Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Practical Electron Microscopy	
Course name in Polish:	Mikroskopia elektronowa w praktyce	
Number of hours:	30	
Type of course:	Elective course	
Form of course:	mixed forms (combination of lecture, seminar and laboratory)	
Code of course:		
Course leader:	*Dr hab. inż. Andrzej Żak*	
Faculty of the course leader:	W3 Faculty of Chemistry	
Email address of the course leader:	andrzej.zak@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, electrical engineering and space technologies	☒
	Information and communication technology	☐
	Biomedical engineering	☒
	Chemical engineering	☒
	Civil engineering, geodesy and transport	☒
	Materials engineering	☒
	Mechanical engineering	☒
	Environmental engineering, mining, and energy	☒
	Mathematics	☐
	Chemical sciences	☒
	Physical sciences	☒
	Management and quality studies	☐

2. Objectives

C1 Acquainting the theoretical foundations of transmission and scanning electron microscopy
C2 Acquainting the methods of sample preparation for transmission and scanning electron microscopy
C3 Acquainting the available range of electron microscopy techniques and their applications
C4 Basic practical training in the use of electron microscopes
C5 Enabling the use of electron microscopy methods in PhD students research

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes

1	Lecture - electron microscopy - introduction, review of applications	2	lecture
2	Lecture - preparation of samples for transmission electron microscopy	2	lecture
3	Workshop - preparation of samples for transmission electron microscopy	2	laboratory
4	Lecture - structure and operation of the transmission electron microscope	2	lecture
5	Workshop - operation of the transmission electron microscope, part 1	2	laboratory
6	Lecture - methods of electron diffraction and chemical analysis	2	lecture
7	Workshop - operation of the transmission electron microscope, part 2	2	laboratory
8	Workshop - performing and calculating electron diffractograms	2	laboratory
9	Lecture - preparation of samples for scanning electron microscopy	2	lecture
10	Workshop - preparation of samples for scanning electron microscopy	2	laboratory
11	Lecture - structure and operation of a scanning electron microscope	2	lecture
12	Workshop - operation of the scanning electron microscope	2	laboratory
13	Lecture - cryogenic methods (cryoEM) and 3D imaging	2	lecture
14	Lecture - in-situ, magnetic, liquid and phase electron microscopy	2	lecture
15	Seminar, discussion	2	seminar

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

1. Basic knowledge of solid state physics and chemistry
2. Basic knowledge of research techniques in the field of light and electron microscopy

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	Learning outcome	
	KNOWLEDGE. Doctoral student knows and understands:	
SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☐
SzD_W4	research methodology;	☒
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☐

SzD_W6	the fundamental dilemmas of modern civilization;	☐
SzD_W7	the legal and ethical conditions of scientific activity;	☐
SzD_W8	the economic and other relevant conditions of scientific activity;	☐
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☐
	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☒
SzD_U4	disseminate research results, including in popular forms;	☐
SzD_U5	initiate debates and participate in a scientific discourse;	☐
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☐
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☐
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☐
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☐
	SOCIAL COMPETENCES. Doctoral student is ready to:	
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☐
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☒

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Knowledge outcomes - colloquium in the remote formula, skills outcomes - report on classes, participation in the discussion, social competences outcomes – participation in the disscusion

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

N1. Stationary or remote lecture with the use of multimedia presentation and film materials;
N2. Remote access to additional film materials for self-familiarization before practical classes.
N3. Practical classes in the field of self-preparation of samples and microscopic observations.

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

PRIMARY LITERATURE:

[1] David B. Williams, C. Barry Carter, Transmission Electron Microscopy, Springer, https://doi.org/10.1007/978-0-387-76501-3;
[2] Andrews, Kenneth William, Dyson, David John, Keown, Samuel Robert, Interpretation of Electron Diffraction Patterns, Springer, 1967;
[3] Anwar Ul-Hamid, A Beginners' Guide to Scanning Electron Microscopy, Springer, 2018;

SECONDARY LITERATURE:

[4] Annie Cavalier, Daniele Spehner, Bruno M. Humbel, Handbook of Cryo-Preparation Methods for Electron Microscopy, CRC Press

[5] Joachim Frank, Electron Tomography. Methods for Three-Dimensional Visualization of Structures in the Cell, Springer 2006

9. Other remarks

Additional remarks, comments, (e.g., language of the course)

Language - English