MNE3127: ELECTRON MICROSCOPY

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Electron Microscopy

Subject Code
MNE - Mechanical Engineering
Course Number
3127

Academic Unit
Mechanical Engineering (MNE)

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
MSE3171 Materials Characterization

Exclusive Courses
Nil

Part II Course Details

Abstract
This course introduces the theoretical and practical aspects of electron-beam microanalysis based on modern electron microscopy techniques, including Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and X-

Ray Energy Dispersive Spectroscopy (XEDS). The lectures cover vacuum system and instrumentations, basic electron optics, electron-beam and specimen interactions, electron diffraction, image formation and interpretation, generation of X-rays, qualitative X-ray microanalysis. The theoretical understanding gained by students will help them understand and interpret experimental data as well as perform electron microscopy experiments. Hands-on experience is also emphasized, which includes sample preparation techniques and use electron microscope(s).

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Present the fundamentals of electron optics, electron-beam and specimen interactions.		x		
2	Describe the applications of scanning/ transmission electron microscopy and spectroscopy (techniques SEM/TEM/XEDS).			x	
3	Explain the SEM/TEM/XEDS principles and the basic instrumentation and hardware.			x	
4	Apply SEM/TEM/XEDS for imaging and spectroscopy analysis.				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	Lectures will introduce the basic theories and applications of electron microscopes.	1, 2, 3	3 hrs for 13 weeks
2	Laboratory Work	Lab projects will help students to develop the skills for SEM/TEM/XEDS microanalysis.	3, 4	3 hrs for 2 weeks

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Tests and Assessments	1, 2, 3	20	One mid-term test
2	Laboratory Reports	3, 4	40	4 reports to be submitted

Continuous Assessment (%)
60

Examination (%)

40

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Assessment Rubrics (AR)

Assessment Task

Tests and Assignments

Criterion

Ability to understand the basic theories, instrument design principles, and applications of electron microscopy and spectroscopy

Excellent (A+, A, A-)

Strong evidence of:
- Understanding the fundamental theories of microanalysis and their applications in microstructural characterization
- Capability to analyse and interpret electron images

Good (B+, B, B-)

Some evidence of:
- Understanding the fundamental theories of microanalysis and their applications in microstructural characterization
- Capability to analyse and interpret electron images

Fair (C+, C, C-)

- Moderate ability to understand the fundamental theories
- Moderate explanation of instrument design principle

Marginal (D)

Basic familiarity with the instrument design principles of electron microscopy

Failure (F)

Not even reaching marginal levels

Assessment Task

Laboratory Reports

Criterion

Demonstration of the theoretical understanding gained from lectures to interpret experimental data and perform the SEM (and hopefully TEM) experiments

Excellent (A+, A, A-)

Strong evidence of:
- Extensive knowledge of SEM/TEM imaging process and interpretation
- Capability to analyse and interpret electron images

Good (B+, B, B-)

Some evidence of:
- Extensive knowledge of TEM/TEM imaging process and interpretation

· Capability to analyse and interpret electron images

Fair (C+, C, C-)

· Moderate ability to understand the instrument design principle
· Moderate capability to analyse electron images

Marginal (D)

Sufficient familiarity with the electron imaging process and interpretation

Failure (F)

Not even reaching marginal levels

Assessment Task

Examination

Criterion

Ability to explain the electron microscopy (SEM/TEM) principles and the basic theories of X-Ray Energy Dispersive Spectroscopy (XEDS), as well as their applications for microanalysis

Excellent (A+, A, A-)

Strong evidence of:
· Understanding the fundamental theories of electron-based microanalysis
· Original thinking of microstructural characterization for various materials

Good (B+, B, B-)

Some evidence of:
· Understanding the fundamental theories of electron-based microanalysis
· Original thinking of microstructural characterization for various materials

Fair (C+, C, C-)

· Moderate ability to understand the fundamental theories of microanalysis
· Moderate understanding of microstructural characterization

Marginal (D)

Basic ability to understand the fundamental theories of microanalysis and their applications in microstructural characterization

Failure (F)

Not even reaching marginal levels

Additional Information for AR

Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus

· This course covers theory and applications of electron microscopy techniques with an emphasis on scanning/transmission electron microscopy (SEM/TEM). Topics include modern electron microscope and instrumentation, electron optics, electron beam-specimen interactions, imaging formation and interpretation, electron diffraction, generation of X-rays, and X-ray microanalysis (energy dispersive spectroscopy, EDS).

- The laboratory involves both online and hands-on training. The online laboratory will take advantage of MyScope (https://myscope.training/# (https://myscope.training/)) and the hands-on laboratory will use the department's SEM (JEOL JSM-5600, FEI Quanta 250). The students are expected to gain the knowledge and ability necessary to prepare the samples, operate the instruments and analyse data independently.

Reading List

Compulsory Readings

	Title
1	J. Goldstein et al., "Scanning Electron Microscopy and X-Ray Microanalysis" Springer (3rd edition).
2	D.B. Willams and C.B. Carter, "Transmission Electron Microscopy: A Textbook for Materials Science" Springer (2nd edition).

Additional Readings

	Title
1	P.J. Goodhew, J. Humphreys and R. Beanland, "Electron Microscopy and Analysis" Taylor & Francis Group (3rd edition).