Universitat Autònoma de Barcelona

2018/2019

Advanced Nanomaterials

Code: 103297
ECTS Credits: 6

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OT	4	0

Contact

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Use of languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

External teachers

Josep Fontcuberta

Prerequisites

A good level in Solid State Physics and Chemistry, Thermodynamics and Supramolecular Chemistry is required.

Objectives and Contextualisation

The main objectives of this course are:

- To provide the students with the most characteristic knowledge for each type of material.

- To learn the most advanced tools for the preparation of thin films and molecular assemblies.

- To correlate the structure of nanomaterials with their properties.

- To understand the forces and effects that give rise to the formation of nanoparticles and their specific properties as materials.

By the end of the course the students must be capable to select, among all the possible materials, those that are preferred for a certain application. In addition, they should be able to synthesize or prepare such materials and, more specifically, to understand:

- How to achieve composition and morphology control on the atomic level for the preparation of thin films.

- How to assemble molecules onto a surface or in nanoparticles.

- How to measure the magnetic, electric and optical properties of the resulting materials.

- How to uncover the size-dependent properties of materials: from bulk to the atomic level.

- The intimate relationship between the composition, structure and properties of materials.

Skills

- Adapt to new situations.
- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Communicate clearly in English.
- Communicate orally and in writing in ones own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Operate with a certain degree of autonomy.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Learning outcomes

1. Adapt to new situations.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Communicate clearly in English.
4. Communicate orally and in writing in ones own language.
5. Critically evaluate experimental results and deduce their meaning.
6. Describe characterisation techniques derived from synchrotron radiation and its applications.
7. Describe the synthesis, structure and properties of liquid glasses, gels, porous materials, nanoparticles and molecular and supramolecular threads.
8. Design chemical or material compounds for their use as liquid glasses or gels and methods for preparation of porous materials.
9. Distinguish techniques for the determination of crystalline structures, energy bands, chemical bonds, composition and optical characterisation of materials.
10. Draft and present reports on the subject in English.
11. Explain surface diffraction techniques to characterise crystalline surfaces.
12. Interpret texts in English on aspects related with the physics and chemistry of nanoscience and nanotechnology.
13. Learn autonomously.
14. Manage the organisation and planning of tasks.
15. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
16. Operate with a certain degree of autonomy.
17. Perform bibliographic searches for scientific documents.
18. Propose creative ideas and solutions.
19. Propose methods for the characterisation of materials and nanomaterials based on synchrotron radiation
20. Propose physical methods for the characterisation of material and nanomaterials
21. Propose preparation and characterisation methods for nanoparticles, molecular and supramolecular threads.
22. Reason in a critical manner
23. Recognise the physical and chemical methods for preparing epitaxial structures and optoelectronic, thermo and photochromic materials.

24. Recognise the relative terms of chemistry.
25. Resolve problems and make decisions.
26. Resolve problems with the help of the provided complementary bibliography.
27. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Content

1. Introduction to materials and nanomaterials

Organic and inorganic materials. Hybrid materials and composites. Molecular materials. Hard and soft matter. From materials to nanomaterials: properties. Colloids. Gels. Liquid crystals.

2. Thin films and self-assembled monolayers

Seld-assembled monolayers: preparation, properties and applications. Other types of organic thin films: preparation, properties and applications. Micro- and nanostructuration of organic thin films. Inorganic thin films, epithaxy and heterostructures. Methods for growing and characterizing inorganic thin films. Magnetic and ferroelectric materials. Thin films of magnetic and ferroelectric materials. Methods of functional characterization. Integration of magnetic and ferroelectric thin films into information storage and data processing devices.

3. Nanoparticles

General aspects: nucleation and growth. Stability. Methods for the synthesis of nanoparticles. Magnetic nanoparticles. Nanoparticle magnetism. Properties and characterization. Applications of magnetic nanoparticles. Nanoparticles with relevant optical properties: plasmonic metal nanoparticles; semiconducting nanoparticles; luminescent organic nanoparticles.

Methodology

The theoretical concepts of the course will be introduced and worked out during the theory lectures and problem-solving sessions. Practical sessions will consist in the visit to research labs.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Practical sessions	8	0.32	5, 9, 23
Problem-solving sessions	10	0.4	1, 2, 13, 5, 3, 14, 15, 16, 18, 19, 21, 20, 22, 26, 25, 27
Theory lectures	34	1.36	5, 7, 6, 8, 9, 11, 12, 19, 21, 20, 23, 24
Type: Autonomous			
Autonomous study	72	2.88	1, 2, 13, 5, 7, 6, 8, 9, 11, 14, 12, 15, 18, 19, 20, 22, 23, 24, 26, 25

Evaluation

Continuous assessment of student progress will be perfomed during the course. With this aim, the following evaluation activities will be carried out: (a) two midterm exams, which will account for 75% of the final note; (b) short exercises and quizzes, which will account for 5% of the final note; (c) an oral presentation of a scientific article, which will account for 20% of the final note.

To pass the course, the following requirements must be fulfilled: (a) a minimum note of 4/10 for each of the two midterm exams; (b) a minimum note of 5/10 after averaging over the two midterm exams; (c) a minimum note of 5/10 after averaging over all the evaluation activities.

For those not reaching these requirements by the end of the course, a final exam will be programmed where each of the two midterm exams could be retaken independently. The marks previously obtained in the midterm exams will be replaced by those obtained in the final exam. In order to pass the course after the final exam, the requirements stated above should also be fulfilled.

Access to the final exam will only be granted to those students who had previously developed evaluation activities during the course that account for 2/3 of the final note. Those students that do not meet this condition will obtain a "No presentat" grade.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Exercises and short quizzes	5%	10	0.4	2, 13, 5, 3, 4, 9, 11, 17, 14, 12, 15, 16, 18, 22, 23, 24, 10, 26, 25, 27
Midterm exams	75%	6	0.24	2, 5, 3, 4, 7, 6, 8, 9, 11, 19, 21, 20, 22, 23, 24, 26
Presentation of a scientific article	20%	10	0.4	1, 2, 13, 5, 3, 4, 7, 6, 11, 17, 14, 12, 15, 16, 21, 22, 24, 10, 26, 27

Bibliography

Literature

- G. Cao, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press, London, 2004.
- G. A. Ozin, A. C. Arsenault, L. Cademartiri, *Nanochemistry: A Chemical Approach to Nanomaterials*, RSC Publishing, Cambridge, 2008.
- G. Burns, *Solid State Physics*, Academic Press, 1985.
- M. Fox. *Optical Properties of Solids*. Oxford master series in condensed matter physics, 2010.
- N. W. Ashcroft , N. D. Mermin, *Solid State Physics*, Cengage Learning ,1976.
- M. Ohring, *Materials Science Thin Films*, Academic Press, 2002.