

# PROGRAM STRUCTURE

## Nanoelectronics and Its Industrial Applications Program

This structure combines flexibility with integration of the separate components right from the fundamental level to the high-end applications thereby providing a holistic view of the whole gamut of Nanotechnology in electronic industries.

### Module 1: Fundamentals of Nanotechnology

- **Historical Aspects of Nanotechnology:** Pre-18th Century, 19th Century, 20th Century, 21st Century
- **What are Nano & Nanometer:** Nanodimension, The Nanometer
- **Nanoscience & Nanotechnology:** Definitions & Components: Nanoscience, Nanotechnology

### Module 2: 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 Nanotube based field effect transistors, Electron Field Emission Cathodes, Solar cells and Photovoltaic devices, Quantum well devices, Quantum well lasers, Heterojunctions Bipolar Transistor, Photonic crystals, Nanomaterials in Biology.
- **Health Hazards of Nanomaterials:** Parameters determining toxicity, Uptake of nanomaterials and harmful effects.

### Module 3: Nanostructures: Concepts & Fundamentals

- **Zero Dimensional Nanostructures:** Nanoparticles
- **One Dimensional Nanostructured:** Nano-rods
- **Two Dimensional Nanostructures:** Thin Films
- **Some Other Nanostructures:**
  - Quantum Heterostructures

- Nanofabrics
- Nanocapsules
- Dendrimers
- Nanoshells
- Nanocages
- Nanoflowers
- Nanofoams
- Nanofibers
- Nanomesh
- Nanotubes
- Fullerenes

- **Nanocomposites**

#### **Module 4: Semiconductor Nanostructures & Nanomaterials**

- **Introduction**
- **Importance of Semiconductor Nanomaterials in Electronic Industry**
- **Various Silicon Nanostructures**
  - Silicon Nanowires
  - Silicon Quantum Dots
  - Carbon Nanotubes
  - Carbon Quantum Dots

#### **Module 5: Carbon Nanotubes- Technology & Applications**

- **Introduction:** Introduction of Carbon Nanotubes
- **Technology and Applications:** Types of carbon nanotubes , Chemistry and physics of carbon nanotube, Properties of carbon nanotubes , Industry wise applications of carbon nanotubes, Synthesis/production of carbon nanotubes, Characterization tools for carbon nanotubes, CNT Technology development in India and World
- **Patents and Scientific Literatures :** Patents, Scientific literature
- **Support for CNT Research and Challenges:** Worldwide, Indian context, Environmental, health and safety issues
- **Industries Involved in the Production of CNTs:** List of companies involved in the Production of Carbon Nanotubes.

#### **Module 6: Nano Scale Synthesis & Fabrication**

- **Epitaxial Growth:** Set-ups of MBE, Analyzing Techniques , Examples of Epitaxial Film with Growth Mechanism, Electronic Properties of Epitaxial Materials , Future Directions
- **Self-Assembly :** Principles of Self-Assembly, Self-Assembly of Nano Metals, Self-Assembly of Compounds, Efficiency of Self-Assembly, Applications
- **Top Down And Bottom Up Approach:** High-Energy Ball Milling as Top down Approach, Bottom-Up Approach, Examples of System Using Bottom-Up Approach
- **Hybrid Techniques And Materials :** Nanoparticles as Radiosensitizers for Cancer Therapy, Techniques, Materials, Applications

### Module 7: Nano Scale Characterization & Manipulation

- **Nanomaterials Characterization:** Transmission Electron Microscope (TEM) , Scanning Electron Microscope (SEM), X-ray Diffraction (XRD) , Atomic Force Microscopy (AFM), Investigation of the Surface Charge Nanomaterials by Zeta-Potential, Thermal Stability by Thermogravimetric Analysis (TA) and Differential Scanning Calorimetry (DSC), Nano Tensile Tests, Dynamic Mechanical Analysis (DMA), Structural Characterisation of Nanomaterials, Scanning Tunneling Microscope (STM)
- **Molecular Nanomechanics :** Molecular Dynamics (MD) , Nanomechanics of CNT, Bridging Scale Method , Nanomechanical Biosensors, Nanomechanics of Adhesion Proteins , Nanotribology and Nanomechanics, Nanomechanics in Natural Fibers
- **Nanomanipulation and Nanolithography:** Template Fabrication , Micro Electromechanical Systems (MEMS), Nano-Electromechanical Systems (NEMS), 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

### Module 8: Nanoelectronics: Present & Future Aspects

- **Electronic Market**
- **Introduction and Importance of Quantum Mechanics**
- **Present state of Nano-Electronics**
- **Single-Molecule Electronics:** Molecular electronics, Molecular logic gate, Molecular wires

- **Solid State**
  - Nanoelectronics:** Nanocircuitry, Nanolithography, Nanosensors
- **Silicon Nanotechnology :** CMOS Nanotechnology, Ballistic Properties, Memory
- **Carbon Nanotubes Electronics:** Carbon Nanotube Transistors
- **Nano Emissive Display Devices**
- **Quantum Dots**
- **Nano chips**
- **Use Electron Beam to Unravel the Secrets of an 'Atomic Switch'**
- **Nano wire:** Growing Glowing Nan wires to Light up the Nanoworld
- **Emergence of Electronic Nano Computers**
- **Notable Achievements in Nano Electronics**
  - Fabrication of a Self-Assembled Molecular Electronic Circuit Array
  - Quantum Dot Cell and wireless Electronic Computing
  - Fabrication and Testing of Quantum Corrals
  - Construction and Demonstration of the Nanomanipulator
  - Printing of Nanostructures Using Self-Assembling
  - Molecular Monolayers
  - Formation of the ULTRA Electronics Research Programme
  - Fabricating Hybrid Nanoelectronic- Microelectronic Logic
  - Room-Temperature Manipulation of Individual Molecules
  - Arrays of Micro-STMs and Micro-AFMs
- **Nano Electro Mechanical System (NEMS)**
- **Future of Nanoelectronics**

## **Module 9: Electronic Consumer Products Manufactured using Nanotechnology**

- **Computer Hardware**
  - Flash Memory Chip
  - Processors
  - Hard Disk Drive
  - Cellular Memory cards
  - Wireless Laser Mouse
  - Laser Travel Mouse
  - Wireless Keyboard
  - iPod memory chips
  - Conductive inks use in printed electronics
  - Random access memory chip
  - Anti -bacterial coating of keyboard, skins of Laptop
  - Cooling fan of Laptops
  - Cartridge for inkjet and laser printers
- **Display:**
  - Transparent Conductive Films

- OLED screens in Mobiles
- Television Displays
- **Mobile Devices and Communications:**
  - iPhones
  - Mobile Memory cards
  - Mobile flat panel displays
  - Anti-germs, antibacterial and anti-mold mobile phone
  - Cell Battery
- **Audio:**
  - Hearing Aid
  - Guitar Strings
  - iPod
  - Car stereo displays
- **Camera and Films:**
  - Camera Lenses
  - Mobile Phone image sensors
  - Photo Paper