UNIVERSITY OF MUMBAI

No. UG/141 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular No. UG/259 of 2006, dated 17th July, 2006, relating to ordinances and syllabus of the M.Sc. in Nano Science and Nano Technology degree course.

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in Nano Science and Nano Technology at its meeting held on 14th August, 2018 have been accepted by the Academic Council at its meeting held on 8th September, 2018 **vide** item No. 4.9 and that in accordance therewith, the revised syllabus as per the (CBCS) for the M.Sc. in Nano Science and Nano Technology (Sem. III & IV), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Prof. Sunil Bhirud)
I/c. REGISTRAR

MUMBAI – 400 032
17th January, 2019

To

The Principals of the affiliated Colleges, the Heads University Departments and Directors of the recognized Institutions in Science & Technology Faculty.(Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.9/08/09/2018

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No. UG/141 -A of 2018 MUMBAI-400 032 17th January, 2019

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Nano Science and Nano Technology,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-ordinator, University Computerization Centre,

(Prof. Sunil Bhirud)
I/c. REGISTRAR

UNIVERSITY OF MUMBAI

Program: M.Sc.

(Choice Based Credit System)

Course: M.Sc. Nanoscience and Nanotechnology

Part- II

Syllabus for Semester III & IV

(To be implemented from the Academic year 2018-2019)

Minutes of the syllabus committee meeting

Agenda: To discuss the revision of syllabus for M.Sc. SEM III and IV in Nanosciences and Nanotechnology under Choice Base Credit System (CBCS)

The meeting of syllabus committee was held on 4th August 2018 at National Center for Nanoscience and Nanotechnology University of Mumbai at 11.30 am, to discuss the revision of syllabus for M.Sc. SEM III and IV in Nanoscience's and Nanotechnology.

Following committee members were present

1. Prof. S. K. Kulkarni
2. Prof. A. K. Shrivastava
3. Prof. Deepa Khushalani
4. Dr. Pankaj Poddar
5. Dr. Ratnesh Jain
6. Dr. Pragati Thakur
7. Prof. Santosh Haram

Following faculty members from National Center for Nanoscience and Nanotechnology University of Mumbai were presented as observers,

1. Dr. Atul Chaskar
2. Dr. Suhas Jejurikar
3. Dr. Kunjal Shah
4. Dr. Bhavesh Sinha
5. Dr. Harshawardhan Bhatkar

The committee discussed the revised syllabus and proposed the following syllabus

Semester III:

Core Courses:

1. Micro-Nanofabrication	(4 Credit)
2. Nano-SHE (Safety Health and Environment)	(4 Credit)
A. Nanotechnology in Biomedical Applications	(3 Credit)
B. Human Health, Environment and Nanotechnology	(1 Credits)

Elective Courses:

1. Nanodevices (Chemistry, Physics, Biology approaches)	(4 Credit)
2. Advance Instrumentation methods	(4 Credit)
3. Nanotechnology in Food and Agriculture Industry	(4 Credit)

Optional Courses:

1. Electrochemical Power sources and Nanotechnology	(4 Credit)
2. Industrial nanotechnology	(4 Credit)
3. Nanotechnology in Defense and Space	(4 Credit)

Practical's:

1. Numerical methods and recipes (3 Credit)
2. Research methodology (2 Credit)
3. Short Term Project (3 Credit)
   (Literature Survey, Review Writing and presentation)

Semester IV:

Project Work

Proposal writing (2 page Synopsis), Defending the idea of work via oral presentation (20 %); Mid Semester presentation and assessment by supervisor (30 %); Dissertation (30 %); End of Semester presentation, Defense of Dissertation and assessment by committee (20 %).

University of Mumbai
National Centre for Nanosciences and Nanotechnology
M.Sc. II

Semester III:

Core Courses:

1. Micro-Nanofabrication (4 Credit)
2. Nano-SHE (Safety Health and Environment) (4 Credit)
   A. Nanotechnology in Biomedical Applications (3 Credit)
   B. Human Health, Environment and Nanotechnology (1 Credits)

Elective Courses:

1. Nanodevices (Chemistry, Physics, Biology approaches) (4 Credit)
2. Advance Instrumentation methods
3. Nanotechnology in Food and Agriculture Industry

Optional Courses:

1. Electrochemical Power sources and Nanotechnology (4 Credit)
2. Industrial nanotechnology (4 Credit)
3. Nanotechnology in Defense and Space

Practicals:

1. Numerical methods and recipes (3 Credit)
2. Research methodology (2 Credit)
3. Short Term Project (3 Credit)
   (Literature Survey, Review Writing and presentation)

Core Courses:

Paper I:

Micro-Nanofabrication **(4 Credit, 60 Lectures)**

Nano Fabrication by photons (10 L)

Optical projection lithography, Optical lithography at short wavelengths (deep UV, Extreme UV, X-rays), near field optical lithography, Interferometry optical lithography, Massless Optical Lithography

Nano Fabrication by Charged Beam (10 L)

Focusing Charged particle beam, Charged particle optics, Sources (electrons, ions), Scattering and proximity effect, E-Beam Lithography (E-BEL), Focused Ion beam Lithography (FIB), Resists and materials

Nano Fabrication by Scanning Probes (5L)

Principles of SPM, Exposure of Resists, Local Oxidation Lithography, Dip-pen lithography,

Mask Making (3 lectures) Nanofabrication by Self Assembly (5L)

Self-assembly process, Guided Self Assembly, self-assembly using Surface Forces, self-assembly using electrostatic forces, self-assembly using magnetic force, Building blocks of future nano systems (DNA scaffold, Carbon Nanotubes, Black co-polymers, Porous Alumina), Soft lithography

MEMS - NEMS fabrication, **(6 L)**

CNC milling and micro-machines, **(6 L)**

3D printing and case studies (Bio printers, Robot printers, semiconductor printers **(10 L)**

Softwares CAD-CAM / Wavemaker design software (Dr. Suhas suggest the correct name if it is not) **(5 L)**

Reference Books

- Nanofabrication: Principles, Capabilities and Limits by Zheng Cui,, Springer.
- Nanofabrication fundaments and applications by A. A. Tseng, World Scientific
- Handbook of Nanofabrication by G. Wiederrecht, Academic Press

Paper II: Nano-SHE (Safety, Health and Environment) (4 Credit, 60 Lectures)

A. Nanotechnology in Biomedical Applications (3 Credit, 45 Lectures)

Functional principles of Bionanotechnology therapies (10 L)

Introduction - Development of nanomedicines, Drug Delivery system administration – Nanotechnology in diagnostic application. Information driven, nanoassembly, Self replication, Molecular recognition and Flexibility of biomaterials. DNA based nanostructures, Nano diagnostics- Nanoarrays for Molecular Diagnostics, Nanofluidic/Nanoarray Devices to Detect a Single Molecule of DNA-Self Assembling Protein Nanoarrays, Quantum Dots for Molecular Diagnostics Magnetic Nanoparticles -Use of Nanocrystals in Immunohisto chemistry -Imaging Applications of Nanoparticles Study of Chromosomes by Atomic Force Microscopy-Applications of Nanopore Technology for Molecular Diagnostics DNA.

Nanomachines, Nanobarcodes and Nanobiosensors (10 L)

Negligible gravity and inertia, atomic granularity, thermal motion, water environment and their importance in bionanomachines. Overview of natural Bionanomachines: ATP synthetase, Actin and myosin, Opsin. Sensors- Introduction and characterization of sensors DNA Nanomachines for Molecular Diagnostics –Nanobarcode Particle Technology for SNP Genotyping–Based Colorimetric DNA Detection Method Cantilevers as Biosensors for Molecular Diagnostics – Carbon Nanotube Biosensors –FRET-Based DNA Nanosensors. Ion Channel Switch Biosensor Technology –Electronic Nanobiosensors -Electrochemical Nanobiosensors–Quartz Nanobalance Biosensors -Viral Nanosensors –PEBBLE Nanosensors -Microneedle-Mounted Biosensors Optical Biosensors- Nanowire (NW) Biosensors -Nanoscale Erasable Biodetectors.

Nanopharmaceuticals (10 L)

Introduction -Nanobiotechnology for Drug Discovery -Gold Nanoparticles for Drug Discovery – Use of Quantum Dots for Drug Discovery - Role of AFM for Study of Biomolecular. Nanotechnology Enables Drug Design at Cellular Level Nanobiotechnology-Based Drug Development – Dendrimers as Drugs- Fullerenes as Drug Candidates –Nanosuspension

Formulations Viruses as Nanomaterials for Drug Delivery -Nanoparticle-Based Drug Delivery - Trojan Nanoparticles -Self-Assembling Nanoparticles for Intracellular Drug Delivery - Nanoparticle Combinations for Drug Delivery Liposomes -Liposome–Nanoparticle Hybrids- Nanospheres-Nanotubes - Nanomolecular Valves for Controlled Drug Release.

Nanomedicine: Applications **(15 L)**

Drug Delivery: Modes of drug delivery – Absorption Distribution Metabolism Excretion characteristics of Drugs and Kinetics of the Drug delivery - Controlled and sustained delivery – site specific drugs - Barriers for drug targeting - Passive and Active targeting, Types of Targeted Drug Delivery systems based on surface modification: Bioconjugation – PEGylation. Polymers - Classification - Polymer Micelles as Drug Carriers- Polymer Nanotubes- Magnetic Nanoparticles as Drug Carriers- Dendrimers - Synthesis –Tectodendrimers, Nanoscafold systems – Gene transfection – Carbon nanotubes in diagnosis and therapy - Liposomes for - Liposomal Drug Carriers in Cancer Therapy - lipid-DNA complexes – liposomal peptide and protein drug delivery Liposomal anticancer and antifungal agents. Theragnostic Metal Nanoshells Photothermally-modulated Drug Delivery Using Nanoshell-Hydrogel Composites Nanoporous Microsystems for Islet Cell Replacement - Molecularly-derived Therapeutics - Transdermal Drug Delivery using Low-Frequency Sonophoresis Nanoporous Implants for Controlled Drug Delivery- Functionalized Cyclodextrin Nanoparticles.

References:

1. Kewal K. Jain , The Handbook of Nanomedicine Humana Press, (2008).
2. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005).
3. Robert A. Freitas Jr., Nanomedicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).
4. C. M. Niemeyer, C. A. Mirkin, —Nanobiotechnology: Concepts, Applications and Perspectives‖, Wiley – VCH, (2004).
5. T. Pradeep, —Nano: The Essentials‖, McGraw – Hill education, (2007).
6. Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer, ‖Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact‖, Wiley – VCH, (2005).
7. Nicholas A. Kotov, —Nanoparticle Assemblies and Superstructures‖, CRC, (2006).
8 Nanotechnology in Modern Medical Imaging and Interventions. Xiaoming Yang. Nova Science Publisher.
9. The Clinical Nanomedicine Handbook. By Sara Brenner. CRC Press

10. Nanomedicines and Nanoproducts: Applications, Disposition, and Toxicology in the Human Body. Eiki Igarashi.
11. Novel Drug Delivery Systems. by Yie W. Chien

B. Human Health, Environment and Nanotechnology (1 Credit, **15 L**)

Nanoparticle in Aquatic and Terrestrial Environment **(5 L)**

Overview of current knowledge. Fate and behavior in natural aquatic systems

Natural and engineered nanoparticle interactions, Structural determination and analysis, Interactions with pollutants pathogens and nutrients, effects of pollutant and pathogen fate and behavior.

Nanoparticles as pollutants:

Sources and sinks of nanoparticles, engineered nanoparticles, nanoparticle interaction with naturally occurring material, transport of nanoparticles, nanoparticles as a vector of pollution.

Nanoparticle Safety: United States perspective **(5 L)**

National nanotechnology initiative in US, Government activities in support of safe Nanotechnology, Industry and other Non-government activities in support of safe nanotechnology, Ensuring development of safe Nanotechnology

Human Effects of Nanoparticle Exposure **(5 L)**

The Regulatory Issues, Nanosciences and nanotechnologies in contest of dangerous Substances. Current Issue and Knowledge Gaps; Toxicology of Nanoparticles, Epidemiology, Human challenge studies, Risk Assessment of Engineered Nanoparticles

References:

Nanotechnology Consequences for Human health and the Environment
by: RE Hester and RM Harrision
Nanotechnology risk, ethics and law
by: Geoffrey Hunt and Michael Mehta
Nanomaterials Toxicity and Risk Assessment
by: Sonia Soloneski and Marcelo L. Larramendy
Nanotechnology: Environmental Aspects
by: Harald F. Krug.

Elective Courses:

Paper I: Nanodevices (Chemistry, Physics, Biology approaches)

(4 Credit, 60 L)

Basic Concepts **(15L)**

Energy bands and energy gap, electron flow, conductivity, drift, carrier transport phenomena (Capacitance; Resistance; Piezoelectric effect, Hall Effect, carrier concentration at thermal equilibrium, ballistic and diffusive transport, etc), thermoelectricity (Seebeck effect, Peltier Effect), heterojunction, nanostructures

Device Concepts **(15L)**

p-n Junction (depletion region, current voltage characteristics, terminal functions, heterostructures); metal semiconductor contacts (barrier formation, current voltage characteristics, measurement of barrier height, Ohmic contacts, device structures); Metal Insulator Semiconductor Capacitors; Bipolar transistor (device structures and device characteristics); MOSFETs (device structures and device characteristics, single electron transistor);

Sensor and detector Materials **(5L)**

Silicon as sensing material ideal case; plastics, metals, ceramics, glasses and various nanomaterials

Humidity and moisture sensors **(5 L)**

Concept; Capacitive sensors, electrical conductivity sensors, thermal conductivity sensors, optical hygrometer

Temperature Sensors **(5L)**

Concept, Temperature reference points, Themoresistive Sensors, Thermistors, Thermoelectric Contact Sensors, Semiconductor pj junction sensor, optical temperature sensors and piezoelectric temperature sensors.

Light Detectors **(5 L)**

Concept, radiative transitions, photo-conductors, photo-resistors, photodiodes (Light Emitting Diodes (LED), Laser diodes (LD)); Charge Coupled Device (CCD); Solar Cell

Radiation Detectors **(2 L)**

Concept, Scintillation detectors, Ionization detectors

Chemical Sensor **(5 L)**

Chemical sensor characteristic; Elastomer Chemiresistors; Metal Oxide sensors; Ion Sensitive Field Effect Transistor, Catalytic Metal Sensors; Optical Transducers; Multisensor arrays

Lab on Chip devices for clinical diagnostics **(3 L)**

Concept, Microfluidic dispensers, Electrophoretic separator, micro bio-reactor, DNA sensor chip, Lab on a chip for bacteria detection, Lab on a chip for blood sampling, microarrays

Reference Books:

- Physics of Semiconductor Devices by S. M. Sze, Wiley Interscience
- Lessons from Nanoelectronics: A New Perspective on Transport, Supriyo Datta
- Handbook of Modern Sensors: Physics, Designs and Applications by Jacob Fraden, Springer
- Lab on a Chip by Edwin Osterbroek, A. van den Berg, Elsevier Science

Paper II: Advance Instrumentation methods (4 Credit, 60 Lectures)

Transmission Electron Microscopy (TEM)

1) Pump & Holders,
2) Instrument: Illumination Systems, Objective lenses & stages, Diffraction pattern & Images, STEM images, Alignment and Stigmation, Calibrating imaging system
3) Specimen/Sample Preparation
4) Diffraction in TEM: Kikuchi Diffraction
5) Imaging: Amplitude & Phase Contrast
6) High Resolution TEM (HRTEM)
7) EELS Measurement

Atomic Force Microscopy (AFM)

1) Overview of AFM
2) Distance dependent Interactions
3) Z-Direction dependent Force measurements
4) Topographic Imaging
5) Probing Material Properties (a – Phase Imaging, b – Adhesive nano mechanics)

Scanning Tunnelling Microscopy (STM)

1) Instrumentation & Tunnelling effect
2) Scanning Probe Microscopes
3) STM studies of clean surfaces
4) Applications

X-Ray Diffraction (XRD)

Generation of X-Rays, Introduction to Diffraction and the Reciprocal Lattice, concepts such as lattice, point and space groups, Bragg's Law and explain its the relation to crystal structure, Crystal lattices, nomenclature. Geometry, symmetry, Powder XRD, Structure determination and refinement, Stress, crystallite size, phase identification, lattice parameter measurements, phase quantification, Thin films, multipurpose diffractometer geometry, XRR, Grazing incidence X-ray Diffractometry (GIXD), Texture, phi scans, pole figures, High resolution XRD, reciprocal space mapping, High temperature XRD, Low temperature XRD,

Basics of electrical measurements, electronic bridge used for electrical measurements, Resistivity measurements for low and high resistance materials, Impdance: basic principle and methods, measurements at low and high temperatures, Thermal Transport measurements, Basics of Magnetization measurements, ZFC and FC measurements at different temperatures, electrical and thermal properties under the influence of magnetic field, AC Susceptibility, Torque magnetometry.

Spectrochemical Methods:

Introduction to Spectrochemical Methods, Instruments for Optical Spectrometry, Molecular Absorption Spectrometry, Molecular Fluorescence Spectroscopy, Atomic Spectroscopy, Mass Spectrometry, Gas Chromatography, High-Performance Liquid Chromatography.

References:

1. A textbook for Materials Science: **David. B. Williams & C. Barry Carter**.
2. AFM: Understand basic modes and Advanced Applications: **Greg. Haugstad**
3. Reference: STM & its Applications: **Chunli Bai**
4. General text on x-ray diffraction: Elements of X-Ray Diffraction (3rd Edition) Cullity and Stock. (2001) ISBN: 0201610914
5. Materials Science and Engineering: An Introduction Callister and Rethwisch (2009) ISBN: 0470419970
6. Text on thin film analysis: Thin Film Analysis by X-Ray Scattering Birkholz. (2005) ISBN: 3527310525
7. Fundamentals of Analytical Chemistry, Skoog and West

Paper III: Nanotechnology in Food and Agriculture (4 Credit, 60 Lectures)

Intermolecular interactions and supramolecular structures:

Water - Hydrophobic and Hydrophilic Interactions - Dispersion Interaction Electrostatic Interactions - Atoms and Small Molecules - Polymers, Particles, and Surfaces - Steric Interactions Involving Soluble Polymers - Depletion Aggregation of Particles by Non-adsorbing Polymers - Bridging Aggregation of Particles by Adsorbing Polymers - Stabilization of Dispersed Particles by Adsorbing Polymers - Polymer Brushes to Prevent Particle Aggregation and Particle Deposition at Surfaces - Plant Cells - Organized Self-Assembled Structures - Langmuir Layers Lipid Bilayers - Solid-Supported Lipid Bilayers.

Nanoparticles in agricultural and food diagnostics:

Enzyme Biosensors and Diagnostics - DNA- Based Biosensors and Diagnostics Radiofrequency Identification- Integrated Nanosensor Networks: Detection and Response- Lateral Flow (Immuno)assay - Nucleic Acid Lateral Flow (Immuno)assay - Flow-Through (Immuno)assays - Antibody Microarrays Surface Plasmon Resonance Spectroscopy.

Nanotechnology in food production:

Food and New Ways of Food Production - Efficient Fractionation of Crops Efficient Product Structuring -Optimizing Nutritional Values - Applications of Nanotechnology in Foods : Sensing,Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients - NanoEmulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks Preparation of Food Matrices - Concerns about Using Nanotechnology in food production.

Nanotechnology in food packaging:

Crop improvement - Reasons to Package Food Products - Physical Properties of Packaging Materials - Strength - Barrier Properties Light Absorption – Structuring of Interior Surfaces - Antimicrobial Functionality - Visual Indicators – Quality Assessment - Food Safety Indication - Product Properties - Information and Communication Technology - Sensors - Radiofrequency Identification Technology- Risks - Consumer and Societal Acceptance.

TEXT BOOKS:

1) Nanoparticle Assemblies and Superstructures by Nicholas A. Kotov, CRC, 2006.
2) Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage,, Woodrow Wilson International, 2006.
3) Bionanotechnology by David S Goodsell, John Wiley & Sons, 2004.
4) Nanobiomaterials Handbook by Balaji Sitharaman, Taylor & Francis Group, 2011

Optional Courses:

Paper I. Electrochemical Power sources and Nanotechnology (4 Credit, 60 Lectures)

Basics of Electrochemistry:

Introduction and overview of electrode process, potential and thermodynamics of cell, kinetics of electrode reaction, mass transfer by migration and diffusion, basic potential step methods, potential sweep methods, polarography and pulse voltammetry, controlled current techniques, concept of impedance. The Governing Equations: Faraday Nernst and Butler Volmer , Chlor Alkali and Electrolysis, Corrosion, Pourbaix diagrams.

Batteries:

[A] Batteries with Aqueous electrolyte – General Aspect, Types of batteries including Pb, Ni, cad, NIMH, Lithium batteries, Electrical Characterization of batteries, Miscellaneous batteries (reserve batteries, compound batteries etc.), Design parameters including scale factor, separators, sealing, Ohomic losses, thermal process in batteries. General aspect of battery maintenance.

[B] Batteries with non-aqueous electrolytes: Different kind of electrolytes, 1) Primary Li Battery-design, fundamentals, electrical and operational characterizations. 2) Li-Ion Batteries- basics, characterizations. 3) Alternative to Li-Ion batteries- Li-Air, Li-Sulphur and Na ion batteries. 4) Solid state batteries, 5) batteries with molten salt electrolytes.

Supercapacitors:

Electrochemical capacitors and supercapacitors: ideal electrostatic capacitor, electrolytic capacitor, double layer capacitor, pseudo-capacitor, and impedance of supercapacitor, electrochemical Transducers.

Fuel Cells:

Introduction, efficiency and open circuit voltage, operational fuel cell voltage, Details about various types of fuel cells including Proton exchange membrane fuel cell (PEMFC), Direct Liquid fuel cell with gaseous, liquid and/or solid reagents, Molten Carbonate fuel cell (MCFC), Solid oxide fuel cells (SOFC), Alkaline electrolyte fuel cells (AFC), Direct Methanol fuel cell, Medium and High Temperature fuel cells, other types of fuel cells. Fuel cells as electrolysers, Applications of fuel cells.

Unit 5: Other electrochemical systems:

Concepts of electro-catalysis, Photo electrochemistry and bio-electrochemistry with an example.

References:

1. J. Bard, and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, Wiley, 2001.
2. R. Huggins, Advanced Batteries: Materials Science Aspects, 2008.
3. V. S. Bagotsky, Fundamentals of electrochemistry, 2nd ed., 2006.
4. J. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd ed., 2003.
5. J. Newman, and K. E. Thomas-Alyea, Electrochemical Systems, 3rd ed., 2004.
6. M. Mench, Fuel Cell Engines, Wiley, 2008.
7. G. A. Prentice, Electrochemical Engineering Principles, 1990.
8. M. Root, The TAB Battery Book: An In-Depth Guide to Construction, Design, and Use, Tab Electronics, 2011.
9. A.C. West, Electrochemistry and Electrochemical Engineering. An Introduction, 2012.

Paper II: Industrial Nanotechnology (4 Credit, 60 Lectures)

Nanotechnology in Chemical Industry (20 Lectures)

Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays

Nanotechnology in Textiles and Cosmetics (20 Lectures)

Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – Polymer nanofibers - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers - Bionics– Swim-suits with shark-skin-effect,Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear) Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics

Nanomaterials for Solar Power: (20 Lectures)

Solar energy materials, Solar energy devices, silicon solar technology for clean energy. Nanomaterials and coating for nuclear power: Radiation resistance of nanomaterials, Nanonuclear materials and coatings for generation IV fission and future fusion reactors. Applications of catalysis and supramolecular chemistry.

TEXT BOOKS:

1. Nanotechnology in the Food, Beverage and Nutraceutical Industries, Ed: Qingrong Huang, 2012, Elsevier
2. Applications of Nanoscience in Photomedicine, Eds:Michael R. Hamblin and Pinar Avci, 2015, Elsevier
3. Nanotechnology in Catalysis 3, Eds: Zhou, B., Han, S., Raja, R., Somorjai, G.A., 2007 Springer

4. Nanopharmaceutics-The Potential Application of Nanomaterials, Ed: Xing-Jie Liang, 2012, World Scientific.

Paper III: Nanotechnology in Defense and Space (4 Credit, 60 Lectures)

Electrochemistry: Electrochemistry in nanoscale patterning: Basics of large scale eletrochemical patterning and study of electrochemical techniques for patterning materials such as metals (nanowire etc.) to produce nanoscale features for antennas, sensors, meta-materials, and catalysts.

Thermal properties: Novel nanomaterials and composites with tunable thermal properties: Basics of thermal transport in bulk and nanomaterials. Study of materials and structures for thermal insulators between an electronic device and the next layer of the package. Novel nanomaterials for larger thermal conductivity to quickly dissipate the heat build-up to save electronic devices. Use of nanomaterials and composites for smart clothings with greater tolerance for temperature change and in build sensors and surveillance against the chemical and biological threats.

Nanobio: Smart nanobio materials/sensors for chemical/bio-warfare: Basics of bio and chemical warfare. DStudy of Nanotechnology to detect and identify genetically modified organisms and naturally emerging diseases with forensic certitude and without the need for reagents (Chemical and Biological Defense). Use metallic nanoparticles to deliver anti-viral therapeutic agents (CBDP). Basics of the biodegradation of coatings. Antifouling, antibacterial coatings for the ship hulls for naval ships.

Mechanical properties: Surfaces and coatings: Mechanical properties at the nanoscale and development of surfaces with nano sized features for scratch resistance. Nano-armors: Armor-like fabric with greater protection from bullets and other projectiles. Bullet proof vests mhelmets and protective enclosure (from the materials such as graphene etc.). Smart and anti-degradable coatings.

Electrical properties: Superconducting wires: Basics of superconductivity and superconducting material currently used in the industry. Better nanomaterials and technologies to create multi- layer superconducting wire with carefully controlled particles dispersion via an amenable industrial process.

Magnetic materials: Novel magnetic nanomaterials for EMI shielding and other applications in mine detection inside the sea

Control the physical and chemical properties of nanoscale carbon materials and doped nanowires for electron devices, sensors, and solid- state energy conversion.

Practicals:

1. **Numerical methods and recipes (3 Credit)**

Modeling and Simulation of Nanoscale Materials

Unit:1 Numerical Techniques and Analysis:

Derivatives, Curve fitting, Interpolation and Roots of Equations, Numerical Integration and Solution to Simultaneous Equations, Solution of Differential Equation, Optimization Techniques, Application of Standard Libraries, Solution to Simultaneous Equations – II and Eigenvalues

Unit:2 Operating Systems and Programming Language:

Operating system and Hardware, Programming language, techincal programming, system development programming, scientific programming, bash-shell programming

Unit:3 Computational Methods for Nanoscale materials:

Atomic scale modeling, Molecular Mechanics, Molecular dyanmics, Conntinuum scale modeling, Multiscale modeling (QM/MM), High performance computing.

Unit:4 Applications:

Macromolecular materials, Mechanical properties of nanocrystalline metals and alloys, Diffusion and radiation damage in metals, Biomimetic materials, Phase transition, 1-D wave equation, electronic structures of molecules and solids.

References:

1. V. Rajaraman: *Computer oriented Numerical methods*, PHI earning Pvt. Ltd., 2004
2. *Numerical Recipes in C++ (2nd ed.)*, W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P
3. H. M. Antia: *Numerical methods for scientists and engineers*.
4. Jain M.K., Iyengar SRK, Jain R.K. : *Numerical methods for scientific and Engineering Computation*, New Age International, 1992.
5. S. S. Sastry: *Introductory method of numerical analysis*, PHI India 2005

6. P. B. Patil and U. P. Verma : *Numerical Computational methods*, Narosa Publ.
7. *Introduction to High Performance Scientific Computing* , Victor Eijkhout , Edmond Chow, Robert van de Geijn , 2nd edition, revision (2015).
8. *Understanding Molecular Simulation, Daan Frenkel and B. Smit, Academic Press, 1996.*
9. *Multiphysics and Multiscale Modeling: Techniques and Applications, Young W. Kwon, CRC Press (2015)*
10. *Novel approaches to multiscale modelling in materials science, J. A. Elliot, Int. Mat. Rev., **56,** 207-225 (2011).*
11. *Understanding Molecular Simulation, Daan Frenkel and B. Smit, Academic Press, 1996.*

2. Research methodology (2 Credit)
   a. Statistical analysis of experimental data
   b. Use of scientific calculator for data analysis
   c. Distinguish between noise and signal
   d. Advanced data analysis using MS excel
   e. Writing scientific report using LaTeX
   f. Deconolation of peaks
   g. Referencing of scientific document using mendeley.
   h. Virtual instrumentation using Labview
   i. Laboratory safety.
   j. Workshop on IPR

3. Short Term Project (3 Credit)
   a. Literature Survey
   b. Review Writing
   c. Presentation

Semester IV:

Major Research Project in Contemporary area of Nanoscience and Nanotechnology with Dissertation.
(24Cedits)

Unit 1: Proposal writing (2 page Synopsis), defending the idea of work via oral presentation (20 %);

Unit 2: Mid Semester presentation and assessment by supervisor (30 %);

Unit 3: Dissertation (30 %);

Unit 4: End of Semester presentation, Defense of Dissertation and assessment by committee (20 %).

S. K. Kulkarni

Prof. S. K. Kulkarni
(member)

Deepa Khushalani

Prof. Deepa Khushalani
(member)

Dr. Ratnesh Jain
(member)

SK Haram

Prof. Santosh Haram
Convener and Director, NCNNUM

Prof. A. K. Shrivastava
(member)

Dr. Pankaj Poddar
(member)

P.R. Thakur

Dr. Pragati Thakur
(member)

Prof Jayesh Bellare
(Chairman, BOS)