Techniques for Characterising Materials 2014/2015

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: anglès (eng)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Maria Dolors Baró Mariné
Juan Francisco Piniella Febrer
Lluís Casas Duocastella
Miguel Guerrero Hernandez

Prerequisites

Bachelor or Engineering in the fields of materials, physics, chemistry or biology.

This module partially overlaps (approximately 30-35%) 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 M15 and M12 modules, 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. Solid State NMR Spectroscopy and Mössbauer Spectroscopy.

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

Methodology

Lectures covering the fundamentals of the main topics of the course

Practical sessions in UAB research facilities (UAB-CIE Sphere) to acquire experimental skills in characterization techniques and also to improve cooperation ability (group work):

- Characterization of thin film samples by X-ray diffraction (including SAXS), optical and electron microscopy (FESEM and EDX)
- Characterization of nanoparticles by TEM, HRTEM, EDX, electron diffraction and X-ray diffraction
- Thermal analysis experiments
- Solid State NMR spectroscopy measurements

Delivery of exercises related to the topics of the lectures 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	18	0.72	6, 7, 5, 1, 2, 9, 12
Practical sessions	18	0.72	8, 1, 9, 10, 12
Type: Supervised			
Tutorials	5	0.2	11, 10
Type: Autonomous			
Delivery of exercises	10	0.4	10, 3, 4
Reports of practical laboratory work	24	0.96	8, 11, 1, 9, 10, 3, 4
Self-work	72	2.88	6, 7, 5, 1, 4

Evaluation

The students must attend 90% of the lectures and 100% of the practical sessions in order to pass the module. The delivery of the practical reports is also compulsory.

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
Delivery of exercises	10%-15%	0	0	8, 1, 10
Practical sessions	15%	0	0	8, 1, 9, 10, 12
Reports of practical laboratory work	25%-35%	0	0	8, 11, 10, 12, 3, 4
examination	35%-50%	3	0.12	6, 7, 5, 8, 11, 1, 2, 9, 10

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
- International Union of Crystallography http://www.iucr.org/
- 2014 International Year of Crystallography http://www.iycr2014.org/learn
- "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