

MSE4179: ADVANCED MATERIALS CHARACTERIZATION

Effective Term

Semester A 2023/24

Part I Course Overview

Course Title

Advanced Materials Characterization

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

Fundamental Physics, mathematics (Fourier Transformation and Calculus)
MSE3171 Materials Characterization Techniques

Precursors

Fundamental Physics, mathematics (Fourier Transformation and Calculus)

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 materials characterization, e.g. crystallographic structure, atomic position, electronic structure, spin texture, elemental distribution, magnetic properties, chemical bonding and dynamical evolution. 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. This knowledge guides the students to choose the suitable characterization techniques to investigate the targeted structure of materials and understand its structure-property relationship.

Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if DEC-A1 DEC-A2 DEC-A3 app.)		
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			x
3	Recognize the physical principles and quantitative analysis of spectroscopic techniques in synchrotron X-Ray and analytic electron microscopy			x
4	Recognize the physical principles of neutron diffraction and its applications in materials science			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.			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.

Teaching and Learning Activities (TLAs)

TLAs		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 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 homeworks related to fundamental knowledge; interpretation of data analysis in the various techniques	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	Homeworks	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. Homeworks, 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
- X-ray/Electron Spectroscopy
- Neutron diffraction
- Ultrafast imaging and spectroscopy by X-ray and Electron

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.