MSE4179: ADVANCED MATERIALS CHARACTERIZATION AND ITS INDUSTRIAL APPLICATIONS

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Advanced Materials Characterization and its Industrial Applications

Subject Code
MSE - Materials Science and Engineering
Course Number
4179

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
MSE3171 Materials Characterization Techniques

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

The course "Advanced Materials Characterization Techniques" aims at the physical principles and quantitative analysis of imaging, diffraction and spectroscopy of photon (synchrotron X-Ray), electron and neutron, and their applications in a wide range of industrial sections, e.g. semiconductor, energy materials, chemical engineering, construction, information technology (IT) and aerospace. In terms of the spatial resolution, energy resolution, time resolution, detection sensitivity and efficiency, the various characterization techniques in the advanced instrumentation facilities such as synchrotron radiation X-ray source, spallation neutron source and aberration-corrected electron microscopes are compared to show their advantages and disadvantages on accessing the information, e.g. crystallographic structure, atomic position, electronic structure, spin texture, elemental distribution, magnetic properties, chemical bonding and dynamical evolution. This knowledge guides the students to choose the suitable characterization techniques to investigate the targeted structure of materials and understand its structure-property relationship in the industrial applications.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Recognize the characteristics of photon, electron and neutron provided by advanced instrumentation facilities such as synchrotron radiation X-ray source, spallation neutron source and aberration-corrected electron microscopes, respectively.			x	
2	Recognize the imaging theory of high-resolution transmission electron microscopy (TEM) and scanning TEM and the relevant industrial applications.			x	
3	Recognize the physical principles and quantitative analysis of spectroscopic techniques in synchrotron X-Ray and analytic electron microscopy and the relevant industrial applications.			x	
4	Recognize the physical principles of neutron diffraction and the relevant industrial applications.			x	
5	Recognize the various types of ultrafast characterization techniques in synchrotron X-Ray and analytic electron microscopy, and be able to relate them to structural dynamics of materials in industrial applications.			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	Lectures	Describe the physical principles and quantitative analysis of imaging, diffraction and spectroscopy of synchrotron X- Ray, electron and neutron, and their relevant industrial applications in materials characterization, e.g. crystallographic structure, atomic position, electronic structure, spin texture, elemental distribution, magnetic properties, chemical bonding and dynamical evolution.	1, 2, 3, 4, 5	3 hrs/ wk
2	Tutorial	Explanation of homework related to fundamental knowledge; interpretation of data analysis in the various techniques in the relevant industrial applications.	1, 2, 3, 4, 5	1 hr/ wk
3	Laboratory	Demonstration of three important materials characterization techniques.	2, 3, 5	3 hrs/wk

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Homework	1, 2, 3, 4, 5	10	
2	Midterm tests	1, 2, 3, 4, 5	30	
3	Lab Reports	1, 2, 3, 4, 5	10	

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

1.Homework, Midterm exam

Criterion
Achievements in CILO

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching the marginal leave

Assessment Task
2. Lab reports

Criterion
Achievements in CILO

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching the marginal leave

Assessment Task
3. Final exam

Criterion
Achievements in CILO

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching the marginal leave

Part III Other Information

Keyword Syllabus

- Characteristics of photon, electron and neutron
- Imaging theory of electron microscopy and the relevant industrial applications
- X-ray/Electron Spectroscopy and the relevant industrial applications
- Neutron diffraction and the relevant industrial applications
- Ultrafast imaging and spectroscopy by X-ray and Electron and the relevant industrial applications

Reading List

Compulsory Readings

	Title
1	Lecture Notes

Additional Readings

	Title
1	D. B. Williams, C. B. Carter, 2009, Transmission Electron Microscopy A Textbook for Materials Science, Second Edition.
2	J. Stohr, H. C. Siegmann, 2006, Magnetism From Fundamentals to Nanoscale Dynamics.
3	Yu. A. Izyumov, V. E. Naish, R. P. Ozerov,1991, Neutron Diffraction of Magnetic Materials.
4	L.Reimer H. Kohl, 2008, Transmission Electron Microscopy: physics of image formation, Fifth Edition.