MSE-361 Nanomaterials

Credit Hours: 2-0

Pre-requisites: Nil

Course Description

In this course, students will study the behavior of materials at the nanoscale. This multi-disciplinary course integrates principles of physics, chemistry, biology, and engineering to achieve special properties. Emerging applications of nanomaterials will also be discussed.

Course Contents

- Overview of Nanostructures and Nanomaterials; Bottom up and Bottom Down approaches; Surface Energy concept; Chemical potential of surface; different types of stabilizations.
- Nanostructures:
    - Zero Dimensional nanomaterials: Nanoparticles, Quantum Dots,
    - One-Dimensional nano-materials: Nanowires nano-rods, carbon nanotubes,
    - Two-Dimensional nanomaterials: Thin films and monolayers,
    - Carbon-based nanomaterials: Carbon nanotubes, Graphene, Nanostructured carbon.
- Synthesis of Nanomaterials.
- Applications of nanostructures: Reinforcement in Ceramics, Drug delivery, Giant magneto- resistance, etc. Cells response to nanostructures.
- Overview of characterization of nanostructures and nanomaterials (Introduction to Scanning Tunneling microscope and its various types e.g. atomic force microscopy; Piezo-force microscopy; Magnetic force microscopy etc. Introduction to Raman spectroscopy and its use in materials science).
- Surfaces and interfaces in nanostructures. Ceramic interfaces, Superhydrophobic surfaces, Grain boundaries in Nano-crystalline materials, Defects associated with interfaces.

Weekly Plan

Week	Topics
1	Overview of Nanostructures and Nanomaterials; Bottom up and Bottom Down approaches
2	Surface Energy concept; Chemical potential of surface; different types of stabilizations
3	Nanostructures:

4	o Zero Dimensional nanomaterials: Nanoparticles, Quantum Dots, o One-Dimensional nano-materials: Nanowires nano-rods, carbon nanotubes, o Two-Dimensional nanomaterials: Thin films and monolayers, o Carbon-based nanomaterials: Carbon nanotubes, Graphene, Nanostructured carbon
5	Synthesis of Nanomaterials.
6	
7	Applications of nanostructures: Reinforcement in Ceramics, Drug delivery, Giant magneto- resistance, etc. Cells response to nanostructures
8	
9	**Mid-Semester Exams**
10	Overview of characterization of nanostructures and nanomaterials (Introduction to Scanning Tunneling microscope and its various types e.g. atomic force microscopy; Piezo-force microscopy; Magnetic force microscopy etc. Introduction to Raman spectroscopy and its use in materials science)
11	
12	
13	
14	Surfaces and interfaces in nanostructures. Ceramic interfaces, Superhydrophobic surfaces
15	
16	Grain boundaries in Nano-crystalline materials, Defects associated with interfaces.
17-18	**End Semester Exams**

Course Outcome

At the end of the course, students will be able to:

- Apply the basic theories of surface energy to understand the stabilization mechanisms of nanoparticles.
- Examine the synthesis, properties, characterization, and utilization of 0-, 1- and 2-D materials.
- Choose the appropriate processing and characterization technique for a given scenario.
- Design solutions for common problems related to nano materials.

Suggested Books

- Nanomaterials: The original product of nanotechnology by M. Benelmekki. IOP Science (2019)
- Nanostructures and Nanomaterials: Synthesis properties and applications by G. Cao, Y. Wang. 2nd ed. World Scientific (2011).
- Nanoscale Science and Technology edited by R. W. Kelsall, I. W. Hamely, M. Geoghegan. Wiley, (2005)