Universitat Autònoma de Barcelona

2019/2020

Microscopy Lab and Material Characterisation Techniques (year-long)

Code: 103307
ECTS Credits: 6

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OB	2	A

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Martí Gibert Roca
Aitor Lopeandía Fernández

External teachers

Ignasi Mata

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 ones 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.
- Perform correct evaluations of the environmental and socioeconomic impact of chemicals and nanomaterials.
- 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 ones 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. Recognise the risks for the environment associated to the manipulation of chemical and material compounds in general.
35. Resolve problems and make decisions.
36. Resolve problems with the help of the provided complementary bibliography.
37. Show motivation for quality.
38. Understand texts and bibliographies in English on each of the techniques, methodologies, tools and instruments in the subject area.
39. Use computer tools for the development, manipulation and automation of instrumentation and control systems.
40. Use suitable software for each microscopy technique to obtain optimum experimental results
41. 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.
Practice. 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.
Practice. Use of a teaching STM Equipment. 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.
Practice. Virtual practice Analysis of the surface microstructure of different materials using SEM 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.
Practice. 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.

Practice: 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.
Virtual practice. Use of the CaRIne Crystallography Program for the study of crystalline structures and obtaining of powder diffraction diagrams. Crystallochemical analysis of structures (link distances, coordination number, etc.). Use of the PDF database (Powder Diffraction File), of the ICDD (International Center for Diffraction Data) for the identification of phases
Practice real. Use of a teaching diffractometer set-up. Acquisition of monocrystalline diffraction spectra. Analysis of the data. Determination of cell parameters, indexation of peaks.

Methodology

The content is divided into 21h of theory, 6 hours of classroom problems and 40 hours of practice in the laboratory.
In the theoretical part, the physicochemical concepts that will be used in the different experimental ectivities will be introduced. Exercises sessions will allow a better understanding of the theoretical phenomena involved, as well as to teach treatment of data and correct interpretation. The practical sessions will be held in groups. Students will find in the moodle classroom the lecturing sessions pdf, the distribution by groups and the calendar of practices, the guides of the practices, as well as the instructions for the reports. Students are required to work on this preparatory material, and complementary material (articles, videos, etc.) previously to the practice sessions.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practice laboratory	40	1.6	1, 3, 2, 23, 9, 5, 38, 6, 37, 11, 16, 24, 18, 19, 21, 20, 22, 7, 17, 4, 25, 29, 30, 31, 28, 32, 13, 35, 14, 15, 41, 8, 39, 40
Problem solving	6	0.24	2, 23, 9, 27, 19, 21, 20, 26, 31, 36, 35, 39, 40
Theory lectures	21	0.84	38, 10, 12, 33, 32
tutorized learning	8	0.32	3, 2, 23, 9, 38, 6, 10, 12, 27, 24, 21, 25, 26, 31, 33, 32, 35
Type: Autonomous			
Bibliography research	2	0.08	23, 38, 37, 27
Individual and autonomous Study	16	0.64	23, 38, 37, 27, 24, 21, 20, 25, 26, 30, 31, 32, 36, 35
Practice report redaction	28	1.12	2, 9, 38, 6, 37, 10, 27, 21, 20, 30, 13, 41
Practice guides lectures	22	0.88	24, 32, 14, 15
Problem solving	4	0.16	3, 23, 9, 27, 18, 21, 20, 26, 31, 36, 35

Assessment

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

- Theoretical examinations: two written tests will be carried out, before and after the practices, with a total weight of 30% of the final mark, which will allow to evaluate the theoretical concepts studied throughout the course. The minimum mark of the theoretical tests to pass the subject will be 3.5.

- A delivery of problems: on the virtual practice of using the software CARINE with a weight of 10%.

- Delivery of 6 Reports of practices: the reports of the practices realized in group, with a weight for each report of 10% will be evaluated.

- To emphasize that prior to each session, the teacher will do a brief oral test about the theoretical content seen in the classroom and on the guideline of the practice, of compulsory pre-reading, in order to make sure that students have Successfully prepared the session. The NO passing of this test can mean a penalty with respect to the final mark or the NO practice with the corresponding qualification of the same with a zero.

- Attendance to practice labs is mandatory. There is no recovery session for the practical activities.

- Assistance to virtual practice (CARINE) in the computer room is mandatory

- Attendance at the theory and problem classes is highly recommended, as there will be a test of knowledge in one of the final sessions.

To pass the course, it is necessary to have a final mark equal to or greater than 5, provided that a minimum of 3.5 has been obtained in the theoretical tests. In the case that a mark equal to or greater than 3.5 is not obtained in the theoretical tests, you will be entitled to a proof of theoretical recovery that will count for 50% of the final mark of theory, that is to say, 30% of the mark overall of the course.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Electron Microscopy Practice Report	10	0	0	3, 2, 23, 9, 6, 37, 10, 11, 12, 24, 18, 19, 21, 22, 4, 25, 26, 29, 31, 33, 13, 41, 8, 40
Exam	30	3	0.12	3, 2, 9, 10, 12, 18, 21, 20, 25, 31, 33
SPM (AFM &STM) Practice reports	20	0	0	1, 3, 2, 23, 5, 38, 6, 37, 10, 12, 27, 24, 18, 21, 22, 7, 17, 25, 26, 29, 30, 31, 28, 33, 32, 36, 14, 41, 8, 39, 40
SurfaceTreatments Practice report	10	0	0	1, 2, 23, 9, 38, 6, 37, 16, 24, 22, 7, 4, 25, 26, 30, 31, 34, 32, 14, 15, 41, 39
Vacuum Practice Report	10	0	0	1, 2, 9, 38, 6, 37, 24, 22, 4, 25, 31, 32, 36, 35, 15, 41
XRD Carine solved problems	10	0	0	2, 23, 9, 38, 6, 37, 24, 19, 20, 4, 25, 26, 31, 32, 36, 35, 41
XRD Practice report	10	0	0	2, 9, 38, 6, 37, 11, 27, 24, 20, 22, 7, 4, 25, 26, 31, 32, 36, 35, 14, 41

Bibliography

- Materials characterization: introduction to microscopic and spectroscopic methods / Yang Leng

Llibre en línia | John Wiley & Sons | 2008

- X-Ray Diffraction Crystallography : Introduction, Examples and Solved Problems / by Yoshio Waseda, Eiichiro Matsubara, Kozo Shinoda

Llibre en línia | Springer Berlin Heidelberg | 2011

- Láminas Delgadas y Recubrimientos : Preparación, propiedades y aplicaciones J.M. Albella (ed.) ISBN: 978-84-00-08166-9