Universidad Zaragoza

Academic Year/course: 2021/22

66104 - Characterisation II: Advanced microscopies

Syllabus Information

Academic Year: 2021/22
Subject: 66104 - Characterisation II: Advanced microscopies
Faculty / School: 100 - Facultad de Ciencias
Degree: 539 - Master's in Nanostructured Materials for Nanotechnology Applications
ECTS: 6.0
Year: 1
Semester: Second semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

This course, together with 66114 ?*Characterization I: physical chemistry techniques*?, is aimed at instructing the student in the different methods available for the characterization of nanostructured materials and its application to the study of morphological, structural, analytical, optical, electric or magnetic properties of interest.

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.

These approaches and objectives are aligned with the following Sustainable Development Goals (SDG) of the Agenda 2030 of the United Nations (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of learning outcomes of the subject provides training and competence to contribute to some extent to the achievement of O9. Industry, innovation and infrastructures. More specifically, they will create action to enhance research, foster innovation and upgrade industrial technologies.

1.2. Context and importance of this course in the degree

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 and Materials Institute of Aragon (INMA) 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.

1.3. Recommendations to take this course

The ?*Characterization II: Advanced Microscopies*? course is obligatory and is equivalent to 6 ECTS credits or 150 student work hours. Of these 6 credits, 3 are for theory and 3 correspond to practice sessions. The course is given in the second term of the academic year..

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.

2. Learning goals

2.1. Competences

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.

2.2. 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.

2.3. 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. Assessment (1st and 2nd call)

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

The student will prove that he/she has achieved the expected learning results by means of the following assessment tasks.

- For students choosing **Continuous Assessment** (attendance to at least 80% of both module lectures and practicals is required):

1. Assessment of the **3 ECTS theory credits** of the course (50% of the final mark):
    a) Problem solving, exercises and questions set during the theory sessions, 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). 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.

b) Monographic Report by groups (2-3 students) related to some of the topics in the syllabus 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 search, data interpretation, oral and written communication skills, interaction with colleagues and professionals from other areas, etc.

Specifically in the report, the following aspects 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 aspects 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 practical credits** (50% of the final mark):

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.

A minimum mark of 4 out of 10 is needed in each of the three parts to pass the subject. In any case, the average over the three tasks must be at least 5 out of 10 to pass the subject. Plagiarism (the illicit copying of another person's work, especially written content, for presentation as one's own) is not allowed.

- For students that did not pass the ongoing assessment or wish to increase their mark, the **Global Assessment** comprises:

1.- Assesment of the **3 ECTS theory credits** (50% of the final mark):

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.

b) 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 (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.

2.- Assesment of the **3 ECTS practical credits** (50% of the final mark). Firstly, there will be a multiple choice test which 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.

A minimum mark of 4 out of 10 is needed in each of the three parts to pass the subject. In any case, the average over the three tasks must be at least 5 out of 10 to pass the subject. Plagiarism (the illicit copying of another person's work, especially written content, for presentation as one's own) is not allowed.

4. Methodology, learning tasks, syllabus and resources

4.1. 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.

The methodology followed in this course is oriented towards achievement of the learning objectives. Students are expected to participate actively in the class throught the semester. Classroom materials will be available via Moodle. These include a repository of the lecture notes used in class, the description of the practicals sessions, the course syllabus, as well as other course-specific learning materials. Further information regarding the course will be provided by the coordinator of the course on the first day of class.

4.2. Learning tasks

This is a 6 ECTS course organized as follows:
• **Lectures (3 ECTS)**. Lecture notes will be available for the students. Each topic of the course will be presented, analysed and discussed by the lecturer through lectures of 50 minutes. The lecturers will provide the students with notes, handouts or summaries of class content prior to the beginning of the class (preferably via Moodle) along with the recommended reading for more in-depth understanding of the topic. Additionally, open forum activities on the basic concepts and their application, comparison with real developments, problem-solving and practical case studies are included in this module.

• **Laboratory Sessions (3 ECTS)**. 4 Laboratory practicals through which the student will face real problems in the characterization of nanostructured materials. Thanks to the work with their colleagues in practical groups, the students will develop group work skills. Students are provided in advance with task guidelines for each session. Other activities such as the visit to the singular facility "Advanced Microscopy Laboratory (LMA)" to see first hand the "TITAN" microscopes with subatomic resolution is planned within the course. .s to Singular Scientific Facilities may be included in this course.

• **Assignments**. At the end of every topic, each student will complete the Q&As that the lecturers give them over the course. The Q&As are to be completed individually by students and sent electronically or handed in to the lecturers. In some cases, the Q&As will be presented and openly debated during class. Here, the students must also show their oral communication skills. Students will receive a reply from the lecturers as a result of the Q&As and there will be a discussion on the areas of discrepancy in the answers. Monographic reports on specific topics proposed by the lecturers to get insight specialised aspects of the technique that have not previously been analysed in class will be assigned to groups (2-3 students). In addition, the students will elaborate an oral exposition for the presentation to the class in front of a committee.

• **Autonomous work**. Students are expected to spend about 100 hours to study theory, solve problems, prepare lab sessions, assignments and take exams.

• **Tutorials.** Teacher’s office hours allow students to solve questions and discuss unclear course contents. It is advisable to come with clear and specific questions to tutorials.

Note: The teaching and evaluation activities will be carried out in person unless, due to COVID-19, the provisions issued by the competent authorities and by the University of Zaragoza oblige to carry out virtually.

4.3. 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.

4.4. Course planning and calendar

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

The course starts at the end of course 66114 "*Characterization I: physical chemistry techniques*? (around the mid of March) and continues for about 4 teaching weeks.

Further information concerning the timetable, classroom, assessment dates and other details regarding this course, will be provided on the first day of class by the coordinator of the course.

Additionally, the student can set up regular appointments for office hour consultation