Course Guide
43304 Fundamentals of optoelectronics

COURSE DATA

Data Subject	
Code	43304
Name	Fundamentals of optoelectronics
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2022 - 2023

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
GARRO MARTINEZ, NURIA	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)

2150 - Master's degree in Advanced Physics

- 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.
- Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.
  ?
  ?
- Poseer la capacidad para el desarrollo de una aptitud crítica ante el aprendizaje que le lleve a plantearse nuevos problemas desde perspectivas no convencionales.
  ?
  ?
- Comprender de una forma sistemática el campo de estudio de la Física y el dominio de las habilidades y métodos de investigación relacionados con dicho campo.
- Concebir, diseñar, poner en práctica y adoptar un proceso sustancial de investigación con seriedad académica.
- Realizar un análisis crítico, evaluación y síntesis de ideas nuevas y complejas en el área de la Física.
- Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.
- Evaluar la validez de un modelo o teoría propuesto por otros miembros de la comunidad científica.
- Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.

- Elaborar una memoria clara y concisa de los resultados de su trabajo y de las conclusiones obtenidas en el área de la Física.
- Exponer y defender públicamente el desarrollo, resultados y conclusiones de su trabajo en el área de la Física.
- Comprender las bases físicas de las propiedades de los materiales que determinan sus ?aplicaciones optoelectrónicas.
- Comprender cómo se modifican las propiedades optoelectrónicas de los materiales en ?medios nanoestructurados y su influencia en dispositivos optoelectrónicos/fotónicos.
- Comprender las técnicas más habituales de preparación, crecimiento y caracterización de ?materiales optoelectrónicos en monocristal, capa delgada o nanoestrucutura.
- Comprender el funcionamiento de los dispositivos optoelectrónicos a partir de las ?propiedades de los materiales y la estructura del dispositivo, así como conocer los avances ?recientes en el campo.
- Ser capaz de seleccionar los materiales y diseñar (aspectos más básicos) un dispositivos ?optoelectrónico que permita abordar una aplicación o problema planteado.

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. Single quantum dots. 2D Materials.

6. Unit 6

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

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
MD5 - Seminars.
MD6 - Visit to external scientific facilities and companies
MD7 - Addressed debate or discussion.

EVALUATION

Each student will chose to be evaluated either in a final exam or by continous marking of exercises, presentations, etc.

SE1 - Written exam on the theory and practical lectures: based on the results of learning and the specific objectives of each subject (100%).

SE3 - Continuous evaluation of students in the classes of theory and practice: participatory assistance and exercises in the classroom (50%).

SE5 - 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).
- Optoélectronique, E. Rosencher, B. Vinter, Ed. Masson, Paris (1998).
- John Wilson & John Hawkes, Optoelectronics: an introduction,
- Karl W. Böer, Introduction to space charge effects in semiconductors,

- Michael A. Parker, Physics of optoelectronics,
- E. C. Le Ru, P. G. Etchegoin, Principles of surface-enhanced Raman scattering, Elsevier (2009).