MSE4178: NANOSTRUCTURES AND NANOTECHNOLOGY

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Nanostructures and Nanotechnology

Subject Code
MSE - Materials Science and Engineering
Course Number
4178

Academic Unit
Materials Science and Engineering (MSE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
AP4178 Nanostructures and Nanotechnology

Exclusive Courses
Nil

Part II Course Details

Abstract

This course will enable students to develop a fundamental understanding of the current concepts in the field of nanoscience and nanotechnology, and provide them with state-of-the-art knowledge on the fabrication, properties, and applications of selected advanced functional materials.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Demonstrate the capacity for self-directed learning on a broad range of topics related to nanoscience and nanotechnology.		x		
2	Describe the potential and be able to select the proper fabrication and characterization techniques for selected classes of nanomaterials, functional materials and devices.			x	
3	Apply the above knowledge to explicit functional nanomaterials in selected applications, such as optoelectronics, photovoltaics, energy and biotechnology fields.			x	
4	Describe and analyse most recent developments in nanoscience and nanotechnology through special topics which may vary from year to year.				x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture and tutorials	Explain key concepts and engage in inquiry	1, 2, 3, 4	3 hrs/wk
2	Tutorial assignments	Demonstrate the capability of analysis and critical thinking	1, 2, 3, 4	1 hr/wk
3	Lab work	Produce creative solutions to real-life problems	2, 3	3 hrs/wk

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Active class participation	2, 3, 4	5	
2	Discussion at tutorial	1, 2	5	
3	Quiz and homework essay	1, 2, 3, 4	10	
4	Two Lab reports	2, 3	10	

Continuous Assessment (%)
30

Examination (%)
70

Examination Duration (Hours)
2

Additional Information for ATs
For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained

Assessment Rubrics (AR)

Assessment Task
1. Discussion at tutorial

Criterion
CAPACITY for SELF-DIRECTED LEARNING to understand the principles

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
2. Quiz

Criterion
ABILITY to EXPLAIN methodologies

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
3. Homework essay

Criterion
ABILITY to GENERATE new concepts

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
4. Lab report

Criterion
ACCOMPLISHMENT to PRODUCE creative solutions

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task

5. Final examination

Criterion

ALL including 1 to 3

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

1. Introduction to nanomaterials & nanotechnology: Nano in nature; history of nanotechnologies; nano-size effects; overview of nanomaterials applications.

2. Electronic properties of solids including bulk materials and nanomaterials. Basic concepts of Quantum Mechanics. Quantum confined crystals.

3. Types of nanomaterials: perovskite nanoparticles, semiconductor nanocrystals, metal nanoparticles, carbon-based nanostructures.

4. Synthesis /Preparation of nanomaterials: hot-injection, ligand-assisted reprecipitation, solvothermal, chemical vapour deposition, physical vapour deposition, molecular beam epitaxy, etc. Patterning and assembly of nanomaterials.

5. Characterization methods of nanomaterials: microscopy (scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM), optical microscopy, including confocal, polarized, luminescent, etc), spectroscopy (energy dispersive x-ray spectroscopy (EDX), cathodoluminescence (CL), electron energy loss spectroscopy (EELS), X-ray and Ultraviolet Photoemission Spectroscopy (XPS & UPS), Optical Spectroscopy, including Raman spectroscopy, Photoluminescence (PL), Fourier-transform Infrared (FTIR)), X-ray diffraction (XRD), computer tomography (CT), etc.

6. Properties of nanomaterials: energy level structure, optical properties, electrical properties, catalytic properties.

7. Applications: biomedical applications, energy-related applications, lighting and displays.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Guozhong Cao, “Nanostructures & Nanomaterials: synthesis, properties and applications”, Imperial College Press (2004).

2	(Ed.) Zhong Lin Wang, “Nanowires and nanobelts : materials, properties and devices”, Kluwer Academic Publishers (2003).
3	Geoffrey A Ozin and André C Arsenault, “Nanochemistry: A Chemical Approach to Nanomaterials”, Royal Society of Chemistry (2005).
4	Mildred S Dresselhaus, Gene Dresselhaus & Phaedon Avouris (eds.), “Carbon nanotubes: synthesis, structure, properties, and applications, Springer (2001).