PG.Diploma in Nanoscience and Technology Programme

Syllabus & Regulations

2016-17 ONWARDS
PG. Diploma in Nanoscience and Technology Programme

REGULATION (2016-17 Onwards)

1. **Duration of the Course:** 1 Years

2. **Eligibility for Admission:**
   A candidate having BE/B.Tech any branch in Engineering other than Nanoscience and Technology with 55% of marks. (OR) Masters degree in Physics /Applied Electronics/ Chemistry / Applied Chemistry / Materials Science/Biotechnology/Biological Sciences with 55% of marks.

3. **Examinations**
   End semester examinations under CBCS Scheme comprising of external question paper setting and double valuation by the course teacher and an external examiner for each theory courses. If the difference between the two valuations is more than 15%, the script will be evaluated by the third subject expert within the University, and the mark awarded by that expert will be the final. But for laboratory courses, the valuation will be done only by the Faulty in -Charge.

3. **Proportion of marks for internal assessment and end-semester examination for each theory and laboratory courses are 40:60, respectively.**

4. **Guidelines for awarding marks for Research project.**

   Marks for project awarded by the **Research Supervisor** : 100 Marks
   Marks for project **viva-voce** awarded by 2 Members Committee : 100 Marks

   [The mid-term review will be conducted and the assessment shall be made by all the faculty members of the Centre (50 Marks) and then at the end public viva – voce exam will be conducted and the assessment shall be made by the project supervisor of the Centre and one external examiner (50 Marks)]

5. **Passing Requirements**
   The student should have a minimum of 40% marks in University Examination and a minimum total of 50% marks in Internal assessment and University Examination put together, in all courses.

6. **Internal assessment**
   Total internal marks 40; Mark distribution: Three internal tests to be conducted for 30 marks, out of which best two to be taken, and for another 10 marks to be given for Assignment and Seminar.
7. Internal assessment test question paper pattern
   Time duration : 2 Hours
   Maximum Marks: 30

   PART A: 5 × 2 = 10 Marks
   Answer ALL Questions

   Question 01 To Question 05

   PART B: 4 × 5 = 20 MARKS
   Answer any FOUR out of Five Questions

   Question 06 To Question 10

8. End semester examination question paper pattern:
   Time duration : 3 Hours
   Maximum Marks : 60

   PART A: 10 ×2= 20 Marks
   Answer ALL Questions
   (Two Questions must be asked from each unit)

   Question 01 To Question 10

   PART B: 5×8=40 MARKS
   Answer FIVE out of Eight Questions
   (Equal weightage must be given to each unit)

   Question 11 To Question 18

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# PG Diploma in Nanoscience and Technology

## Curriculum (2016-17 Onwards)

<table>
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<tr>
<th>Sem</th>
<th>Code No.</th>
<th>Subject</th>
<th>Course Type</th>
<th>Class hours</th>
<th>University Examination</th>
<th>Credit</th>
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<td>Internal</td>
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<td>I</td>
<td>CNST-611</td>
<td>Elements of Materials Science and Physical Properties of Nanomaterials</td>
<td>HC</td>
<td>3</td>
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<td>NAST-612</td>
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<td>Polymers and Nanocomposites</td>
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<td><strong>Soft- Core Courses</strong> <em>(Any ONE to be selected)</em></td>
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HC – Hard Core Course; SC - Soft Core Course;
Syllabus for Courses

Semester - I

CNST-611: Elements of Materials Science and Physical Properties of Nanomaterials

UNIT-I  
Crystal structures  
(9 hrs)
Crystal geometry: crystal lattices, space lattices, basis and crystal structure, unit cell, lattice parameter of a unit cell - Seven crystal systems - Bravais lattices - Crystal directions and crystal planes (Miller indices) - Coordination number, radius ratio, packing factor - Some special crystal structures - Calculation of lattice constant – Symmetry elements and symmetry operations - Point groups - Crystallographic nomenclature - Imperfections/defects in crystalline solids.

UNIT-II  
Bonding in Nanostructures  
(9 hrs)
Atomic bonding in solids, Types of bond: Metallic, Ionic, Covalent, Coordination/dative bonds; Vander Waals interactions/Electrostatic interactions: Ion pair interactions, solvent effects, Ion-dipole and dipole – dipole interactions, π-interactions - Hybridization, Hydrogen bonding - hydrophobic interactions. MO theory for simple molecules such as diatomic molecules. Size effect of Nanomaterials: Size, shape, density, melting point, wet ability, specific surface area, solid state phase transformation and band gap variation - Quantum confinement, Effect of strain on band gap in epitaxial quantum dots..

UNIT-III  
Bonding in Nanostructures  
(9 hrs)

UNIT-IV  
Electronic Properties  
(9 hrs)

UNIT-V  
Mechanical behavior  
(9 hrs)
Stress-strain behavior, tensile strength, toughness, micro-hardness, wear resistance, corrosion resistance behavior of nanostructures. Thermal properties: Concept of phonon,thermal conductivity, thermal expansion and thermal expansion coefficient.
**Magnetic properties:** Fundamentals of magnetism - Different kinds of magnetic materials: dia, para, ferro, ferri and anti-ferromagnetic materials - Magnetic hysteresis – Superparamagnetism – Important properties in relation to nano-magnetism.

**TEXT BOOKS**

**REFERENCE BOOKS**

**CNST-612: Fundamentals of Biology for Nanotechnology**

**Unit I**

(9 hrs)

monomers, dimers, oligomers - fibrous proteins and globulins - primary, secondary, tertiary, quaternary structures - disulfides, hydrogen bonds, Schiff’s base - amino and carboxy termini - alpha helix and beta pleats - triple helix - Ramachandran plots.

Unit II  (9 hrs)

Unit III  (9 hrs)

Unit IV  (9 hrs)

Unit V  (9 hrs)

TEXT BOOKS

REFERENCE BOOKS
5. Molecular Cell Biology, Harvey Lodish; David Baltimore; Arnold Berk. WH Freeman and Co.

**CNST-613: Synthesis and Characterization of Nanostructured Materials**

**UNIT-I**

**Soft Chemical processes**

Synthesis of Nanomaterials by Soft Chemical Methods: Chemical precipitation and co-precipitation: Metal nanocrystals synthesis by polyol, and borohydride reduction methods, Sol-Gel synthesis; Microemulsions synthesis, normal and reverse micelles formation, Hydrothermal, Solvothermal.

**UNIT-II**

**Chemical processes**

Synthesis methods of dimensionally modulated Inorganic nanostructured materials Thermolysis routes, Microwave assisted synthesis; Sonochemical assisted synthesis, Core-Shell nanostructure, Organic –Inorganic Hybrids, Quantum dot (QDs) synthesis. Carbon Nanotubes, (SWCNT, MWCNT), Graphene nanosheets. Photochemical synthesis, Synthesis in supercritical fluids and Electrochemical synthesis

**UNIT-III**

**Physical processes**

Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, RF- plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy (MBE), Chemical vapour deposition (CVD) method. Template assisted synthesis, Catalyst assisted chemical vapour deposition (CCVD).

**UNIT-IV**

**Biological Methods of Synthesis**

Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the nanostructured materials; synthesis process and application, Role of plants in nanoparticle synthesis.
UNIT-V (9 hrs)

Nanostructured materials Characterization Techniques
X-ray diffraction (XRD), SEM, EDAX, TEM, Elemental mapping, FTIR, UV-Visible spectrophotometer, Nanomechanical Characterization using Nanoindentation, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis (TGA), TEM, X-ray Photoelectron Spectroscopy (XPS), Electrochemical Characterization measurements.

TEXT BOOKS
2. Chemistry of Nanomaterials: Synthesis, properties and applications by CNR Rao et.al.

REFERENCE BOOKS
2. Processing & properties of structural nanomaterials - Leon L. Shaw (editor)

CNST-614: Nanostructure Fabrication and Metrology

UNIT-I (10 hrs)

Principles of Photo Lithography

UNIT-II (8 hrs)

Advances in Optical Lithography and Pattern transfer

UNIT-III (9 hrs)

UNIT-IV
Nonlithographic patterning

UNIT-V
Metrology

TEXT BOOKS

REFERENCE BOOKS
CNST-615: Nanophotonics and Biophotonics

Unit I  (10 hrs)
Introduction to photonics
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.

Unit II  (10 hrs)
Photonic Crystals
Fabrication of photonic crystals: Photonic crystals by self-assembly - Photonic
Crystals by Microfabrication - Photonic Crystals with Tunable Properties.
Harmonic generation in photonic nanostructures: Metal nanoparticles,
Nanoparticles in monolayer – planar photonics structures - photonic crystals.

Unit III  (9 hrs)
Photobiology
Interaction of light with cells: 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

Unit IV  (8 hrs)
Nanotechnology for biophotonics: The interface of bioscience, nanotechnology and
photons - 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

Unit – V  (8 hrs)
Biomaterials for Photonics: Photonics and Biomaterials – Bioderived materials
(Bacteriorhodopsin, Green Fluorescent Protein, DNA, Bio-objects and biocolloids) –
Bioinspired materials – Biotemplates (DNA and Viruses as templates) – Bacteria as
synthesizers for photonic polymers.

TEXT BOOKS
1. Introduction to Nanophotonics, Sergey V. Gaponenko, Cambridge University Press,
2. Photonic crystals: Physics and Technology, (Eds.) C. Sibilia, T. M. Benson, M.

**REFERENCE BOOKS**


**CNST- 616: Nanoelectronics and Bioelectronics**

**UNIT-I**

**LEDs and Semiconductor Lasers**

(9 hrs)

Fundamentals of Semiconductor physics, Review of quantum confinement theory, optical phenomena in various quantum structures: quantum wells, quantum wires, quantum dots, superlattices. GaAs/ GaAlAs quantum well lasers, quantum wire lasers, quantum dot lasers, white light LEDs, vertical cavity surface emitting lasers, quantum cascade lasers, quantum well infrared detectors, digital logic based on quantum wells, GaN and other visible LEDs, semiconductor lasers.

**UNIT-II**

**Nanoscale MOSFETs**

(9 hrs)

Challenges in miniaturization, quantum effects, thin oxides, random dopant fluctuations, tunneling and subthreshold currents, power density, hot electron effects, fundamental limits of MOS operations, MODFET (Modulation Doped FET), GaN based HEMT (High Electron Mobility Field Effect Transistors).

**UNIT-III**

**Molecular Nanoelectronics**

(9 hrs)

Molecular nanowires, organic LEDs, organic FETs, carbon nanotube and graphene based FETs, Silicon nanowire based FETs,

**UNIT-IV**

**Single Electron Tunneling Phenomena and Devices**

(9 hrs)
Single electron tunneling phenomena, Coulomb blockade, Coulomb staircase, Bloch oscillations, resonant tunneling diode and resonant tunneling transistor,

**UNIT-V**

**Nanobioelectronics**

DNA based biosensors, protein based biosensors, materials for biosensor applications, quantum dot based bioimaging, DNA based logic and computing elements.

**TEXT BOOKS**

2. Nanoelectronics- principles and devices, M. Dragoman and D. Dragoman, Artech House publishers, 2005

**REFERENCE BOOKS**


**CNST-610: Synthesis and Processing Laboratory**

Synthesis of semiconducting and ceramic nano-materials by solution combustion, sol-gel, micro-emulsion, chemical co-precipitation, hydrothermal, sono-chemical and microwave assisted methods.

Synthesis of multi-ferrite nano-particles.

Synthesis of silver nanoparticles, and its spectral analysis.

Preparation of nano-composites, nanoporous material, colloidal solid and core–shell nanoparticles.

Preparation of quantum dots such as cadmium selenides and its optical studies.

Preparation of cadmium sulphide nanoclusters and its spectral studies.

**Semester - II**

**CNST-621: Polymers and Nanocomposites**
UNIT-I (9 hrs)
**Basic Aspects:** Classification - Some basic definitions - Addition and condensation polymerizations, and copolymerization - Mechanism of free radical, cationic and anionic polymerizations – Nomenclature - Tacticity – Glassy solids: Glass transition and melting temperatures and their determination by DSC - Factors affecting Tg, importance of Tg, relationship between T_m and T_g and their control - Crystallinity in polymers: Degree of crystallinity, factors affecting crystallinity of polymers, effect of crystallinity on the properties of polymers.
**Polymerization Techniques:** Bulk, Solution, Suspension and Emulsion polymerizations - Polymerization using metal catalysts and surfactants.

UNIT-II (9 hrs)
**Molecular weight of polymers:** Number average, weight average and viscosity average molecular weights of polymers - Determination of molecular weight of polymers by GPC and viscometry methods. **Speciality polymers:** Bio-polymers, Bio-degradable polymers, Fire retardant / Thermally stable polymers, Polymer electrolytes and Liquid crystalline polymers.

UNIT-III (9 hrs)
**Conducting Polymers**
Discovery – Structural characteristics and doping concept - Charge carriers and conducting mechanism – Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

UNIT-IV (9 hrs)
**Polymer Nanocomposites**
Definition of nanocomposites - Nanofillers, Classification of nanofillers, Synthesis and properties of nanofillers - Types of nanocomposites – Synthesis of nanocomposites: Direct mixing, solution mixing, In-situ polymerization - Polymer/ Metal oxide nanocomposites, diblock copolymer based nanocomposites, Polymer/CNTs and Polymer/Nanoclay based composites and their properties and functional applications.

UNIT-V (9 hrs)
**Other Kinds of Nanocomposites:** Fractal based Glass – metal nanocomposites - Core-shell structured nanocomposites - Super hard nanocomposites - Self-cleaning nanocomposites - Metal matrix nanocomposites: Metal with nanoceramic fillers such as SiC, CeO_2_, TiO_2_, ZrO_2_, PTFE, CNTs and their mechanical, corrosion resistance properties and functional applications.

TEXT BOOKS

REFERENCE BOOKS
1. George Odian, Principles of Polymerization, John Wiley & Sons, 1933

**Soft- Core Courses**

**CNST-622: Advanced Nanobiotechnology**

**Unit –I**


**Unit –II**

*Biological Interactions with Materials*


**Unit –III**

*Nanotoxicology*


**Unit –IV**

*Tissue engineering*

Introduction, Stem cells, Morphogenesis, Generation of tissue in the embryo, Tissue homeostasis, Cellular signaling, Extracellular matrix as a biologic scaffold for tissue engineering, Natural polymers in tissue engineering applications, Degradable polymers for tissue engineering, Degradation of bioceramics. Cell source, Cell culture: harvest, selection, expansion, and differentiation, Cell nutrition, Cryobiology, Scaffold design and fabrication, Controlled release strategies in tissue engineering

**Unit –V**
Drug Delivery Systems

TEXT BOOKS

REFERENCE BOOKS


**CNST-623: Surface Engineering for Nanotechnology**

**UNIT-I**

*Introduction to Surfaces*

Surfaces and Interfaces – Importance of Surfaces in Nano Regime – Thermodynamics of surfaces – surface energy – notation of surface structures – surface reconstruction – Surface and interfacial tension and measurement – contact angle and wetting – surfactants, and interfacial forces – Review of Surface Characterization Techniques – optical, topographic, chemical and mechanical properties (XPS, PIXE, RBS, SIMS, LEED, RHEED)

**UNIT-II**

*Processes at Solid Surfaces*


**UNIT-III**

*Role of Surfaces in Bio-nano interactions*

Adhesion and its importance – Adhesion vs cohesion – Work in adhesion and cohesion - Theories on adhesion (Bradley, Hertz, JKR) - Methods of adhesion measurement (Scotch Tape, Peel test, Scratch, Blister, Ultrasonic and acoustic microcavitation methods) – Adhesion measurement in cell (observational, probing and counting techniques) - Surface modification and adhesion - Adhesion of nanoparticles, cells and between nanoparticle & cells - Cancer cell surface interaction.

**UNIT-IV**

*Tribological Aspects of Surfaces*

techniques for friction and wear – Tribometer, Friction Force Microscopy, Nanoindentation and Nanoscratching – Methods to reduce wear and Friction – Fracture – Lubrication – Surface Coatings

UNIT-V
Surfaces in Multidisciplinary Applications

TEXT BOOKS

REFERENCE BOOKS

CNST- 624: Nanomagnetic Materials and Devices

UNIT-I
Magnetism of the solid state
Basics of magnetic materials, magnetic flux, magnetization, magnetic induction, susceptibility and permeability, diamagnetism and diamagnetic susceptibility, Paramagnetism, Curie law and Curie-Weiss law, Pauli paramagnetism,
Ferromagnetism, hysteresis, magnons, domain theory, ferrimagnetism, antiferromagnetism

UNIT-II  
**(9 hrs)**

**Giant magnetoresistance**  
Introduction to spintronics, magnetoresistance in normal metals, MR ratios, Giant magnetoresistance in ferromagnetic multi layers and superlattices, co-operative phenomena and magnetization reversal, applications in spin valve and read heads, comparison of GMR and AMR, oscillation of coupling energy, non-coupling type GMR, CPP and CIP GMR, GMR in nanograins, mechanism of GMR.

UNIT-III  
**(9 hrs)**

**Tunnel magnetoresistance**  
Introduction to tunnel magneto resistance, ferromagnetic tunnel junctions, experiments for TMR, phenomenological theory of TMR, MR ratio and spin polarization, factors influencing TMR, MR ratio for Fe/MgO/Fe system, oscillations in TMR, tunnel junctions with manganites, Heusler alloys, nanoscale graunules, Coulomb blockade in tunnel junctions.

UNIT-IV  
**(9 hrs)**

**Ballistic magnetoresistance and Magnetic nanostructures**  
Ballistic magneto resistance, conductance quantization in quantum confined semiconductors, metals. Anisotropic maneto resistance and applications, magnetism of nanoparticles, nanoclusters, nanowires, hard and soft magnetic materials and their applications, media for extremely high density recording, magnetic sensors, ferro fluids, spinglass- magnetic properties and electronic structure

UNIT-V  
**(9 hrs)**

**Nanobiomagnetism**  
Magnetic targeting, magnetic separation and detection, magnetic tweezers, drug and gene delivery, chemo therapy, MRI, magnetic contrast agents, hyperthermia, application of various nanomagnetic materials in biotechnology, superparamagnetism, core-shell structures and their applications, iron oxide and novel Nanomaterials.

**TEXT BOOKS**

**REFERENCE BOOKS**
1. Magnetism in the solid state, P. Mohn, Springer series in the solid state, sciences,

**CNST- 625: MEMS/NEMS and Microsystems**

**UNIT- I**
**Mechanics and Materials**

**UNIT- II**
**Processing of MEMS/NEMS and Microsystems**

**UNIT- III**
**Interconnects and Bonding**
Interconnects – requirements of interconnects – Metallization Techniques — Damascene process- silicide and refractory metals - Multilevel and nanostructured interconnects – Bonding Techniques. **Packaging and Failure:** Packaging Fundamentals – Packaging Techniques – Electrical and thermal requirements - Packaging Reliability and failure modes and analysis – MEMS process integration- Tribological issues

**UNIT- IV**
**Engineering Mechanics**
Microsystem design – Static bending of thin films – Mechanical vibration– thermomechanics– fracture mechanics – Thermofluidics

**UNIT- V**
**Design and Applications**
Scaling laws in miniaturization – Design considerations – Process and Mechanical design – Finite element method (FEM), Computer aided design CAD – Microsensors and Microactuators– Optical, chemical, thermal, gas, pressure, bio and mechanical sensors – Nanosensors– Applications in automobile, aerospace, health care, industrial, consumer and telecommunications

**TEXT BOOKS**
REFERENCES


REFERENCE BOOKS


CNST- 626: Nanostructured Materials for Clean Energy Systems

UNIT-I
Fundamental Concepts in Energy Systems (9 hrs)
Electrochemical Cell, Faraday’s laws, Electrode Potentials, Thermodynamics of electrochemical cells, Polarization losses in electrochemical cells, Electrode process and kinetics, Electrical double layer, Photoelectrochemical cell, thermoelectric effect.

UNIT-II
Nanomaterials for Energy Conversion Systems (9 hrs)
Issues and Challenges of functional Nanostructured Materials for electrochemical Energy, Conversion Systems, Fuel Cells, Principles and nanomaterials design for; Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC), Current status and future trends.

UNIT-III
Nanomaterials for Photovoltaic Solar Energy Conversion Systems (9 hrs)

UNIT-IV
(9 hrs)
Nanomaterials for Energy Storage (Batteries) Systems

UNIT-V (9 hrs)
Nanomaterials for Energy Storage (Capacitor) Systems

TEXTBOOK

REFERENCE BOOK

CNST - 627: Industrial Nanotechnology

UNIT-I (9 hrs)
Nanotechnology in Electrical and Electronics Industry

UNIT-II (9 hrs)
Nanotechnology in Textiles and Cosmetics

UNIT- III
Nanotechnology in Defence

UNIT- IV
Nanotechnology in Agriculture and Food Technology
Nanotechnology in Agriculture - Precision farming, Smart delivery system – Nanofertilizers: Nanourea and mixed fertilizers, Nanofertigation - Nanopesticides, Nanoseed Science.
Nanotechnology in Food industry – Nanopackaging for enhanced shelf life - Smart/Intelligent packaging - Food processing and food safety and bio-security – Electrochemical sensors for food analysis and contaminant detection.

UNIT-V
Nanotechnology in Environmental and Health Effects
Environmental pollutants in air, water, soil, hazardous and toxic wastes - Application of Nanotechnology in remediation of pollution in Industrial and waste water treatment – Drinking water and Air/Gas purifications - The challenge to occupational health and hygiene, toxicity of nanoparticles, effects of inhaled nanosized particles, skin exposure to nanoparticles, impact of CNTs on respiratory systems, hazards and risks of exposure to nanoparticles, monitoring nanoparticles in work place and sensors.

TEXTBOOK
REFERENCE BOOK

CNST- 620: Fabrication and Characterization Laboratory
- Clean Room: Familiarizing with essential terms, tools and practices.
- Fabrication of thin films by Sputtering, Electron beam and Spray pyrolysis methods.
- Fabrication of TiO$_2$ nanofibers on ITO glass substrate by Electro-spinning technique.
- Synthesis of CNTs by CVD method.
- Nanocrystalline thin film by spin coating.
- Chemical bath deposition by dip coating.
- Electrodeposition of polyaniline on ITO substrate.
- Electroless deposition of Ag or Au on Si substrate
- Band gap determination by diffuse reflectance spectroscopy method.
- Nano indentation on a polycarbonate substrate using AFM for F-D curves and hardness determination.
- Dip-pen lithography using AFM with molecular inks.
- Nano-pattenting by AFM lithography.
- Nanosphere lithography using silica nanospheres.
- Surface topography of a sputtered Au using AFM / STM.
- Electrical resistivity measurement by Four probe method.
- Polymer membrane electrolyte preparation and its porosity, electrolyte uptake and ionic conductivity measurements.
- Determination of thermal expansion of nano-ceramic material by dilatometer.
- Film thickness measurement by ellipsometer.

CNST- 628: Research Project (Report and Viva-Voce)

Students are required to carry out a research project related to Nanoscience and Nanotechnology. Each student is assigned with a supervisor from among the faculty members of the Centre of NST of Pondicherry University and submit a project report.