Universitat Autònoma de Barcelona

Techniques for Characterising Materials 2016/2017

Code: 43442
ECTS Credits: 6

Degree	Type	Year	Semester
4314939 Advanced Nanoscience and Nanotechnology	OT	0	1

Contact

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Use of languages

Principal working language: english (eng)

Teachers

Maria Dolors Baró Mariné

Juan Francisco Piniella Febrer

Angel Álvarez Larena

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Lluís Casas Duocastella

Pau Nolis Fañanas

Miguel Guerrero Hernandez

External teachers

José Luis Garcia-Muñoz

José Santiso

Prerequisites

Bachelor or Engineering in the fields of materials and nanomaterials, physics, chemistry or biosciences

This module partially overlaps (approximately 35%) with the Nanoscience and Nanotechnology (N&N) degree at UAB and is therefore suitable for this graduation unless the student attended the elective course "Advanced Crystallography and Diffraction Techniques for Nanomaterials". In such a case the overlap of the N&N degree with this module turns out to be around 60%.

Objectives and Contextualisation

This module covers a significant part of the main techniques for characterization of materials and nanomaterials, but it is not aimed at comprising all the techniques currently used. Most of them are available at our research facilities (UAB-CIE Sphere). Several laboratory experiments and practical examples are planned as a key part of the course.

The local probe microscopy techniques and the x-ray absorption spectroscopies, not included in this module, are covered in modules "Local Probe Microscopies" and "Spectroscopies with Synchrotron Radiation", respectively.

Skills

- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Continue the learning process, to a large extent autonomously
- Identify the characterisation and analysis techniques typically adopted in nanotechnology and know the principles behind these, within one's specialisation.
- Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

Learning outcomes

1. Choose the most suitable technique for chemical/compositional characterisation: bulk, thin layer, superficial and interlayer.
2. Choose the techniques for identifying the functions of surfaces.
3. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
4. Continue the learning process, to a large extent autonomously
5. Describe the bases of electron microscopy, image formation and the associated spectroscopic techniques.
6. Describe the fundamental physical process underlying vibrational spectroscopies, X-ray and photoelectron emission, etc.
7. Describe the structure of crystalline matter and the bases for X-ray diffraction.
8. Determine the crystalline phase of the material in different morphologies. dust, layer, heterostructure, particle, nanotube, etc.
9. Identify the techniques for establishing the range of sizes of particles of the material and the surface area.
10. Interpret the results from the most important techniques.
11. Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
12. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

Content

Topic I. Structure of materials and X-Ray diffraction

Overview of the fundamentals of crystallography and X-ray diffraction. Experimental diffraction methods for the characterization of the structure of materials and nanomaterials.

Topic II. Structural characterization of materials. Microscopy.

Optical and Confocal Microscopy, Electron Microscopy, Scanning Electron Microscopy and Transmission Electron Microscopy.

Topic III. Other characterization techniques.

IIIA) Thermal analysis techniques. Thermogravimetry Analysis (TGA) and Differential Scanning Calorimetry (DSC)

IIIB) Spectroscopic techniques. Solution and Solid State NMR Spectroscopies, Vibrational Spectroscopies, Optical Spectroscopies and Mössbauer Spectroscopy.

A total of five practical sessions covering different aspects of each topic are planned.

Methodology

Lectures covering the fundamentals of the main topics of the course

Five practical sessions in UAB research facilities (UAB-CIE Sphere) to acquire experimental skills in characterization techniques and also to improve cooperation ability (group work). It is planned to carry out these practices in the Microscopy Service (UAB), XRD Service (UAB), NMR Service (UAB) and ICN2 (Catalan Institute of N&N). It is expected to conduct a series of activities such as:

- Characterization of nanoparticles by TEM, HRTEM, EDX, electron diffraction and X-ray diffraction
- Characterization of thin film samples by reflectometry, X-ray diffraction, optical microscopy, EDX
- Observation and characterization of biological structures by TEM
- Solid State NMR spectroscopy measurements

Delivery of works and exercises related to the topics of the lectures and practices that could involve the use of specialized software

Reports of practical laboratory work

Tutorials supervising learning activities

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Lectures	25	1	1, 5, 6, 7
Practical sessions	13	0.52	1, 2, 8, 9, 10, 12
Type: Supervised			
Tutorials	5	0.2	11
Type: Autonomous			
Deliveries: practical reports, exercises, other works	35	1.4	3, 11
Self-work	70	2.8	4

Evaluation

The students must attend 90% of the lectures and 100% of the practical sessions in order to pass the module. It is also compulsory the delivery of practical reports and other works or exercises that are requested by the professor.

Student's behaviour and attitude during practical sessions will be also taken into account for the module evaluation.

The final mark will be weighted as follows:

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes

Deliveries: practical reports, exercises, other works	30%-50%	0	0	3, 4, 10, 11
Exam	20%-40%	2	0.08	5, 6, 7, 10, 11
Practical sessions	30%-40%	0	0	1, 2, 8, 9, 10, 12

Bibliography

- "Fundamentals of materials science and engineering". W.D.Callister and D.G. Rethwisch, 4th ed. Ed. John Wiley, 2013.
- "Fundamentals of crystallography". C. Giacovazzo, H.L. Monaco, D. Viterbo, F. Scordari, G. Gilli, G. Zanotti & M. Catti. IUCr texts on crystallography, 2nd ed. Oxford University Press, 2002.
- "Thin Film Analysis by X-Ray Scattering". M. Birkholz. Wiley-VCH Verlag, 2006.
- Instituto de Química-Física Rocasolano (Crystallography Department) http://www.xtal.iqfr.csic.es/Cristalografia/index2.html
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- "Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM". Ray F. Egerton. Kluwer Academic-Plenum Publishers, 2005. ISBN: 0-387-25800-0
- "Transmission Electron Microscopy". M D.B. Williams, C.B. Carter. Plenum Press, New York, 1996. ISBN: 0-306-45247-2.
- "Scanning electron microscopy and X-Ray micronanalysis". J.I. Glodstein, D. Newbury, D. Joy, C. Lyman, P. Echlin, E. Lifshin, L. Sawyer, and J. Michael. 3rd ed. Kluwer Academic-Plenum Publishers, 2003. ISBN: 0-306-47292-9.
- "Principles of Thermal Analysis and Calorimetry". P.J. Haines, Royal Society of Chemistry, 2002. http://ebook.rsc.org/?DOI=10.1039/9781847551764
- "Characterization of Solid Materials and Heterogeneous Catalysts: From Structure to Surface Reactivity". Ed. M. Che, J. C. Vedrine, Wiley-VCH, 2012.
- "Fundamentals of Fluorescence Microscopy: Exploring Life with Light". P. P. Mondal, A. Diaspro. Springer, 2014.