of polymers. Intra ocular lenses. Biomaterials for Ophthalmology: Contact lenses; Optical implants for glaucoma; adhesives; Artificial tears; Protection gears.

UNIT IV **9**

Metallic and ceramic implant materials: Bone regeneration, Nano crystalline structures of Bone and Calcium phosphate cements. Cobalt-based alloys; Titanium and its alloys, Stainless steel. Nanoparticles relating to Aluminium oxides; Hydroxyapatite; Glass ceramics; ceramic implants; Carbon implants. Nano dental materials.

UNIT V **9**

Synthesis of nanodrugs – metal nanoparticles and drug delivery vechicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology**.**

TOTAL : 45 PERIODS

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. Neelina H.Malsch. Biomedical Nanotechnology,2005, Taylor & Francis

NO9323 INDUSTRIAL NANO TECHNOLOGY LT P C
3 0 0 3

UNIT I **9**

Semiconductor synthesization techniques, electronic structure and physical processes in semiconductor nanostructures, principles and performance of semiconductor nanostructure based electronic and electro-optical devices.

UNIT II **9**

Micro and Nano-Electromechanical systems - fabrication process- choice of materials, calculations - the performance of different structures - advantages and disadvantages of different approaches, thermal – radiation, magnetic,chemical, and mechanical sensors, Microactuators.

UNIT III **9**

Nanoparticles and Micro –organism, Nano-materials in bone substitutes & Dentistry, Food and Cosmetic applications, Textiles, Paints, Catalysis, Drug delivery and its applications.

UNIT IV **9**

Nano catalysists. Hybridisation, conjugation, excitations, Molecular crystals, conducting semiconducting polymers, Organic electroluminescent displays injection, transport, Exciton formation, light emission, Influence of supramolecular order: excimers, H- and J-aggregates, liquid crystallinity.

UNIT V **9**

Revision of magnetism in solids, property- nanostructure relationships, fabrication and properties of nanostructured magnets - probes of nanomagnetic properties, electronic magneto-transport, micromagnetic modeling.Nanomagnetic materials and industrial applications.

TOTAL : 45 PERIODS

TEXT / REFERENCES:

1. Verdeyen. J, Laser Electronics, II Edition, Prentice Hall, 1990.
2. Turner.C.W. and Van Duzer.T, Principles of Superconductive Devices and Circuits, 1981
3. Reynolds and M.Pomeranty in Electroresponsive molecules and polymeric systems Ed. by Skotheim T. Marcel Dekker New York 1991.
4. Yariv.A, Principles of Optical Electronics, John Wiley, New York, 1984
5. Nanocatalysis, Deiz.
6. M C Petty, M R Bryce, D Bloor (eds.), 'Introduction to Molecular Electronics', Edward Arnold, London, 1995 (ISBN 0-340-58009-7)
7. G Hadziioannou, P F van Hutten, 'Semiconducting Polymers: Chemistry, Physics, and Engineering', Wiley-VCH, 2000 (ISBN 3-527-29507-0)
8. D D C Bradley, Current Opinion in Solid State & Materials Science Vol. 1, 789 (1996)

NO9324 **NANO ELECTRONICS** **L T P C**
3 0 0 3

UNIT I **9**

Electronic states in crystal energy bands, 1 D nanostructures (quantum wires), OD nanostructures (quantum dots), Concepts of 2 and 3D nanostructures (quantum wells), artificial atomic clusters.

UNIT II **9**

Size dependent properties, Size dependent absorption spectra, Blue shift with smaller sizes, Phonons in nanostructures, Contacts at Nano level, AFM(classification), lSTM tip on a surface.

UNIT III **9**

Charging of quantum dots, Coulomb blockade, Quantum mechanical treatment of quantum wells, wires and dots, Widening of bandgap in quantum dots, Strong and weak confinement, Properties of coupled quantum dots, Optical scattering from Nano defects,

UNIT IV **9**

Nanocomposites, Ceramic, Polymer and metal material composites. Electronic and atomic structure of aggregates and nanoparticles. Theory and modeling of nanoparticles fictionalization processes, organic electronics.

UNIT V **9**

Nanosystems: Synthesis and charecterization methods, Molecular beam epitaxy, MOCVD, chemical routes, nanoparticles of polymers, pulsed laser deposition, ion beam assisted techniques including embedded nanoparticles, RF sputtering. Inert gas condensation.

TOTAL : 45 PERIODS

TEXT / REFERENCES:

1. Low Dimensional Semiconductor Structures, K.Bamam and D.Vvedensky(Cambrige University Book) 2001
2. Semiconductor Quantum Dots, L.Banyai and S.W.Koch(World Scientific) 1993
3. http://www.nanotec.org.uklworkshop.october03health.htm(for health and safety aspects of nanostructures)
4. An introduction to the physics-af low dimensional semiconductors, J.H. Davies, Cambridge Press, 1998.
5. Nanoelectronics and Nanosystems , Karl Goser, Peter Glosekotter, Jan Dienstuhl., Springer, 2004

NO9325 **NANOLITHOGRAPHY** **LT P C**
3 0 0 3

UNIT I **9**
Lithography – Printing – chemical process – refinements – The modern process – optical, micro, nanolithography – Lithography in artistic medium – nanometer design for electronic circuits.

UNIT II **9**
Optical lithography – Light sources – photo mask and alignment, Resolution in projection systems – positive and negative photo resists – ultraviolet lithography – X-ray lithography – Synchrotron radiation – Ion beam lithography.

UNIT III **9**
Microlithography – Microchips – Electron beam lithography – Ion beam lithography – Maskless lithography – immersion lithography – Semiconductor processing – MEMS design.

UNIT IV **9**
Nanolithography, Nanosphere lithography – Molecular self-assembly Nanoimprint lithography, Dip-pen nanolithography, soft lithography, Stereo-lithography, nanoscale 3D shapes – NEMS design.

UNIT V **9**
Tools for nanolithography, molecular manipulation by STM and AFM - LB flim resists - nanopattern synthesis – Nano scratching.

TOTAL : 45 PERIODS

TEXT / REFERENCES:

1. Microlithography Sciences and Technology – Sheats J.R and Amith B.W.Marcel Dekker Inc. New York 1998.
2. Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies – M.Gentili (Ed) Carlo Giovannella Stefano Selci, Springer; I edition (1994)
3. Handbook of Microlithography, Micromachining, and Microfabrication (4 vols.0 – P Rai – Choudhury – 1997 – Bellingham, Wash., USA: SPIE Optical Engineering Press; London.

NO9326 **ADVANCED NANOBIOTECHNOLOGY** **L T P C**
3 0 0 3

UNIT I **9**
Utilization of biological systems. Cells, Cellular components. Nucleic acids and proteins refinement and application of instruments, generation and manipulation of nanostructured materials.

UNIT II **9**
Interphase systems, biocompatible inorganic and organic devices, microfluidic systems, micropumps, microwalves, pressure measurement devices, microelectronic silicon substrates.

UNIT III **9**

Protein based nanostructures building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events – nanobioelectronic devices and polymer nanocontainers – microbial production of inorganic nanoparticles – magnetosomes.

UNIT IV **9**

DNA based nanostructures – Topographic and Electrostatic properties of DNA – Hybrid conjugates of gold nanoparticles – DNA oligomers – use of DNA molecules in nanomechanics and Computing.

UNIT V **9**

Nanoparticles and nucleic acid and protein based recognition groups – application in optical detection methods – Nanoparticles as carrier for genetic material. Genetically Modified Organisms (GMO) and applications.

TOTAL : 45 PERIODS

REFERENCES:

1. Nanobiotechnology – Concepts, Applications and Perspectives – 2004. Edited by CM, Niemeyer , C.A. Mirkin. Wiley – VCH.
2. Nano: The Essentials: T. Pradeep. McGraw – Hill education – 2007.
3. Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact. 2005 - By Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer. Wiley – VCH.
4. Nanoparticle Assemblies and Superstructures. By Nicholas A. Kotov.2006 - CRC.

NO9327 II. CHARECTERISATION OF NANOMATERIALS **L T P C**
0 0 4 2

1. Particle size determination – Spectroscopy
2. Particle size determination – Centrifugal Sedimentation
3. Determination of surface area – Porosity – nanoparticles - AFM
4. Morphological study of nano particles – AFM/STM
5. Photoluminescence study of nanoparticles _ Spectrsocopy
6. Molecular simulation of nano particles
7. Conductivity studies of nanoparticles – STM/Impedance
8. Nanolithography - AFM
9. NEMS – Nanofilm - Interferometry
10. Nanoparticle band gap –Spectroscopy
11. Atomic size/Interatomic distance - STM
12. Energy studies - Potentiostat

TOTAL : 60 PERIODS

NO9331 **NANODEVICES** **L T P C**
3 0 0 3

UNIT I **9**

Potentials of silicon technology – SIA roadmaps – Nanofabrication techniques in semiconductors, Transistor technology, Quantum devices – quantum dots, QED, Quantum computing & algorithms

UNIT II **9**

MOS transistor, Characteristics of sub 100nm, CMOS scaling, MOSFETs, limits to scaling and system integration, Resonant Tunneling Transistors, Single electron transistors, optoelectronic, and spintronics devices.

UNIT III **9**

Molecular electronics - single molecule electronic devices, transport in molecular structures, molecular interconnects polymer surfaces and interfaces preparation, photonic band gap systems; application and devices.

UNIT IV **9**

Carbon nano tubes – types, fabrication, electrical, mechanical properties, electronics, band structure and transport, devices, CNT transistor fabrication, applications – field emission and shielding, fuel cells, chemical sensors

UNIT V **9**

Molecular devices, self assembly and 'bottom up' manufacturing, current practice - applications in nano-bio, Drexler-Smalley debate - realistic projections, Synergy of Nano-Bio-Info.

TOTAL : 45 PERIODS

TEXT/ REFERENCES

1. K. Goser, P. Glosekotter and J. Dienstuhl, "Nanoelectronic and Nanosystems – from Transistors to Molecular Quantum Devices", Springer (2004)
2. W.R. Fahrner, "Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques", Springer (2006)
3. K.E. Drexler, "Nano systems", Wiley (1992)
4. John H. Davies, "The Physics of Low-Dimensional Semiconductors", Cambridge University Press (1998)
5. C. Poole Jr., F.J. Owens, "Introduction to Nanotechnology", Wiley (2003)

NO9332 **MEMS and NEMS** **L T P C**
3 0 0 3

UNIT I **9**
Development of micro electronics, region of nanostructures, methods and limits on microminiaturization in semiconductors, Micro Electro Mechanical Systems.

UNIT II **9**
Silicon micromachining, Bulk micromachining, wet etching, dry etching, Surface micro and macro machining, semiconductors and insulators, Microsystems fabrication techniques, silicon MEMS fabrication technology, single crystal reactive etching and metallization process, SOI technology.

UNIT III **9**
Non-silicon MEMS and fabrication techniques, Lithographic galvano forming aboforming (LIGA), SiC MEMS, biomedical MEMS. Integration of microsystem with electronics – RF MEMS – applications.

UNIT IV **9**
Polymers in Microsystems, packaging of MEMS devices by bonding techniques, pressure sensors and packaging, MEMS performance and evaluation. Bio MEMS.

UNIT V **9**
Nano Electro Mechanical Systems - fabrication and processing techniques, Bio NEMS, integration of Nanosystems and devices, applications and future challenges. Nanomaterials health hazards and safety measures.

TOTAL : 45 PERIODS

TEXT/ REFERNCES:

1. W.R.Farhner, “Nanotechnology and Nanoelectronics- Materials, Devices and Measurement Techniques” Springer(2006)
2. K.Goser, P. Glosekotter & J. Dienstuhl, “Nanoelectonis and Nanosystems-from Transistors to Molecular Quantum Devices” Springer(2004)
3. S.E. Lyshevski, “MEMS and NEMS: System, Devices and Structures”, CRC Press (2002)
4. Gregory Timp, “Nanotechnology”, Springer(2005)
5. Steinfeldt, Nanotechnologies, Hazards and Resource efficiency, Springer, 2007

NO9333 **NANO BIOPHYSICS** **L T P C**
3 0 0 3

UNIT I **9**
Size and confinement effects – introduction, fraction of surface atoms, surface energy and surface stress, effect of lattice parameters, nanoparticle morphology, equilibrium shapes of macroscopic and microscopic crystals.

UNIT II **9**

Nanoparticle preparation and gas phase methods, gas solid reaction precipitation and colloidal methods. Characterization of nanoparticles 1) HRTEM (High Resolution Transmission Electron Microscopy), STM, Analytical Electron Microscopy and X-ray analysis and chemical mapping

UNIT III **9**

Magnetic properties – magnetism in small systems, thermal activation and super magnetism, magnetism in coupled nano systems. Optical properties – nano size effect, optical response – quantum effect. Conducting properties doped nano particles, carbon nanotubes, nano wires and single electron transistors.

UNIT IV **9**

Basic concepts of cell biology – DNA, RNA, Photosynthesis, photo chemistry- quantum efficiency – photo chemical reactions

UNIT V **9**

Nanoparticle – biomaterial hybrid systems for bio-electronics and circuitry DNA – protein nano structures, DNA template electronics, biometric fabrication of DNA based metallic nanowires and networks. X-ray medical imaging and nano particle therapeutics.

REFERENCES:

1. Nano technology: Basic Science and Emerging technologies, Mick Wilson, Kamali Kannargare., Geoff Smith Overseas Press (2005)
2. Nano technology ed by Gregory Timp, Springer – Verlag, New York 1999.
3. Nano: The Essentials: Pradeep.T, 2007, Tata McGraw-Hill Publishing Company Ltd.
4. Nanoscale Technology in Biological Systems: Editors: Ralph et al, 2005, CRC-Press.
5. Solid State Physics, A.J.Dekler.
6. Nanotechnology: Basic sciences and emerging technologies, Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkar Raguse, Overseas Press (2005).
7. Instrumental Methods of Analysis, Willard, 2000.
8. G Hadziioannou, P F van Hutten, 'Semiconducting Polymers: Chemistry, Physics, and Engineering', Wiley-VCH, 2000 (ISBN 3-527-29507-0)
9. Nanoparticle Assemblies and Superstructures. By Nicholas A. Kotov.2006 - CRC.
10. Functional Nanostructures, Seal
11. Nanoand Micro materials of research, Dohno, Springer, 2008.
12. Nanomaterials and nanochemistry, Brechignac.

TOTAL : 45 PERIODS

NO9334	**PROJECT WORK (PHASE I)**	**0 0 12 6**
NO9341	**PROJECT WORK (PHASE II)**	**0 0 24 12**