Universitat Autònoma de Barcelona

2023/2024

Advanced Physical Properties of Nanomaterials

Code: 43437
ECTS Credits: 6

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

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject.
Please note that this information is provisional until 30 November 2023.

Teachers

Javier Rodríguez Viejo

External teachers

Alejandro Goñi

Anna Palau

Cristian Rodriguez Tinoco

Javier Rodríguez

Jordi Sort

Prerequisites

Basic Knowledge of Solid State, quantum mechanics and basic concepts of Materials Science.

Objectives and Contextualisation

Deepen the understanding of size effects in the properties of low-dimensional materials.

Competences

- Analyse the benefits of nanotechnology products, within one's specialisation, and understand their origins at a basic level
- Continue the learning process, to a large extent autonomously
- Design processes for nanomaterials with properties and functionalities default (specialty Nanomaterials).
- 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.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Learning Outcomes

1. Assess the importance of scale for describing advanced physical properties in materials, whether electronic, optical, magnetic, mechanical or transport-related.
2. Continue the learning process, to a large extent autonomously
3. Describe in qualitative terms the principles behind superconductivity and know its applications.
4. Identify the emergence of thermoelectric phenomena at the nanometric scale.
5. Interpret the phenomena of light absorption and emission, both interband and intraband, in nanostructures.
6. Interpret the results of experimental measurements on the basis of the theoretical principles acquired.
7. Interpret the variation of electronic properties of solids with the dimensionality of the system based on advanced band theory models.
8. Make calculations on the physical properties of materials in nanometric-scale systems.
9. Recognise the concept of transmission in ballistic transport and formulate problems and solutions in the field of low-dimensionality devices.
10. Recognise the different methods of characterisation and the principles behind them on the basis of the physical property to be measured.
11. Recognise the importance of spin in transport and understand the workings of spintronic devices.
12. 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.
13. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
14. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Content

A range of physical properties are studied with an emphasis on electronics, optics, mechanics, magnets, superco

Electronic and Optical properties*: Energy bands.* K.p and pseudopotencials. Optical properties of low-dimensional semiconductors. Light absorption. Spontaneous and stimulated emission. Luminiscence. Pressure effects.

Transport: electrons and phonons*. kinetic theory. Boltzmann transport equation. Landauer formalism:* Conductance and fluxes. Aplication to low-dimensional semiconductors and graphene. Thermoelectric effects in semiconductor nanostructures.

Mechanical properties*:* Correlation of the microstructure with mechanical properties: Hall-Petch effect. Nanoindentation: Oliver & Pharr Method. Size effects. Nanoindentation in crystalline and amorphous solids.

Superconductivity: This part is focused on the study of superconducting materials. We will describe the basic properties of a superconductor; including the phenomenon of zero resistance, the Meissner and Josephson effects, type I and type II superconductors, and the different theoretical approaches developed to understand the superconducting state. The importance of nanotechnology, and its implication on the powerful applications of superconducting materials will be revised.

Methodology

Students have notes in the Virtual Campus or pdf copies before class.

Lessons: The teacher explains the most important concepts of each subject. The notes will be available at the Virtual campus or distributed by the professor.

Discussion lectures: reading of scientific articles and their discussion in class.

Supervised activities: In specified hours the teachers will be accessible to discuss the contents of their respective subjects.

Self-learning activities: Solving problems and studying.

Handouts: teachers can ask for research, bibliographic works or problem solving to consolidate the contents of every subject.

Study for exams: Personal work by the student.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
regular teaching	46	1.84	3, 7, 13, 9, 11
Type: Supervised			
supervised work	14	0.56	13, 2, 14
Type: Autonomous			
autonomous work	77	3.08	3, 7, 2, 9, 11

Assessment

Final exams (50-60%).

Handouts: that include several activities such as problem solving, minireserach works and small lab or simulation experiments (40-50%).

It is possible to have the chance to increase the marks of the synthesis exams in an extra test (only for those students that have carried out all previous evaluations along the course).

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exams	50-60%	3	0.12	3, 12, 8, 4, 5, 7, 13, 9, 11, 1
Handouts	40-50%	10	0.4	12, 8, 6, 2, 10, 14, 1

Bibliography

Teachers of the various subjects will provide references for books and scientific articles the first day of the activity.

Software

Use of windows-based programs to help slide presentation