COURSE DATA

Data Subject	
Code	43304
Name	Fundamentals of optoelectronics
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2024 - 2025

Study (s)

Degree	Center	Acad. year	Period
2150 - Master's degree in Advanced Physics	Faculty of Physics	1	First term

Subject-matter

Degree	Subject-matter	Character
2150 - Master's degree in Advanced Physics	5 - Optoelectronics	Optional

Coordination

Name	Department
MORAIS DE LIMA MARQUES, MAURICIO	175 - Applied Physics and Electromagnetism

SUMMARY

In this course we study the physical processes involved in the light-matter interaction which constitute the basis of the operation of optoelectronic devices. Following several formalisms, classical and mecano-quantum, we study the processes of transmission, reflection, absorption and emission of light in solid materials with photonic applications, within the limits of linear optical processes. Particular attention is paid to metals and semiconductors, also exploring the effect of the reduction of dimensionality in their optical response. The models of electrostatic equilibrium and conduction in junctions of the type metal-semiconductor and metal-oxide-semiconductor are also addressed. In the final part of the course, the processes of stimulated emission and gain are introduced both in massive materials and in semiconductor nanostructures.
From the methodological point of view, it is sought that students enter into the world of scientific research. To do this, they solve and discuss, throughout the different subjects, non-academic problems. Theoretical knowledge is also accompanied by practical demonstrations and laboratory sessions, in which students learn the main experimental techniques (absorption and emission measures), as well as the treatment and presentation of the experimental data. It also affects the use of advanced bibliography, such as books and scientific articles, and in the techniques of scientific writing.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

At the end of the teaching-learning process the student will have learned:

1. Understanding the physical basis of the material properties that determine their optoelectronic applications.
2. Understanding how to modify the optoelectronic properties of nanostructured media materials.
3. Understanding the most common techniques of preparation and growth of optoelectronic materials in single crystal, thin film or nanoestrucutura and characterization techniques relevant to optoelectronic applications and photonics.
4. Understanding the operation of the emission optoelectronic devices, modulation and detection of light from the basic properties and structure of the device.
5. Being able to select or design optoelectronic devices by which to manage an application or problem, both in basic research laboratories, such as R & D in an industrial environment (sensors and bio-optical sensors, spectroscopy for physico-chemical process control, optical communications, ...).

DESCRIPTION OF CONTENTS

1. Unit 1

Processes and optical coefficients. Dielectric function. Optical Measurements. Optical materials.

2. Unit 2

Optical properties of metals: the Drude model, plasmons, plasmon-polariton surface.

3. Unit 3

Absorption and emission in semiconductors: classical approach, processes of absorption and density of states, critical points of different dimension, excitonic effects and impurity emission processes.

4. Unit 4

Quantum heterostructures: the envelope function approximation, confinement of carriers in heterostructures (wells, wires and quantum dots), absorption and emission in heterostructures.

5. Unit 5

Quantum technologies with semiconductors. Fundamnetals and applications. Semiconductor single quantum dots.

6. Unit 6

Spontaneous and stimulated emission in semiconductors and semiconductor nanostructures: Einstein relations, balance equations, gain. Exciton polaritons and condensates.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	32,00	100
Laboratory practices	4,00	100
Other activities	4,00	100
Seminars	3,00	100
Development of group work	8,00	0
Development of individual work	8,00	0
Preparing lectures	45,00	0
Preparation of practical classes and problem	46,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

MD1 - Standar theory lecture

MD2 - Laboratory demonstrations

MD3 - Problems solving

MD4 - Problems and simulations

MD5 - Seminars.

MD6 - Visit to scientific facilities and experimental demonstrations

MD7 - Addressed debate or discussion.

EVALUATION

Each student will be evaluated continosly by the work done in class (SE1) and other non-presential activities (SE2).

SE1 - Continuous evaluation of students in the classes of theory and practice: participatory assistance

and exercises in the classroom. 50%

SE2 - Evaluation of non-presential activities related to theory and practical lectures: reports (and problems) submitted, oral presentations. 50%

REFERENCES

Basic

- J. Singh, Electronic and Optoelectronic Properties of Semiconductor Structures, Cambridge University Press (2003).
- M. Fox, Optical Properties of Solids. Oxford University Press (2001).
- H. Ibach and H. Lüth, Solid State Physics, Springer (2009).
- C. F. Klingshirn, Semiconductor Optics. Springer (1997).
- John H. Davies, The Physics of Low-Dimensional Semiconductors. Cambridge University Press (1998).
- John Wilson & John Hawkes, Optoelectronics: an introduction,
- E. C. Le Ru, P. G. Etchegoin, Principles of surface-enhanced Raman scattering, Elsevier (2009).

- R. Feymnman, The Feynman Lectures Vol I (2010).
- S.M. Sze, M.K. Lee "Semicoductor devices. Physics and technology" John Wiley & Sons.
- B.H. Bransden, C.J. Joachain. Quantum Mechanics. Prentice Hall.
- Serge Haroche, Jean Michael Raimond, "Exploring the Quantum: Atoms, Cavities and photons". Oxford Graduate Texts.
- Olivier Ezratty "Understanding quantum technologies" Le lab quantique.
- Christopher Gerry, Peter Knight. "Introductory Quantum Optics" Cambridge University Press.