MSE3171: MATERIALS CHARACTERIZATION

Effective Term
Semester B 2023/24

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

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. They are integral parts of the material production and processes for

development of novel materials. Therefore, characterization techniques and production/development processes are equally important. This course aims at the foundation of knowledge in modern methodologies of 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	Recognize the characteristics of analytical instruments for advanced materials, such as their sensitivities, spectral resolution, spatial resolution, depth of analysis, etc.		x		
2	Recognize the various types of materials characterization techniques, and be able to relate them to the principles of fundamental physics and chemistry.		x		
3	Select advanced analytical techniques and apply them to 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.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Explain key concepts, such as the foundation of knowledge in modern methodologies of materials characterization and their applications	1, 2, 3, 4	3hrs/wk

2	Tutorials	Quizzes related to fundamental knowledge; interpretation of data analysis, such as determination of chemical and phase composition, crystal structure	1, 2, 3, 4	1hr/wk
3	Laboratory	Demonstration of three important materials characterization techniques	1, 2, 3, 4	3hrs/wk

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

- General classification analytical techniques and major limitations. Guidance for their choice.
- Scanning electron microscopy (SEM). Environmental SEM. Energy dispersive x-ray spectroscopy (EDS). Wave dispersive spectroscopy (WDS) Cathodoluminescence (CL).
- Crystallography and diffraction. Real and reciprocal space.

- Transmission electron spectroscopy (TEM). Bright and dark field imaging. High resolution TEM (HRTEM). Selected area diffraction (SAD).
- Analytical techniques associated with TEM
  Electron energy loss spectroscopy (EELS). Energy dispersive x-ray spectroscopy integrated (EDS) in TEM.
- Auger electron spectroscopy (AES). Scanning Auger spectroscopy (SAM). X-ray photoelectron spectroscopy (XPS). Ultraviolet photoelectron spectroscopy (UPS).
- Mass spectrometry. Secondary ion mass spectrometry (SIMS).
- Rutherford backscattering spectroscopy (RBS). Elastic recoil detection analysis (ERDA). Proton induced x-ray emission (PIXE).
- Surface profiling. Scanning probe microscopy (SPM). Atomic force microscopy (AFM). Scanning tunnelling microscopy (STM).

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.