COURSE DATA

DATA SUBJECT

Code: 44424
Name: Molecular electronics
Cycle: Master's Degree / Doctorate
ECTS Credits: 4.5
Academic year: 2026-27

STUDY (S)

Degree	Center	Acad. year	Period
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Facultat de Química	1	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Molecular electronics	COMPULSORY

COORDINATION

CORONADO MIRALLES EUGENIO

SUMMARY

The students will become familiar with the basic concepts of organic or molecular electronics and the most important applications of the molecular materials in this area.

The students will also get insights into the basic concepts, both experimental and theoretical, of the techniques used to measure the electronic properties of a single molecule deposited on a substrate or connected to metallic electrodes, and their potential applications in nanoelectronics.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

OTHER REQUIREMENTS

Previous knowledge of chemistry, physics or materials science as taught in the degrees indicated in the recommended entry profile to the master's degree is required. Previous knowledge of molecular nanoscience and nanotechnology as taught in the Introduction and Basic Modules is required.

COMPETENCES / LEARNING OUTCOMES

2208 - Master's Degree in Molecular 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.

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 acquire the basics knowledge in fundamentals, use and applications of microscopic and spectroscopic techniques used in nanotechnology.

To assess the molecules and hybrid materials relevance in electronics, spintronics and molecular nanomagnetism.

To assess the relationships and differences between the materials macroscopic properties and those of unimolecular systems and nanomaterials.

To know the main applications of nanoparticles and nanostructured materials obtained or functionalised using a molecular approach- in magnetism, molecular electronics and biomedicine.

To know the main biological and medical application in this area.

To know the main molecular nanomaterials technological applications and to be able to put them in the Material Science general context.

To know the methodological approaches used in Nanoscience.

To know the technical and conceptual problems laid out by the physical properties measurement in single molecular systems (charge transport, optical properties, magnetic properties).

To possess the necessary knowledge and abilities to continue with future studies in the PhD program in Nanoscience and Nanotechnology.

DESCRIPTION OF CONTENTS

1. Electronics based on molecular materials and unimolecular electronics: Introduction and basic concepts.
2. Molecular electronic devices: OFETs, OLEDs and photovoltaic cells; devices structure and types; operating physical basics; constituent materials; comparison with inorganic devices. Third generation solar cells such as DSSC, OPV and perovskite photovoltaic cells.
3. Unimolecular electronics: basic concepts of coherent electron transport through molecules; experimental techniques for measuring the quantum transport and for the fabrication of molecular nanodevices.
4. Quantum transport theoretical modelling.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	6,00
Theory	22,50
Seminar	7,50
Other activities	2,00
Total hours	**38,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	18,00
Preparation for assessment activities	56,50
Resolution of case studies	0,00
Total hours	**74,50**

TEACHING METHODOLOGY

Classes in this subject will be taught, together with the rest of the advanced module, intensively during 3 weeks in May and each year at a different university.

During the **theory classes**, professors will give an overview of the subject under study, emphasising new or particularly complex aspects. The necessary bibliographical sources will be indicated for students to study the subject in depth.

The **practical classes** of this subject will be devoted to the organisation of seminars in which problems related to the theoretical content will be posed and solved. Likewise, practical cases and other topics related to the subject will be discussed with the students.

During these hours of practical activities, as far as possible, visits to laboratories and facilities related to the contents of the theoretical classes will be organised. This includes visits to the controlled atmosphere and clean room device fabrication laboratories and to the electrical and optical device measurement equipment. In addition, simple practical exercises will be carried out with the main computer programmes used for the theoretical modelling of quantum transport in molecular electronic devices.

After the intensive face-to-face classes, the lecturers will ask students a series of **questions** about the contents of the course that the student will have to solve.

Professors will hold **tutorials** with the students to resolve any doubts and questions they may have. These tutorials will take place in person or remotely (email, videoconference, telephone, etc.) depending on whether the student and teacher are from the same or a different university.

Through all these activities, students will acquire the competences described in the corresponding section. The basic competences will be worked on above all during the seminars.

EVALUATION

The acquisition of the competences of the subject will be assessed by means of a written exam based on the questions posed to the students. The mark for this exam will represent 90% of the final mark for the subject.

Student participation during the training activities will represent 10% of the final grade.

To pass the course, it will be necessary to have attended 80% of the face-to-face training activities.

REFERENCES

- Organic Electronics: Foundations to Applications. Stephen R. Forrest. © Stephen R. Forrest 2020. Published in 2020 by Oxford University Press. DOI: 10.1093/oso/9780198529729.001.0001
- World Scientific Series in Nanoscience and Nanotechnology: Volume 1. Molecular Electronics. An Introduction to Theory and Experiment. Juan Carlos Cuevas (Universidad Autónoma de Madrid, Spain), Elke Scheer (Universität Konstanz, Germany)
- Lessons from Nanoelectronics. A New Perspective on Transport. Supriyo Datta (Purdue University, USA) World Scientific, 2012 - "Dye-Sensitized Solar Cells: Advances and Challenges", Peng Wang, CRC Press, ción: 2018

- "Organic Photovoltaics: Concepts and Realization" Christoph Brabec, Ullrich Scherf, Springer, 2018 - "Perovskite Solar Cells: Technology and Practices" Showkat Ahmad Bhawani, Iek-Heng Chuah, Ahmad Shahrizan bin Sulaiman, Wiley , 2020
- "Electrons in Molecules. From Basic Principles to Molecular Electronics", Jean-Pierre Launay, Michel Verdaguer. Oxford University Press, 201