MSE3171: MATERIALS CHARACTERIZATION

Effective Term

Semester A 2024/25

Part I Course Overview

Course Title

Materials Characterization

Subject Code

MSE - Materials Science and Engineering

Course Number

3171

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

AP2102/MSE2102 Introduction to Materials Engineering

Equivalent Courses

AP3171 Materials Characterization Techniques
/MNE3127 Electron Microscopy

Exclusive Courses

Nil

Part II Course Details

Abstract

Materials characterization techniques are used in quality and assurance programs, i.e., processes of verification, quality management and contamination reduction. These include the integral parts of the material production and processes for development of new materials. Therefore, characterization techniques and production/development processes are equally important. This course aims to provide the foundation of knowledge about working principles and key concepts in modern instrumentation for materials characterization and their applications to engineering and scientific problems appearing at production and development of materials, nanomaterials, solid state devices and nanodevices. This knowledge guides the students to select suitable analysis techniques to identify the problems in above processes, to recognize the product quality and/or feedback the analysis data to the material processing.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the characteristics of analytical instruments for advanced materials, such as their sensitivities, spectral resolution, spatial resolution, depth of analysis, etc.		x		
2	Compare and contrast the various types of materials characterization techniques, and be able to relate them to the principles of fundamental physics and chemistry.		x		
3	Apply advanced analytical techniques to the characterization of different materials and nanomaterials under various analysis conditions.		x	x	x
4	Analyze, interpret and mutually correlate data to arrive at meaningful conclusions.				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	Students will engage in lecture activities about working principles and key concepts in modern instrumentation for materials characterization.	1, 2, 3, 4	3hrs/week

2	Tutorials	Students will take short qiuzzes related to fundamental knowledge; interpretation of data analysis, such as determination of chemical and phase composition, crystal structure.	1, 2, 3, 4	1hr/week
3	Laboratory	Students will engage in the demonstration of three important materials characterization techniques.	1, 2, 3, 4	3hrs/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Quizzes & Assignments	1, 2, 3, 4	15	
2	Midterm test	1, 2, 3, 4	20	
3	Three Lab reports	1, 2, 3, 4	15	

Continuous Assessment (%)

50

Examination (%)

50

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. Quizzes, midterm test

Criterion

Achievements in CILOs

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. Lab reports

Criterion
Achievements in CILOs

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. Examination

Criterion
Achievements in CILOs

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

- A general classification and overview of different analytical techniques

- Optical microscopy
- Scanning electron microscopy (SEM); Energy dispersive X-ray spectroscopy (EDS); Wave dispersive spectroscopy (WDS); Cathodoluminescence (CL)
- Transmission electron spectroscopy (TEM); High resolution TEM (HRTEM); Selected area diffraction (SAD)
- Crystallography and diffraction. Real and reciprocal space.
- X-ray diffraction (XRD)
- Photospectroscopy
- Nuclear magnetic resonance spectroscopy (NMR)
- Auger electron spectroscopy (AES); Scanning Auger spectroscopy (SAM); X-ray photoelectron spectroscopy (XPS)
- Secondary ion mass spectrometry (SIMS)

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	David B. Williams, C. Barry Carter, Transmission Electron Microscopy A Textbook for Materials Science, 2009.
2	Myeongkyu Lee, X-Ray Diffraction for Materials Research from Fundamentals to Applications, 2016.
3	Anwar Ul-Hamid, A Beginners’ Guide to Scanning Electron Microscopy, 2018.
4	Ludwig Reimer, Scanning Electron Microscopy Physics of Image Formation and Microanalysis, 1998.
5	Bert Voigtländer, Scanning Probe Microscopy Atomic Force Microscopy and Scanning Tunneling Microscopy, 2015.
6	Brent Fultz, James Howe, Transmission Electron Microscopy and Diffractometry of Materials, 2012.
7	Mark Ladd, Crystal Structures in Stereoview, Horwood publishing, Chichester 1999.
8	M Grasserbauer and H W Werner (Editors), Analysis of Microelectronic Materials and Devices, Willey Chichester 1991.
9	Douglas A Skoog, James J Holler, Timothy A Nieman, Principle of Instrumental Analysis, Sanders College Publishing, Philadelphia 1998.
10	Hobart H Willard, lynne L Merritt, Jr, John A Dean, Frank A Settle, Jr, Instrumental Methods of Analysis 7th Edit., Wadsworth Pub Comp, Belmont, California, 1988.
11	J F Watts, J Wolstenholme, An introduction to surface analysis by XPS and AES, J Willey, New York 2003.
12	D Briggs, Surface Analysis of Polymers by XPS and Static SIMS, Cambridge University Press, Cambridge 1998.
13	P E J Flewit and R K Wild, Physical Methods for Materials Characterization, Institute of Phys Publising Bristol 1994.
14	D Briggs and M P Seah (Eds), Practical Surface Analysis, Willey, Chichester 1990.
15	D J O'Connor, B A Sexton, R St C Smart (Eds), Surface Analysis Methods in Materials Science, Springer -Verlag Berlin c2003.
16	Lee E Fitzpatric (Ed), Characterization of Organic Thin Films, Boston, Butterworth-Heinemann, Boston 1995.
17	David J Whitehouse, Hanbook of Suface Metrology, Institute of Phys. Publ. Bristol 1994.
18	John B Wachtman, Z H Kalman, Characterization of Materials, Butterworth-Heinemann, Boston 1993.
19	G Fizgerald, B E Storey, D Fabian, and P Osborne (Eds), Quantitative Microbeam Analysis, Proceeding Scottich University Summer School in Physics, Instit of Phys Pub Bristol 1993.
20	R Howland, and L Benatar, A Practical Guide to Scanning Microscopy, Park Scientific Instrument 1993-1997.