COURSE DATA

Data Subject	
Code	44419
Name	Physical characterisation techniques
Cycle	Master's degree
ECTS Credits	4.5
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
2208 - M.D. in Molecular Nanoscience and Nanotechnology	Faculty of Chemistry	1	First term

Subject-matter

Degree	Subject-matter	Character
2208 - M.D. in Molecular Nanoscience and Nanotechnology	3 - Physical characterisation techniques	Obligatory

Coordination

Name	Department
CORONADO MIRALLES, EUGENIO	320 - Inorganic Chemistry

SUMMARY

The aim of this subject is to make the students familiar with physical characterization techniques usually employed in nanoscience (microscopy and spectroscopy), with emphasis on surface sensitive characterization and analysis techniques.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

There are no specified enrollment restrictions with other subjects of the curriculum.

OUTCOMES

2208 - M.D. in Molecular Nanoscience and Nanotechnology

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- To possess the necessary knowledge and abilities to continue with future studies in the PhD program in Nanoscience and Nanotechnology.
- For students from field of knowledge (e.g. chemistry) to be able to scientifically communicate and interact with colleagues from another field (e.g. physics) in the resolution of problems laid out by the Molecular Nanoscience and Nanotechnology.
- To acquire the basics knowledge in fundamentals, use and applications of microscopic and spectroscopic techniques used in nanotechnology.
- To know the technical and conceptual problems laid out by the physical properties measurement in single molecular systems (charge transport, optical properties, magnetic properties).

LEARNING OUTCOMES

The aim of this subject is to make the students familiar with physical characterization techniques usually employed in nanoscience (microscopy and spectroscopy), with emphasis on surface sensitive characterization and analysis techniques.

DESCRIPTION OF CONTENTS

1. Physical characterization techniques.

CHAPTER 1: Far-field microscopies.
1.1. Introduction
1.2. Optical microscopies
1.2.1. Overview of geometrical optics
1.2.2. Resolution limits and superresolution techniques: Aberrations and diffraction
1.3. Electron microscopies
1.3.1. Fundamentals
1.3.2. Instrumentation: electron sources and electrostatic lenses
1.3.3. TEM, SEM y STEM
1.3.4. Information that can be obtained from the different signals.

CHAPTER 2: Optical spectroscopies.
2.1. Optical properties of nanostructures: quantum confinement, excitons and plasmons.
2.2. Absorption and luminescence spectroscopies: energy gaps and the Frank-Condon principle.
2.3. Infrared and Raman spectroscopies: vibrations
2.4. Pump-probe spectroscopy: Excitation lifetimes.

CHAPTER 3: Photoelectron spectroscopies.
3.1. Photoelectric effect, work function, electron mean-free path and final state effects (screening).
3.2. Instrumentation: Light sources, monochromators, flood guns, energy analyzers
3.3. Instrumentation: Ultra-High Vacuum and sample preparation techniques in UHV
3.4. X-ray Photoelectron Spectroscopy (XPS): Chemical identification and Chemical shifts.
3.5. Ultraviolet Photoelectron Spectroscopy (UPS): Valence band, angle resolved UPS, band dispersion.
3.6. Synchrotron-based techniques: Near-Edge X-ray Absorption Fine Structure (NEXAFS) and magnetic dichroism.
CHAPTER 4: Scanning probe microscopies.
4.1. Scanning Tunneling Microscopy
4.1.1. Theoretical foundations and instrumentation.
4.1.2. Topographical and spectroscopic information with the STM
4.1.3. Inelastic spectroscopy and elementary excitations
4.1.4. STM manipulation
4.2. Atomic Force Microscopy
4.2.1. Theoretical foundations and instrumentation
4.2.2. Topography, friction and Force vs. Distance curves
4.2.3. Mechanical properties of nanostructures
4.3. Other Scanning Probe Microscopies: Magnetic Force Microscopy (MFM) and Scanning Near-field Optical Microscopy (SNOM)

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	22,00	100
Seminars	7,00	100
Tutorials	6,00	100
Other activities	2,00	100
Preparation of evaluation activities	57,50	0
Preparing lectures	18,00	0
TOTAL	**112,50**	

TEACHING METHODOLOGY

- Theory classes, participatory lectures
- Articles discussion.
- Chaired debate or discussion.
- Practical cases or seminar problems discussion.
- Seminars.
- Problems.
- Laboratory practices and demonstracions and visit to installations.
- Experts conferences.
- Attendance to courses, conferences and round tables.

EVALUATION

Written exam about the subject basic contents	70-90%
Attendance and active participation in seminars.	0-10%
Questions answering	10-20%

REFERENCES

Basic

- Practical Methods in Electron Microscopy. Ed. Glauer, A.M. Nort Holland Publishing Company. 1990-1997

  Desarrollo de técnicas de espectroscopía láser y su aplicación al análisis químico, Montero Catalina, Carlos, Universidad Complutense de Madrid, Servicio de Publicaciones, 2001.

  Introduction to Scanning Tunneling Microscopy. Chen, C.J. Oxford Scholarship Online. 2007.