

## 66114 - Characterization I: Physical-chemical Techniques

### Información del Plan Docente

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

### 1.General information

#### 1.1.Introduction

In this subject, a wide range of physical chemical techniques are presented for the characterization of nanostructured materials. Generally speaking, the correct use of various complementary techniques allows one to acquire an advanced level of knowledge about the structure of the material, degree of order, parcelling, presence of aggregates, etc, as well as the optical, electrical and magnetic properties of the nanosystem under study.

A brief description of the contents of this subject includes:

Introduction to surface preparation and characterization. Photoelectron spectroscopies (XPS and UPS). Auger Spectroscopy (AES). SANS techniques, X-ray and neutron diffraction. Mössbauer spectroscopy. Techniques based on the use of synchrotron radiation: XANES, EXAFS, and magnetic dichroism. Magnetic characterization of nanosystems (SQUID, VSM). Hall probes and micro-SQUIDS. Characterization of Textural Properties by N<sub>2</sub> physisorption and Hg porosimetry. Particle size and zeta potential determination by DLS. FTIR and Raman Spectroscopies. Quartz Crystal Microbalance (QCM) and Electrochemical techniques.

The lectures are complemented by practical sessions including:

- 1.- Magnetization measurements by VSM
- 2.- SQUID magnetometry
- 3.- X-ray reflectivity of thin films
- 4.- X-ray diffraction of single crystal
- 5.- XPS
- 6.- N<sub>2</sub> physisorption

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7.- QCM

8.- Raman, Raman SERS and FTIR Spectroscopy

9.- Cyclic Voltammetry

### 1.2.Recommendations to take this course

The " *Characterization I: Physical-Chemical Techniques* " module is obligatory and equivalent to 6 ECTS credits or 150 student work hours. Of these 6 credits, 2 are for theory and 4 correspond to laboratory practicals. 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 various chemical and physical characterization methods for nanomaterials.

This is an eminently practical module where students analyse, debate and evaluate different characterization methods for nanostructured materials. The theory classes are accompanied and complemented by numerous laboratory practicals. Through these practical classes, the students will have access to sophisticated characterization equipment, seeing the possibilities and information offered by each of the methods studied and the fact that characterization of a nanostructured material requires the use of diverse complementary techniques.

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.

Additional information about this master (grants, events, etc.) can be found on the web site: [www.unizar.es/nanomat](http://www.unizar.es/nanomat)

### 1.3.Context and importance of this course in the degree

This module, together with module 5 " *Characterization II: advanced microscopies* ", 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

The classes for this module begin at the start of the second term and will last approximately four weeks.

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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>) and the master web site ( [www.unizar.es/nanomat](http://www.unizar.es/nanomat) ).

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

### 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:

- Gain awareness of a collection of different characterization techniques for surfaces and nanosystems, understanding the information from each of them.
- Be able to apply the most appropriate characterization technique in accordance with the morphological, structural, analytical or magnetic information desired.
- Identify specific phenomena and problems for which this kind of tool can provide crucial information.
- Assess the observation difficulties linked to the resolution of the tools and the environmental conditions in which the measurements are taken.

#### 2.2.Importance of learning goals

This module aims to give the student a collection of powerful tools for the characterization 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

Characterization of a nanostructured material is vital to know the architecture, order and structure of the material as well as its optical, electrical and magnetic properties. This, in addition, allows the chemical structure of the compounds to be correlated with the assembly technique used and the end properties of the material.

In this module, 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, its research institutes (INA, ICMA...) and the singular scientific installation LMA (Advanced Microscopies Laboratory) 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

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

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- 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, analytical and magnetic nature of different basic nanoscience techniques

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

- Understand the type of information provided by each characterization method - assuming that complete analysis requires the complementary information obtained from several of these techniques.

- Design experiments to clarify the composition, structure, morphology or properties of a material on the nanoscale.

### 4.Assessment (1st and 2nd call)

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

##### ONGOING ASSESSMENT

The students choosing **ongoing assessment** (attendance to at least 80% of both module lectures and practicals is required), will be assessed as follows :

1.- For the **2 ECTS theory credits** of the module ( 33% of the final qualification ):

a.- Written exam (50% of the theory credits) . Here, the abilities acquired related to surface characterization through the techniques seen in this module are assessed. The exam will feature theory matters including: (i) topic(s) expanded from those corresponding to the contents of this subject, given in the "brief introduction to the subject" section and (ii) short answer or multiple choice questions. In these theory questions, the student has to demonstrate that the abilities required for the subject have been obtained. To do so the student must discuss science using his/her own words since plagiarism is not acceptable. This section will be scored between 1 and 10 for accuracy in topic presentation (scientific quality and written communication skills) as well as correctness of the answers given.

b.- 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 ( 50% of the theory credits ). 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. Specifically, a score of 1 to 10 is given for: the right approach to solving the problem, correct solution, interpretation of the results and explanation of how the problem was solved, giving equations or graphs where necessary.

2. For the **4 ECTS practical credits** of the module (67% of the final mark for the module ):

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The lecturers will assess (scored between 1 and 10) several aspects of the practical which may include, depending on each practical, abilities and skills of the students in the laboratory, instrument handling ability, accuracy performing experiments, attention to detail, ability to solve problems or unforeseen difficulties that may arise, ability to work on experiments in a group, and answers to multiple choice questions and Q&As laid out before, during and/or after the practical sessions.

A minimum mark of 4 out of 10 is needed for each of the two parts of the assessment to pass the subject.

In any case, a pass requires an average of 5 out of 10 or higher over the sections.

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

### GLOBAL EXAMINATION

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

1.- Assessment of theory credits (33%) A written exam with theory questions including: (i) topic(s) to be 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 or short answer questions, exercises and problems also in reference to the class course content and problem solving and exercises where the student shows knowledge, expressed using his/her own words, and discussion abilities regarding characterization of materials through the techniques analyzed in this module. A score of 1 to 10 is given for both the scientific rigor and quality and the written communication skills of the student.

2.- Assessment of the practical credits (67%). 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 test. Once the test is passed, the student begins the laboratory 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 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). Likewise, the data obtained must be interpreted. This part of the test counts for 95% of this assessment of the practical credits.

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

In addition, an average of 5 out of 10 or more needs to be obtained to pass.

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

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allowed.

### 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, identifying the information type provided by each method.

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

These classes are complemented by laboratory practice sessions where the students can study, observe and handle the correct instruments for the characterization of nanostructured materials. In addition, in keeping 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-life cases.

#### 5.2. Learning tasks

Each section of the syllabus for the module 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 ADD) along with the recommended reading for more in-depth understanding of the topic.

Other learning tasks taking place during lectures are open forum on the basic concepts and their application, comparison with real developments, problem-solving, identifying spectra and practical case studies.

Presentation of seminars by highly specialised lecturers where real cases are analysed.

Eight laboratory practice sessions through where students will face real problems in the characterization of nanostructured materials.

Other activities such as visits to Singular Scientific Facilities may be included in this module.

#### 5.3. Syllabus

The course will address the following topics:

Introduction to surface preparation and characterization. Photoelectron spectroscopies (XPS and UPS). Auger Spectroscopy (AES). SANS techniques, X-ray and neutron diffraction. Mössbauer spectroscopy. Techniques based on

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the use of synchrotron radiation: XANES, EXAFS, and magnetic dichroism. Magnetic characterization of nanosystems (SQUID, VSM). Hall probes and micro-SQUIDS. Characterization of Textural Properties by N<sub>2</sub> physisorption and Hg porosimetry. Particle size and zeta potential determination by DLS. FTIR, Raman and Raman-SERS Spectroscopies. Quartz Crystal Microbalance (QCM) and Electrochemical techniques.

### 5.4.Course planning and calendar

Calendar of actual sessions and presentation of works

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>). Additional information could be found at [www.unizar.es/nanomat](http://www.unizar.es/nanomat) . 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