



COURSE DESCRIPTION CARD - SYLLABUS

Course name

MODERN SCANNING ELECTRON MICROSCOPY TECHNIQUES FOR MATERIALS CHARACTERIZATION [S5IMAT>NTSME]

Course

Proposed by Discipline

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Year/Semester

2/4

Level of study

Doctoral School

Course offered in

English

Form of study

full-time

Requirements

elective

Number of hours

Lecture

4

Laboratory classes

0

Other

0

Tutorials

0

Projects/seminars

0

Number of credit points

1,00

Coordinators

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Lecturers

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Prerequisites

Basic knowledge of chemistry, physics, and materials science. Logical thinking and the ability to use information obtained from library and Internet resources. Understanding the need for continuous learning and acquiring new knowledge.

Course objective

1. To introduce doctoral students to the principles of operation of scanning electron microscopy and its application in the advanced characterisation of materials at the micro- and nanoscale. 2. To introduce modern imaging and analytical techniques for the characterisation of the chemical composition, structure, and physical and mechanical properties of materials using scanning electron microscopy and complementary analytical methods. 3. To develop the ability to select appropriate research methods for material characterisation, as well as to analyse and interpret the obtained results in the context of addressing research problems.

Course-related learning outcomes

Knowledge

After completing the course, the doctoral student knows and understands:

1. Recent advances and current research trends in the use of scanning electron microscopy and complementary techniques for the characterisation of materials at the micro- and nanoscale. [P8S_WG / SzD_W01, SzD_W02]
2. The principles underlying selected electron microscopy and complementary analytical techniques and their application to the investigation of material morphology, composition, structure, and properties. [P8S_WG / SzD_W03]

Skills

After completing the course, the doctoral student is able to:

1. Determine which microscopy and analytical approaches are suitable for a particular material or research question, taking into account the type of information required and the characteristics of the investigated sample. [P8S_UW / SzD_U01]
2. Analyse and interpret experimental data obtained using scanning electron microscopy and complementary characterisation techniques in order to assess the morphology, composition, structure, and selected physical or mechanical properties of materials. [P8S_UW / SzD_U01, SzD_U02]

Social Competences

After completing the course, the doctoral student:

1. Is able to critically evaluate scientific literature concerning the application of advanced microscopy and analytical techniques in materials research, taking into account the capabilities and limitations of the methods used. [P8S_KK / SzD_K01]
2. Recognises the importance of selecting reliable and appropriate characterisation methods in scientific research and is able to relate modern materials characterisation approaches to the objectives and scope of their own research. [P8S_KK / SzD_K01, SzD_K02]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Written test: 50–59% = 3.0; 60–69% = 3.5; 70–79% = 4.0; 80–89% = 4.5; 90–100% = 5.0.

Programme content

The course introduces modern scanning electron microscopy (SEM) as a versatile tool for imaging and characterising materials at the micro- and nanoscale. It covers the basic principles of electron–matter interactions, SEM imaging techniques, and the analysis of surface morphology and microstructure. Further topics include analytical methods for determining chemical and phase composition. Selected complementary methods for characterising physical, mechanical, and tribological properties are also discussed. The course focuses on the selection, application, and interpretation of SEM-based techniques in the characterisation of a range of materials and research problems.

Course topics

1. Fundamentals of modern scanning electron microscopy and its role in advanced materials characterisation.
2. Electron beam–sample interactions and their application in obtaining structural and analytical information.
3. Advanced SEM imaging techniques for the characterisation of material morphology, microstructure, defects, and interfaces.
4. Analytical techniques integrated with SEM for chemical composition and elemental distribution analysis.
5. Electron backscatter diffraction and the characterisation of crystallographic structure, phase composition, and crystallographic orientation.
6. Complementary spectroscopic techniques for advanced materials characterisation.
7. Micro- and nanoscale investigation of mechanical and tribological properties in combination with SEM imaging.

Teaching methods

Lecture: multimedia presentation including illustrations, examples, and selected research case studies.

Bibliography

Basic literature

1. Goldstein, J. I., Newbury, D. E., Michael, J. R., Ritchie, N. W. M., Scott, J. H. J., Joy, D. C. et al., Scanning Electron Microscopy and X-Ray Microanalysis, 4th ed., Springer, 2018.
2. Sekiguchi, T., Sato, K. (eds.), Advanced Scanning Electron Microscopy for Material Characterization, Springer, 2026.

Additional literature

1. Brodusch, N., Demers, H., Gauvin, R., Field Emission Scanning Electron Microscopy: New Perspectives for Materials Characterization, Springer, 2018.
2. Pérez Campos, R., Contreras Cuevas, A., Esparza Muñoz, R. (eds.), Materials Characterization, Springer, 2015.
3. Selected articles from Microscopy and Microanalysis, Oxford University Press, published for the Microscopy Society of America.

Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,00
Classes requiring direct contact with the teacher	4	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	21	1,00