COURSE ID SHEET

Course No.	5302	NTUA

Semester:	10	Core		Elective		Specialization	X

Title: **NANOMATERIALS AND NANOTECHNOLOGY**

Aim:

This course aims to introduce the basic principles associated with nanoscience and nanotechnology including the fabrication and synthesis, size dependent properties, characterization, and applications of materials at nanometer length scales with an emphasis on recent technological breakthroughs in the field. using advanced methods and techniques. Special attention is given to students' laboratory training specifically on nanomaterials synthesis taking into consideration contemporary applications, as well as social impact.

Content:

- **NANOSCALE PHENOMENA**: Super-molecular Assembly – The principle: Atom transfer from a surface – Tunneling – Intramolecular Forces – Surfaces – Interfaces – Self-assembly and surface reconstruction.
- **CLASSIFICATION OF NANOMATERIALS**: Nano-, Micro- and Meso-porous Materials – Organic-Inorganic Hybrid Materials – Carbon Nanomaterials (fullerenes and derivatives, Carbon Nanotubes and their products, Graphene Oxides and their products, nanofibers) – Dendrimers – 3-D Nanomaterials, Nanohybrid materials – Nanocomposites – Natural Nanomaterials - Nanoparticles – Nanowires- Nanotubes – Thin Films.
- **PROCESSING AND SYNTHESIS TECHNIQUES FOR THE PREPARATION OF NANOMATERIALS**: Top down and bottom-up approaches. Solution – Gelation Technique (Sol-Gel process). Microprocess Techniques: Lithography, Engrave and Substrate Removal, Substrate Binding – Chemical Vapor Deposition Techniques (CVD): Plasma Technique, Dry plasma etching, Molecular Beam Epitaxy, Hydrothermal and Solubilization Techniques, Microwave synthesis, Patterns or Template assisted methods – Electrophoresis – Electrochemical Deposition – Methods for generating pattern of colloidal dispersions, Centrifugation, Electrospinning.
- **CHARACTERIZATION OF NANOMATERIALS**: Microscopy – SEM (Scanning Electron Microscopy) – TEM (Transmission Electron Microscopy) - SPM (Scanning Probe Microscopy) / STM (Scanning Tunneling Microscopy). STM Method as a tool for Nanolithography, Parameters that influence engraving – Nano-lithographic methods based on Scanning Probe Microscopes –AFM (Atomic Force Microscopy) – Surface Forces Methods – SFA/AFM Method – MFM (Magnetic Force Microscopy) – AES (Auger Electron Spectroscopy-AES) – EELS (Electron Energy Loss Spectroscopy) – EDX (Energy Dispersive X-Ray Spectroscopy) – XPS (X-Ray Photoelectron Spectroscopy) –Raman Spectroscopy.
- **NANOMATERIALS PROPERTIES**: Properties as a function of size – Mechanical/Tribological Properties – Electric, Magnetic, Thermal and Optical Properties.
- **MEMS/NEMS (MICRO AND NANO ELECTRO-MECHANICAL SYSTEMS) AND THEIR APPLICATIONS**: (microflow devices, biomedical nanodevices, environment and nanomaterials, materials and nanodevices, data storage devices etc.).
- **SOCIAL IMPACT AND MORAL ASPECTS OF NANOTECHNOLOGY**.
- **LABORATORY EXERCISES**:

- Synthesis of Carbon Nanotubes via chemical vapor deposition technique and determination of their structure and properties (horizontal CVD system).
- Synthesis of Carbon Nanotubes via chemical vapor deposition technique and determination of their structure and properties (vertical CVD system).
- Synthesis of chemically modified TiO_2 nanoparticles via sol-gel technique. Study of photo-induced properties (photocatalysis and self-cleaning).
- Characterization of TiO_2 nanoparticles (Dynamic Light Scattering Method - DLS, micro-Raman Spectroscopy).
- Study of photo induced cell toxicity of TiO_2 nanoparticles.
- Synthesis of ZSM-5 zeolite.
- Characterization of ZSM-5 zeolite.
- Synthesis of superabsorbent polymer networks in the nanoscale.
- Characterization of superabsorbent polymer networks in the nanoscale.
- Sol-Gel Technique - $Si(OCH_2CH_3)_4$ hydrolysis and study of the produced SiO_2 xerogels.
- Synthesis of ZnO nanostructures using hydrothermal method.

Hours per semester:

LECTURES	**24**	EXERCISES	**85**	LABORA-TORY	**16**	HOME-WORK	**50**	**TOTAL HOURS: 175**

Student performance/ evaluation:

The evaluation of the students will be done through:

- A Final (written) Examination **(FE)**.
- Assigned Projects **(AP)**.
- Laboratory Exercises **(LE)**.

The Final Grade results as follows: Final Grade = 0.6x(FE) + 0.1x(AP) + 0.3x(LE)