

Nanoelectronic Devices

Code: 43430
ECTS Credits: 6

Degree	Type	Year	Semester
4314939 Advanced Nanoscience and Nanotechnology	OT	0	1

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

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Anibal Uriel Pacheco Sanchez

David Jimenez Jimenez

Enrique Alberto Miranda Castellano

Prerequisites

Basic knowledge on electron devices and electronic circuit is convenient (but not mandatory).

Basic knowledge about materials and semiconductors is convenient (but not mandatory).

Objectives and Contextualisation

- 1) Get a general vision about the state-of-the-art in nanoelectronics. This will include the understanding of the most important technological drawbacks, the research goals and the main evolution trends.
- 2) Know the main fabrication techniques of electron devices, with the goal of establishing a direct link between device fabrication and its performance.
- 3) Acquire a broad view of the main simulation techniques for nanoelectronic devices, being able to determine which method is most adequate for each particular device/scenario.
- 4) Understanding the principles of operation of the most important nanoelectronic devices, including devices for high-frequency, logic and memory applications.

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
- Critically analyze the principles of operation and expected benefits of electronic devices operating at the nanoscale (nano-electronics specialty)
- Identify and distinguish the synthesis/manufacture techniques for nanomaterials and nanodevices typically adopted in 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.

Learning Outcomes

1. Choose the most appropriate simulation/modelling method for a nanoelectronic device on the basis of its physical characteristics and operational principle.
2. Continue the learning process, to a large extent autonomously
3. Describe the current state of nanoelectronic technologies and the directions in which they are moving, in accordance with the International Technology Roadmap for Semiconductors.
4. Describe the operational principles of emerging devices, and their main advantages and limitations.
5. Describe the operational principles of what are currently the main logic and memory devices.
6. Know the principles behind the techniques used for making the most important nanoelectronic devices.
7. 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.

Content

Tema 0.- Introduction: Nanoelectronic Devices Landscape

Tema 1.- Physics and simulation of nanoelectronic devices

- 1.1- Overview of simulation techniques and physical modelling
- 1.2- Thermodynamical and mechanical considerations
- 1.3- Landauer model: time-dependent and time independent models
- 1.4- Semi-Classical and quantum Monte Carlo simulation
- 1.5- Noise in nanoelectronic devices.

Tema 2.- Nanoelectronic FET devices

- 2.1- MOS structure.
- 2.2- Long channel MOSFETs.
- 2.3- Short channel MOSFETs.
- 2.4- Scaling of MOSFETs
- 2.5- Design of MOSFETs.

Tema 3.- Advanced nanoelectronic devices for logic and memory

- 3.1- Storage Class memories (FeRAM,MRAM,RRAM,,.....).
- 3.2- Memristors and Memristive Devices.
- 3.3- Neuromorphic circuits and artificial intelligence.

Tema 4.- Emerging devices based on 2D materials

- 4.1- Graphene based devices.
- 4.2- 2D materials based semiconductor devices.
- 4.3- van der Waals heterostructures.

Methodology

We will combine class lectures with autonomous homework, including the reading of research papers, solution of exercises, the critical reading of ITRS documents and the use of device simulation tools.

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			
Autonomous works and report writing	65	2.6	7
Lessons	30	1.2	
Oral presentation	6	0.24	7
Reading of research papers and other scientific documents	30	1.2	
Use of TCAD tools for electron devices	15	0.6	

Assessment

The evaluation of the subject will consist of:

- Exam at the end of courses: 45% of the NOTE
- Simulation practices: 30% of the NOTE
- Problems to resolve: 15% of the NOTE
- Reading of scientific articles: 10% of the NOTE

The student has to pass with a minimum of 5 all previous parts.

To ask for a reevaluation the student must have been received a mark in activities that represent at least 2/3 of the global mark during the course.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Characterization in the laboratory	10	0	0	6, 4, 5, 3, 7
Device simulation tools	30	0	0	5, 7, 1, 2
Final exam	45	4	0.16	6, 4, 5, 3, 7, 1

Bibliography

Campus virtual: <https://cv.uab.es/>

Bibliografia Tema 1:

Y. Taur and T. H. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 1998.

[Simon M. Sze](#), [Kwok K. Ng](#), Physics of Semiconductor Devices, 3rd Edition, Wiley, 2006

R.F. Pierret, Field effect devices (1990) Dispositivos de efecto de campo (1994)

Bibliografia Tema 2:

Fundamentals of semiconductor fabrication. G. S. May and S. M. Sze. John Wiley and Sons. 2004

Bibliografia Tema 3:

Supriyo Datta, Quantum Transport: Atom to Transistor, 2nd Edition

Cambridge University Press, New York

M. Di Ventra, Electrical transport in Nanoscale Systems, Cambridge University Press, New York

D. K. Ferry, S. M. Goodnick and J. Bird, Transport in nanostructures, Cambridge University Press

J.M.Thijssen, Computational Physics, Cambridge University Press, New York

Bibliografia Tema 4:

Rainer Waser Ed. Nanoelectronics and Information Technology. Editorial WILEY-VCH

Advances in non-volatile memory and storage technology, Woodhead Publishing Series and Optical Materials-Elsevier: 64, Ed. Y. Nishi, 2014

Memristor and memristive systems, R. Stanley Williams (auth.), Ronald Tetzlaff (eds.), Springer, 2014

Recursos WEB

<http://nanohub.org/>

<http://www.itrs.net/>

Bibliografía complementaria dispositivos electrónicos:

MODULAR SERIES ON SOLID STATE DEVICES (Addison-Wesley)

R.F.Pierret, Semiconductor fundamentals (1988) / Fundamentos de semiconductores (1994)

Gerold W. Neudeck, The PN Junction Diode (1989) El diodo PN de unión (1993)

G.W.Neudeck, The Bipolar Junction Transistor (1989) / El transistor bipolar de unión (1994)

Bibliografía complementaria circuits electronics:

P. Horowitz and W. Hill The Art of Electronics, Cambridge Editorial Univ. Press (1989)

Bibliografía complementaria dispositius optoelectronics:

Software

The software BITLLES for nanodevices simulations will be used (europe.uab.es/bitlles)