

# PROGRAM STRUCTURE

## Nanotechnology Teacher's Training Program

### Module 1: Fundamentals of Nanotechnology

- **Historical Aspects of Nanotechnology:** Pre-18<sup>th</sup> , 19<sup>th</sup> , 20<sup>th</sup> & 21<sup>st</sup> Century
- **What are Nano & Nanometer:** Nano, The Nanometer
- **Nanoscience & Nanotechnology:** Definitions & Components: Nanoscience, Nanotechnology
- **Modern Aspects of Nanotechnology:** Academics, Publications, Research, Product Development
- **How will Nanotechnology Affect Us:** The future of Medicine, The future of Sports, The future of Food, The future of the Military, The future of the Environment, The future of Cars.

### Module 2: Nanotechnology in Various Sectors

- **Nanotechnology in Agriculture/Food:** Controlled Environment Agriculture, Precision Farming, Nano Techniques in Agriculture, Nanosensors on Crops and Nanoparticles in Fertilizers, Nanotechnology for Food and the Packaging Industry, Nanotechnology in Veterinary Medicine,
- **Nanotechnology in Electronics:** Nano-Electronics, Silicon Nanotechnology, Carbon Nanotubes Electronics, Nano Emissive Displays, Quantum Dots, Nanochips, Nanowire, Emergence of Electronic Nano Computers, The Future of Nanoelectronics
- **Nanotechnology in Textile:** Nanotechnology in Fibers, Nanotechnology in Woven and Knitted Fabrics, Nanotechnology in Dyeing Process, Nanotechnology in Finishing Process, Fashion Fabrics and Garments, Nanotechnology in Textile Industry
- **Nanotechnology in Construction:** Nanomaterials in Construction, Coatings, Fire Protection
- **Nanotechnology in Energy:** Conventional Sources, Non-conventional Sources, Satellite Cloaking, Additional Applications of Nanotechnology in Medicine & Pharmaceuticals: Nanotechnology in Pharmaceuticals, Nanomedicine and Diagnostics, Drug Delivery, Cancer, Repairing Clogged Blood Vessels Using Nanobumps, Artificial RBCs Providing Oxygen, Artificial Mitochondria, Nanotechnology to Treat Heart Disease.
- **Nanotechnology in Automobiles:** Fuels, Frames, Body Paints and Coatings, Tyres, Emissions, Shock Absorbers, Coolants, Spark Plugs, Scratch Free Window Screens, Vehicle light, Engines and Power Train, Lubrication, Suspension Systems.
- **Nanotechnology in Environment:** Nanotechnology and Pollution Control, Possible Applications of Nanotechnology to Environmental Issues, Nanotechnology in Remediation and Treatment, Nanotechnology in Pollution Sensing and Detection.
- **Nanotechnology in Sports:** Golf Club, Tennis, Badminton, Swimming, Sports Shoes, Sports Clothes.

- **Nanotechnology in Chemicals and Paints:** Nanomaterials, Solar Cells, LCD Screen, Fuel Additives, More Efficient Fuel Cells, High Storage Capacity Batteries, Quantum Dot Magic in Chemical Industries, Nanowax, Nano Sunscreen, New Nano Materials, Nanotechnology in Pigments/Paint.

### **Module 3: Introduction to Nanoscale [Physics, Chemistry, Biotechnology]**

#### **Introduction to Nanoscale Physics**

##### **Resume of Structure, Binding, Lattice, Dynamics & Thermal Properties:**

- **Lattice Structure:** Crystal structure, face centered cubic nanoparticles, tetrahedrally bonded semiconductor structures.
- Binding in Solids, Elastic constants, Lattice vibrations, Normal modes, Density of states, Thermal expansion.
- **Energy Band Theory:** Insulator, Semiconductor and Conductor, Reciprocal space, Energy bands and gaps of semiconductor, Effective masses, Fermi surface, Review of electrons in a periodic potential, nearly free electron model, tight binding method.
- **Transport Theory:** Localized Particles: Acceptors and Deep traps, Mobility, Excitons.
- Electronic transport from classical kinetic theory, calculation of relaxation time in metals, Thermal conductivity of metals and insulators, Hall effect and magnetoresistance.
- **Dielectric & Magnetic properties of materials:** Polarization mechanisms, Dielectric functions from oscillator strength, Clausius Mosotti relation, Piezo, Pyro and Ferro electricity, Basics of ferromagnetism in materials.
- **Foundations of Nanomaterials:** Historical aspects of nanomaterials, Effects of Nanoscience and Nanotechnology on various fields, Classifications of Nanostructured materials.
- **Types of various Nanostructured materials:** Sculptured thin films, Quantum heterostructures, Dendrimers, Nanoshells, Nanocages, Nanoflowers, Nanofoams, Nanofibers, Nanomesh, Nanotubes, and Fullerenes.
- **Properties of Nanostructures materials:** Size and shape dependent properties, color, melting point, magnetism, density of states, conductivity and band gap, metal to insulator transition.
- **Basic Quantum Mechanics:** Overview of time dependent & time independent Schrodinger wave equations, Bohr Exciton Radius, Particle in a box applications ( 1D, 2D & 3D), Step Potential, Barrier penetration, Quantum Confinement.
- **Quantum Nanostructure:** Single electron tunneling, Quantum dots, Quantum Wires, Quantum Wells, Spectroscopy of quantum dots

### Introduction to Nanoscale Chemistry:

- **Building Blocks of Nanotechnology:** Covalent architecture, coordinated architecture, Weakly bound aggregates, Interactions and topology.
- **Chemical Properties:** The Effect of nanoscale materials on chemical reactivity, Effect of nanostructures on mass transport, Metal nanocrystallites, Supported on oxides, Supported nanoscale catalysts, The effect of chemistry on nanostructures, Modification of nanoparticles, Langmuir Bolodgett Film Self assembled surface films, Binding of molecules on solid substrate surface Molecular coupling components (Linkers), Molecular distance component (Spacers), Single molecular nanostructures, Strategies of molecular construction, Synthetic supramolecules.

### Introduction to Nanoscale Biotechnology:

- **Introduction to cell structure and the machinery of the cell:** Level of organization in living systems, Cell components and functions, Machinery of the cell: Sugars as energy source, Fatty acids as structure, Nucleotides ( DNA, ATP) as information storage and chemical energy carrier, Amino acids as protein maker.
- **Computational Nanobiotechnology:** Biological Nanocapsules: Alginate capsule, Carbon Nanocapsules, Konjac glucomannan-chitosan Nanocapsules, Polyelectrolyte Nanocapsules.
- **Applications of Nanobiotechnology:** Diagnostic, Drug delivery, Tissue engineering.

### **Module 4: Nanomaterials -Concepts & Fundamentals**

- **Introduction to Nanomaterials:** Historical background, Lessons learnt from nature, The future.
- **Classification of Nanomaterials:** Introduction, Nature of origin
- **Properties of Nanomaterials:** Quantum size effects, Anomalous crystal structure, Physical properties of nanomaterials, Anomalous phase transition, Thermal properties of nanomaterials, Charge and quantum transport in nanomaterials, Electrical Properties of Fullerenes, Optical Properties of Fullerenes, Chemical Reactivity of the Nanomaterials.
- **Applications of Nanomaterials:** Molecular Electronics, Molecular switches, Carbon nanotubes field effect transistor, Electron Field Emission Cathodes, Solar cells and Photovoltaic devices, Quantum well devices, quantum well lasers, Heterojunction Bipolar Transistor, Photonic crystals, Nanomaterials in Biology.
- **Health Hazards of Nanomaterials:** Parameters determining toxicity, Uptake of nanomaterials and harmful effects.

### **Module 5: Carbon Based Nanomaterials & Properties of Individual Nanoparticles**

- **Carbon Molecule:** Types of Carbon Materials, Bonding in Carbon Compounds
- **Fullerene:** Discovery of 60 C, Structure of C 60, Buckyball: Boron buckyball, Variations in buckyball, Carbon Nanotubes: Single Walled Carbon Nanotube, Multi Walled Carbon Nanotube, Properties of Carbon Nanotubes, Production Techniques for Carbon Nanotubes, Applications of Carbon Nanotubes: Sensors and probes, Field emission, Flat panel displays, Fuel cells, Catalytic support.
- **Nanodevices:** Nano diamond, Single electron transistor, Molecular machine, Nanorobots, Nano biometrics, Quantum dot, Nanocapsule.
- **Overview of Properties:** Electrical property, magnetic property, optical property, chemical property, mechanical property, biological property, vibrational property.
- **Metal Nanoparticles:** Nanoparticles, magnetic properties, Structural Magic numbers, Theoretical modeling of nanoparticle, Geometric structure, Electronic structure, Reactivity, Fluctuations magnetic clusters, Balle Nanostructure materials.
- **Semiconducting Nanoparticles:** Electrical properties, Optical properties, Photofragmentation, Coulomb Explosion.
- **Rare Gas & Molecular Clusters:** Inert gas clusters, Superfluid clusters, Molecular clusters.

## Module 6: Fabrication Techniques of Nanomaterials

- **Types of Top- Down Fabrication Methods:**
  - **Top Down Mechanical Energy Fabrication Methods:** Ball milling, Rolling/beating, Mechanical machining, Atomization.
  - **Top- Down Thermal Fabrication Methods:** Annealing, Electrospinning, Evaporation, Thermolysis-pyrolysis.
  - **Top Down High Energy and Particle Fabrication:** Arc Discharge, Laser ablation, RF sputtering, DC sputtering, Electron beam evaporation, Reactive ion etching, Pyrolysis.
  - **Top Down Lithographic Fabrication Methods:** Photolithography, X-ray Lithography, Electron Beam Lithography, Focused Ion Beam Lithography, Nano-Imprint Lithography, Nanosphere Lithography, 2- Photon Polymerization
- **Types of Bottom up Fabrication Methods:**
  - **Bottom up Gas Phase Fabrication Methods:** Chemical vapor deposition, Atomic layer deposition, Molecular beam epitaxy, Ion implantation, Gas phase condensation
  - **Nonbiological Bottom up Liquid Phase Fabrication Methods:** Molecular self assembly, Electrodeposition, Nucleation and sol-gel processes, Chemical bath deposition, Template synthesis.
  - **Bottom Up Lithographic Fabrication Methods:** Nanolithography-Dip pen methods

## Module 7: Characterization Techniques of Nanomaterials

- **Structure Determination Techniques:** Crystallography, Particle size determination, Surface structure.
- **Microscopy Techniques:** Scanning electron microscope, Transmission electron microscope, Scanning probe microscope, Atomic force microscope, Field ion microscope, Confocal microscope, Magnetic force microscope, Chemical force microscope,
- **Spectroscopic Techniques:** Infrared and Raman spectroscopy, X-ray spectroscopy, Optical and Vibrational spectroscopy Magnetic resonance, Luminescence, Mass spectrometry
- **Gel Electrophoresis:** Separation, Visualization, Applications.
- **Thermal Analysis:** Thermogravimetric analysis, Differential scanning Calorimetry.
- **Nanomanipulation and Nanolithography:** Template Fabrication, Nano-Electromechanical Systems, Catalytic Technology, Why Manipulation of Nano Materials Required, Manipulation of Nano Materials by Dielectrophoresis
- **Nano Computation:** Faceted Melt/Crystal Interfaces, Nano-materials Design for High-TC Ferromagnetism, Computer Simulation for the Interaction of Nano-materials, Multiscale Nano-computation for Solidification Phenomena.
- **Molecular Nanomechanics:** Molecular Dynamics (MD), Nanomechanics of CNT Bridging Scale Method, Nanomechanical Biosensors, Nanomechanics of Adhesion Proteins, Nanotribology and Nanomechanics, Nanomechanics in Natural Fibers.