

# Syllabus on Nanomaterials

## **Abstract**

This course will take an in-depth look at nanomaterials used in nanoelectronics. Theory and concepts of nanomaterials will be covered, including the chemistry and physics of nanomaterials. The course will also focus on major classes of nanomaterials, including carbon nanotubes, nanostructured materials, nanowires, nanoparticles, nanoclays, and other nanomaterials. Applications of nanomaterials to technology areas in nanoelectronics will also be discussed.

## **Content**

### 1. Current trends in nanoelectronics

The course will cover the materials for:

- Deep-submicron and nanometer CMOS IC (under 50  $\mu\text{m}$ );
- HEMT ( high electron mobility transistor);
- Devices on carbon nanotubes and graphene;
- Resonant tunnelling devices and circuits;
- Single electron transistors;
- Spintronics;
- Quantum electronics;
- Bioelectronics and molecular electronic devices.

### 2. Materials for deep-submicron and nanometer CMOS IC:

- Materials for the substrate – tight Si;
- Alternative materials for the gate insulator: high K gate insulators;
- Gate electrode materials ( n+ polysilicon, mid-gap, metals);
- SOI;
- Double-Gate Transistor Structures and Multi-Gate Transistor Structures.

### 3. Materials for HEMT:

- Heterostructures on A<sub>3</sub>B<sub>5</sub> (GaAs/ AlGaAs, InGaAs/InAlAs etc.).

### 4. Materials for devices on carbon nanotubes and graphene:

- CNT – Carbon nanotubes – physical characteristics.
- CNT devices: CNT Transistor, CNT –Based Field Emission Devices, Junctions, Heterojunctions and Quantum Confined Structures Based on Carbon Nanotubes, Microwave Devices Based on Carbon Nanotubes, CNT Based Electrical Sensors;
- Graphene.

### 5. Materials for resonant tunnelling devices:

- Structures of resonant tunnelling devices and circuits: AlAs/GaAs/AlAs, AlSb/InAs/AlSb.

### 6. Materials for single electron transistors:

- Single Electron Transistors structure and materials: Si, GaAS.

### 7. Spintronics:

- Physical principles and materials for spintronic devices;

- Spintronic structures: Spin Valves, Spin Pumps, Spin Diodes, Spin Transistors, Spin Based Optoelectronics Devices, Spintronic Computation.

8. Quantum electronics:

- Quantum electronic devices (QED) – physical principles and materials;
- Short-Channel MOS Transistor, Split-Gate Transistor, Electron-Wave Transistor, Electron-Spin Transistor, Quantum Cellular Automata (QCA).

9. Materials for bioelectronics and molecular electronic devices:

- Characterisation of molecular systems: electrical properties of molecules;
- Molecular electronic devices, polymer electronics, self-assembling circuits, optical molecular memories;
- Molecular processor, DNA analyzer as biochip.