66104 - Characterisation II: Advanced microscopies

Información del Plan Docente

Academic Year	2017/18
Faculty / School	100 - Facultad de Ciencias
Degree	539 - Master's in Nanostructured Materials for Nanotechnology Applications
ECTS	6.0
Year	1
Semester	Half-yearly
Subject Type	Compulsory
Module	---

1.General information

1.1.Introduction

This subject will show the student the advanced microscopes (electronic, dual-beam and scanning probe) that allow the morphology and topography of nanostructured materials to be studied with nanometric resolution in addition to being powerful analytical tools, determining electric and magnetic properties at the molecular scale and allowing the handling of the substance at atomic and molecular scale.

A brief description of the contents of this subject includes:

Introduction to electron and scanning probe microscopy. Scanning electron microscopy. Transmission electron microscopy (image and diffraction). Analysis techniques linked to electron microscopy: energy dispersive X-ray spectroscopy and electron energy loss spectroscopy. Atomic and magnetic force microscopy. Scanning tunnelling microscopy. Surface spectroscopy. Other advanced optical microscopes: confocal and near-field.

The theory classes are complemented by practical sessions including:

1.- SEM

2.- TEM

3.- STM

4.- AFM

1.2.Recommendations to take this course

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The " *Characterization II: Advanced Microscopies* " module is obligatory and is equivalent to 6 ECTS credits or 150 student work hours. Of these 6 credits, 3 are for theory and 3 are practical credits. The course is given in the second term of the academic year. As with the other modules in this Master's, this module is taught and assessed completely in English.

The objective of this module is to show the student the enormous possibilities offered by electron, dual-beam and SPM microscopies in the characterization of nanostructured materials, highlighting, in addition, that the SPMs are nanotools themselves to operate at the atomic or molecular level.

This is an eminently practical module where students analyse, debate and evaluate the possibilities offered by the advanced microscopes in the characterization and operation of nanomaterials. The theory classes are accompanied and complemented by numerous laboratory practicals in which the students will have access to sophisticated characterization equipment (some of which are unique in Spain), seeing the possibilities and information offered by each of the microscopes studied in this module.

As the whole course is taught in English, students need to have an upper-intermediate level in the language: minimum level B1 in the European Common Framework Language Reference, but preferably level B2. Level B1 is reached when the student is able to understand the main points of clear, standard-language texts when covering known matters - whether in terms of work, study or leisure; when able to cope in most situations which the student encounters during a trip to places where the language is spoken; when able to write simple, coherent texts on familiar topics or those in which the student has an interest; and when able to describe experiences, happenings, wishes and ambitions as well as briefly justify opinions or explain plans. B2 is achieved when the student is able to understand the main ideas of complex texts that deal with both specific and abstract topics, even if these are technical - though within the field of specialisation; when able to communicate with native speakers with the degree of fluency and ease such that the communication takes place without effort on either side; and when able to write clear, detailed texts on diverse subjects as well as defend a point of view on general topics - giving the pros and cons of the different options.

1.3.Context and importance of this course in the degree

This module, together with module 4 " *Characterization I: physical chemistry techniques* ", is aimed at instructing the student in the different methods available for the characterization of nanostructured materials and the application of various of these to a nanosystem with the intention of characterising it to obtain morphological, structural, analytical, optical, electric or magnetic information of interest.

1.4.Activities and key dates

This module is taken in the second term following module 4 and will last approximately four weeks.

The course is given in the afternoon and the calendar for classes and exam dates will be published prior to the beginning of each academic year in the web site of the Faculty of Science (https://ciencias.unizar.es/web/horarios.do).

In addition, the google calendar for this course will be shared with the students for a more efficient and effective communication.

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2.Learning goals

2.1.Learning goals

The student, in order to pass the course, will have to show her/his competence in the following skills:

- Understand the theoretical and practical basics of electronic, SPM and "dual-beam" microscopy.

- Be able to plan experiments making use of the advanced microscopes, applying the materials preparation techniques for their observation at the nanometric scale.

- Be able to differentiate among the contributions of a morphological, structural and analytical nature at the nanometric scale based on the different microscopes.

- Identify specific phenomena and problems for which this kind of tool can provide vital information.

- Assess the observation difficulties linked to the resolution of the tools and the environmental conditions in which the measurements are taken.

- Identify the scanning probe microscopes - AFM and STM - as nanotools with which to handle the substance at the nanometric scale.

2.2.Importance of learning goals

This module aims to give the student a collection of powerful tools - under the umbrella name of advanced microscopes - for the characterization and, in some cases, for the handling at the atomic or molecular scale of nanostructured materials. In the context of the Master's, the identification of the nanostructure of materials is a key step so that students will be able to correlate by the end of the course the chemical structure and the assembly technique used in the production of a nanodevice and its architecture, morphology and molecular order, as well as the end properties of the device.

3.Aims of the course and competences

3.1.Aims of the course

While the possibility of handling matter atom by atom or molecule by molecule was already noted by Richard Feynman, Nobel prize winner, in the 1950s, it was not until the invention of the scanning tunnelling microscope (1981) when researchers received proof that they had sufficient theoretical knowledge and technology to make Nanoscience a reality.

In this module, students have the opportunity to gain the theoretical knowledge necessary to discern the information provided by the different techniques within the title of advanced microscopy as well as seeing the preparation methods for samples required for each type of microscopy. Students will have the opportunity to use highly specialised scientific instruments to characterise nanostructured materials (the students will study some of the materials that they have prepared in previous modules). Zaragoza University, the Nanoscience Institute of Aragon (INA), the Materials Science Institute (ICMA) and the Laboratory of Advanced Microscopies (LMA) provide the Master's students with next gen equipment allowing them to acquire abilities and skills in the management of instruments that are of great value on the curriculum of a professional in disciplines within the field of Nanoscience and Nanotechnology.

3.2.Competences

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After completing the course, the student will be competent in the following skills:

- Identify specific phenomena and problems for which this kind of tool can provide vital information for the characterization of nanostructured materials.

- Distinguish the contributions of morphological, structural, chemical, electric and magnetic nature of different advanced microscopes.

- Assess the observation difficulties linked to the resolution of the tools and the experimental conditions in which the measurements are taken.

- Design experiments to determine the composition, topography, morphology or properties of a material at nanoscale.

- Contrast the results obtained from the different chemical-physical techniques and advanced microscopes, being able to suggest a model for the molecular level organisation of the nanosystem studied.

- Handle different latest generation advanced microscopy equipment which, in turn, provides a degree of very useful experience for a professional future in the academic or research environment or in industry.

4.Assessment (1st and 2nd call)

4.1.Assessment tasks (description of tasks, marking system and assessment criteria)

ONGOING ASSESSMENT
The assesment of those students choosing ongoing evaluation (attendance to at least 80% of this module lectures and practicals is
required) will be as follows:

1. Assessment of the **3 ECTS theory credits** of the module (50% of the final mark for the module):

1. Problem solving, exercises and questions set during the classes, responded to individually by the student in the same classes or handed in after to the lecturer giving the class (25% of the final mark for the module) . With these questions, the student must
show knowledge about electronic microscopes and SPM. Specifically, the following will be assessed: the right approach to solving the question or problem, correct solution, interpretation of the results and explanation of how the problem was solved, giving equations or graphs where necessary.

2. Undertaking a monographic task by groups (2-3 students) connected to some of the topics in the module descriptors which will be presented to a board of examiners (25% of the final mark) . Through this report, the results of the learning process will be assessed with regard to the abilities required for the module such as bibliographic searches, data interpretation, oral and
written communication skills, interaction with colleagues and professionals from other areas, etc. Specifically in the report, the following will be assessed: i) structure (logical division of content); ii) quality of scientific and technical content (presentation of state of art, correct use of formulae, use of consistent arguments, and correct presentation of most important conclusions); iii) good use of bibliography (number and quality of sources consulted); iv) presentation (well written, correct and fluent use of English, care taken over style). The following are assessed in the oral presentation: i) structure (logical division of content) and good distribution of time; ii) good scientific communication (concise presentation, direct, clear and pedagogical); iii) correct use of audiovisual equipment.

2. Assessment of the **3 ECTS credits for the practical part** of the module (50% of the final mark for the module):

The lecturers for the practicals will score between 1 and 10 on different aspects, depending on each specific practical, such as instrument handling skills, accuracy when performing experiments, attention to detail, ability to resolve unforeseen problems or difficulties that may arise, and/or answering questions proposed by the practical teachers which include questions on the theoretical bases on which the practicals are based as well as the analysis and interpretation of the results obtained in the laboratory.

Plagiarism (the illicit copying of another person's work, especially written content, for presentation as one's own) is not allowed.

A minimum mark of 4 out of 10 is needed in each of the three parts of the exam to pass the subject.

In any case, a pass requires an average of 5 out of 10.

GLOBAL EXAMINATION

For those students that did not pass the ongoing assessment or students that wish to increase their mark, the assessment consists of:

1.- A written test (25% of the final mark) with theory questions including: (i) topic(s) to de developed based on those given in the "brief
introduction to the subject" section in this teaching manual where the complete contents are given and (ii) multiple choice and/or short answer questions, also in reference to the class course content and problem solving and exercises where the student shows knowledge regarding advanced microscopes.

2.- Viva with a board of examiners of a monographic piece of work, for which a written report is also presented (25% of the final mark). Assessed in this report and viva (add here the levels of demand: scoring between 1 and 10 or very low to very high) is the ability for bibliographic searches, correctly explaining the state of art of the topic which has been worked on, and
synthesis capacity. Scientific communication skills will also be scored between 1 and 10 for these tests in which correct use of scientific language, audiovisual aids, graphs, presentation clarity, etc. is required. Both oral and written exams will take place in the language used for the course: English.

3.- Laboratory exam (50% of the final mark). A multiple choice test must be passed before going into the laboratory. Here the judgment is on whether or not the student is ready to respect the laboratory safety norms and if the student is able to manage the instruments involved in the practical test. This is an elimination test which can only be passed with a score of 8 out of 10. This first test counts for 5% of the total for this section. Once the test is passed, the student begins the practical exam. This consists of an experiment in which the student must show the capability to plan the necessary experiments given the objectives to be
achieved. These experiments must be performed adequately, correctly using the corresponding instruments (an expert will at all times be supervising and will halt the exam if this person sees that the student is endangering the equipment used or their own safety) and obtaining a series of data that the student must then interpret. This second part counts for 95% of the mark for this test.

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A minimum mark of 4 out of 10 is needed in each of the three parts of the exam to pass the subject.

In any case, a pass requires an average of 5 out of 10.

5.Methodology, learning tasks, syllabus and resources

5.1.Methodological overview

The aim of this module is to provide students with knowledge on the different characterization techniques for nanostructured materials using advanced microscopy, identifying the information type provided by each method.

Therefore, following a general examination of these methods through lectures, there will be case and problem analysis activities where these principles can be observed, examined in depth, evaluated and clarified.

These lectures will be complemented by laboratory practice sessions where the students can study, observe and handle the correct instruments for the characterization of nanostructured materials. In addition, keeping up with the previous subjects in the Master's related to the production of nanosystems, in this module students will have the opportunity to characterise some of the samples they themselves have prepared.

The module will conclude with the analysis of practical cases where the lecturers will present specialised seminars studying real cases.

5.2.Learning tasks

Each topic area making up the programme for the module will be presented, analysed and discussed by the lecturer through 50-minute lectures. The lecturers will provide the students with notes, handouts or summaries of class content prior to the beginning of the class (preferably via ADD) along with the recommended reading for more in-depth understanding of the topic.

Open forum on the basic concepts and their application. Comparison with real developments. Problem solving, identifying spectra and practical case studies. All the above will take place within the lectures.

In laboratory practice sessions students will face real problems in the characterization of nanostructured materials.

A visit to the scientific facilty "Advanced Microscopy Laboratory (LMA)", a European point of reference, where students will have the possibility to see first hand the "titan" microscopes (subatomic resolution).

5.3.Syllabus

The course will address the following topics:

- Introduction to electron and scanning probe microscopy.
- Scanning electron microscopy.
- Transmission electron microscopy (image and diffraction).

- Analysis techniques linked to electron microscopy: energy dispersive X-ray spectroscopy and electron energy loss spectroscopy.
- Atomic and magnetic force microscopy.
- Scanning tunnelling microscopy.
- Surface spectroscopy.
- Other advanced optical microscopes: confocal and near-field.

5.4.Course planning and calendar

This calendar will be published at the beginning of each academic year in the web site of the Faculty of Science (https://ciencias.unizar.es/web/horarios.do). All classes will be in the afternoon.

In addition, the google calendar for this course will be shared with the students for a more efficient and effective communication.

5.5.Bibliography and recommended resources