UAB
Universitat Autònoma de Barcelona

Microscopy Lab and Material Characterisation Techniques (year-long)

Code: 103307
ECTS Credits: 6

2024/2025

Degree	Type	Year
2501922 Nanoscience and Nanotechnology	OB	2

Contact

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

NONE

Objectives and Contextualisation

Objectives:

- Introduction to electronic microscopy and SPM
- Theoretical foundations and description of the technical equipment in SEM, TEM, STM and AFM microscopes.
- Analysis of surface morphology and microstructure, at the atomic scale, of different materials using microscopes.
- Fundamentals of the crystallographic structure of different materials. Introduction to structural analysis through X-ray diffraction.
- Introduction to the concepts of ideal surfaces and real surfaces. Surface treatments and their applications.
- Introduction to vacuum technology and its application in nanotechnologies

Competences

- Adapt to new situations.
- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Be ethically committed.
- Communicate orally and in writing in one's own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Handle the standard instruments and materials of physical, chemical and biological testing laboratories for the study and analysis of phenomena on a nanoscale.

- Interpret the data obtained by means of experimental measures, including the use of computer tools, identify and understand their meanings in relation to appropriate chemical, physical or biological theories.
- Lead and coordinate work groups.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Operate with a certain degree of autonomy.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Show motivation for quality.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Learning Outcomes

1. Adapt to new situations.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Apply the concepts related with microscopy techniques to characterise materials, devices and systems on a nanoscale.
4. Be ethically committed.
5. Characterise crystalline surfaces by AFM/STM with atomic resolution
6. Communicate orally and in writing in one's own language.
7. Correctly handle the materials and products used to prepare samples.
8. Correctly use microscopy techniques to recognise surfaces, materials, nanomaterials, devices and microorganisms in studies in the field of nanoscience and nanotechnology
9. Critically evaluate experimental results and deduce their meaning.
10. Describe the concepts related with microscopy techniques.
11. Determine crystalline planes using TEM
12. Distinguish the different microscopy techniques (optical, SEM, TEM and local probe microscopies), describing their operation, applications and limitations.
13. Draft reports on the subject in English.
14. Follow correct protocols for preparing samples
15. Follow correctly the safety protocols for laboratories with ambient controlled and white rooms.
16. Functionalise surfaces and characterise them using microscopy techniques
17. Handle the different instruments related with microscopy techniques.
18. Identify the microscopy technique used by means of sample images.
19. Identify the situations in which the different methodologies studied can help to resolve problematic situations and know how to select the best techniques.
20. Interpret and rationalise the results obtained from diffraction studies.
21. Interpret and rationalise the results obtained from studies using different microscopy techniques.
22. Lead and coordinate work groups.
23. Learn autonomously.
24. Manage the organisation and planning of tasks.
25. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
26. Operate with a certain degree of autonomy.
27. Perform bibliographic searches for scientific documents.
28. Perform studies to characterise different samples by means of microscopy techniques
29. Prepare samples for study with microscopy techniques.

30. Propose creative ideas and solutions.
31. Reason in a critical manner
32. Recognise the correct terms for topics related to methodologies and experimentation in nanoscience and nanotechnology.
33. Recognise the physical basics of optical microscopy, electronic microscopy and local probe microscopy.
34. Resolve problems and make decisions.
35. Resolve problems with the help of the provided complementary bibliography.
36. Show motivation for quality.
37. Understand texts and bibliographies in English on each of the techniques, methodologies, tools and instruments in the subject area.
38. Use computer tools for the development, manipulation and automation of instrumentation and control systems.
39. Use suitable software for each microscopy technique to obtain optimum experimental results
40. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Content

- Atomic Force Microscopy. AFM.
Theory. Introduction to the foundations of the AFM microscope. Modes of work, lateral and vertical resolution, convolution concept. Advantages and limitations.
Observation of surfaces of different materials, study of topography, roughness, defects, ordering.

- Scanning Tunneling Microscopy - STM.
Theory: Introduction of the tunnel effect. Piezoelectric Materials. Foundations of STM microscopy. Modes of work, advantages and limitations.
Analysis and interpretation of surface images obtained with graphite, gold and molybdenum disulfide samples.

- Electronic Microscopy. SEM / TEM.
Theory. Introduction to electron microscopies. Applications in the field of materials science and nanotechnology. Visit to the microscopy service of UAB.
Virtual Practice. Virtual practice Analysis of the surface microstructure of different materials using SEM/TEM microscopes. Interpretation of the data.

- Surfaces and surface treatments.
Theory: Introduction to the concepts of ideal surface, functionalization, surface treatments. Concepts of wettability, hydrophobicity and hydrophilicity.
Physical and chemical treatments of various surfaces, observation and discussion of the effects of the treatment on the wettability of the surfaces.

- Vacuum technology.
Theory: Definition of vacuum and its applications. Concepts of kinetic theory of gases, residual gases, Mean Free path, formation time of a monolayer, pumping rate, conductance.
Online practice: Videos and exercices about the use and familiarization with an experimental laboratory of medium vacuum set-up

- X-ray diffraction.
Theory: introduction to crystallography. Reticular theory. Crystalline structures. Miller index. Geometry Bragg-Brentano. X-ray diffraction.
Acquisition of monocrystalline diffraction spectra. Analysis of the data. Determination of cell parameters, indexation of peaks.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem solving	6	0.24	2, 9, 19, 20, 21, 23, 26, 27, 31, 34, 35, 38, 39
Resarch work on laboratory techniques	40	1.6	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 28, 29, 30, 31, 32, 34, 36, 37, 38, 39, 40
Theory lectures	21	0.84	10, 12, 32, 33, 37
tutorized learning	8	0.32	2, 3, 6, 9, 10, 12, 21, 23, 24, 25, 26, 27, 31, 32, 33, 34, 37
Type: Autonomous			
Bibliography research	2	0.08	23, 27, 36, 37
Individual and autonomous Study	16	0.64	20, 21, 23, 24, 25, 26, 27, 30, 31, 32, 34, 35, 36, 37
Practice report redaction	28	1.12	2, 6, 9, 10, 13, 20, 21, 27, 30, 36, 37, 40
Practice guides lectures	22	0.88	14, 15, 24, 32
Problem solving	4	0.16	3, 9, 18, 20, 21, 23, 26, 27, 31, 34, 35

During the 2024/25 academic year, this subject will have an different functioning, because the subject goes from 2nd year to 3rd year in the new curricular plan.

During the 2024/25 academic year, the subject will be developed as follows:

The student will have at their disposal, through the Virtual Campus, a series of material to acquire the knowledge and skills necessary to achieve the objectives of the course. This material will be complemented with face-to-face tutorials with the teacher in charge to be agreed between the two parties.

Repeat students will be able to save the practices of the previous year and take only the theoretical evaluation.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Electron Microscopy Report	5	0	0	2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 18, 19, 21, 22, 23, 24, 25, 26, 29, 31, 33, 36, 39, 40
Exam	25	3	0.12	2, 3, 9, 10, 12, 18, 20, 21, 25, 31, 33
Oral test	20	0	0	2, 3, 5, 6, 8, 9, 10, 12, 14, 15, 16, 18, 19, 20, 21, 26, 28, 29, 30, 31, 33, 36
SPM (AFM &STM)	20	0	0	1, 2, 3, 5, 6, 7, 8, 10, 12, 14, 17, 18, 21, 22, 23, 24, 25, 26, 27, 28,

reports				29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40
Surface Treatments report	10	0	0	1, 2, 4, 6, 7, 9, 14, 15, 16, 22, 23, 24, 25, 26, 30, 31, 32, 36, 37, 38, 40
Vacuum technology test	5	0	0	1, 2, 4, 6, 9, 15, 22, 24, 25, 31, 32, 34, 35, 36, 37, 40
XRD Carine solved problems	10	0	0	2, 4, 6, 9, 19, 20, 23, 24, 25, 26, 31, 32, 34, 35, 36, 37, 40
XRD report	5	0	0	2, 4, 6, 7, 9, 11, 14, 20, 22, 24, 25, 26, 27, 31, 32, 34, 35, 36, 37, 40

The competences of this subject will be evaluated through different ways, each one with a certain weight in the final grade.

- Theoretical exam: a test will be carried out with a total weight of 25% of the final grade, with a minimum grade of 3.5 to pass the subject. Students will have a second chance to pass this minimum, and therefore be able to pass the subject, with a recovery exam.

- oral exam: an individual session will be held for each student to evaluate the knowledge acquired, mandatory and which will have a total weight of 20% of the final grade.

- Deliveries (reports, problems). During the 2024/25 academic year, due to the change in the curriculum of the nano degree (this subject changes to 3rd academic year of the plan), these deliveries may consist of research work carried out by students on different characterization techniques. In the case of repeating students, this part can be validated with similar activities from the previous year.

Note that before some of the proposed activities the student will have to complete an individual and mandatory test. Failure to do so on time will mean a penalty of 0.5 out of 10 points for the corresponding activity. In some cases, it will be proposed to carry out complementary activities prior to the delivery of the practice report.

To pass the course you must have a final grade equal to or greater than 5, as long as you have obtained a minimum of 3.5 on the theoretical exam.

Bibliography

Bibliografia (llibres virtuals disponible a la biblioteca)

A User's Guide to Vacuum Technology

First published:20 June 2003

Print ISBN:9780471270522 |Online ISBN:9780471467168 |DOI:10.1002/0471467162

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Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Second Edition

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Software

Carine Crystallography. Data analysis software (Matlab, Excel or similar).

Language list

Information on the teaching languages can be checked on the CONTENTS section of the guide.