UAB
Universitat Autònoma
de Barcelona

# Nanoelectronic Devices

2026/2027

Code: 45744
Credits: 3

| Degree programme | Type | Course |
|---|---|---|
| Applied Nanoscience: From Materials to Devices | OP | 1 |

## Contact lecturer

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## Teaching staff

Enrique Alberto Miranda Castellano

Xavier Oriols Pladevall

## Group languages

You can consult this information at the end of the document.

## Prerequisites

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

## Objectives

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 nanoelectronic devices and emerging device concepts, including devices based on advanced materials, with the goal of establishing a link between device operation and their performance.

3) Adquire 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 mopst important nanoelectronic devices, including devices for biosensing, high-frequnecy, 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)
- 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

- CA28 (Calculate the behaviour of emerging nanoelectronic devices by solving different models.) Calculate the behaviour of emerging nanoelectronic devices by solving different models.
- KA29 (Describe the current state of micro- and nanoelectronic technologies and the future evolution trends of emerging nanoelectronic devices.) Describe the current state of micro- and nanoelectronic technologies and the future evolution trends of emerging nanoelectronic devices.
- SA37 (Analyse the physical principles of operation of different emerging nanoelectronic devices, as well as their main advantages and limitations.) Analyse the physical principles of operation of different emerging nanoelectronic devices, as well as their main advantages and limitations.

## Contents

Tema 1.- Physics and simulation of nanoelectronic devices

1.1 The Road to Nanoelectronics: Over a Century of Electronic Innovation

1.2 What Is an Electron? What Is an Electronic Device?

1.3 Mechanical and Thermodynamic Considerations

1.4 Overview of Simulation Models and Theories

1.5 Example: Quantum Dots for Memory and Quantum Computing

Tema 2.- Nanoelectronic FETs

2.1 MOS structure.

2.2 Long channel MOSFETs

2.3 Short channel MOSFETs

2.4 Scaling of MOSFETs

Tema 3.- Emerging devices based on 2D materials

3.1 Graphene based devices

3.2 2D materials based semiconductor devices

Tema 4.- Advanced nanoelectronic devices for logic and memory

4.1 Storage Class memories (FeRAM,MRAM,RRAM,,....)

4.2 Memristors and Memristive Devices

4.3 Neuromorphic circuits and artificial intelligence

## Learning activities and methodology

| Title | Hours | ECTS | Learning outcomes |
|---|---|---|---|
| Use of TCAD tools for electron devices | 12 | 0.48 | CA28, SA37 |
| Lessons | 19 | 0.76 | |
| Reading of research papers and other scientific documents | 13 | 0.52 | |
| Autonomous works and report writting | 28 | 1.12 | CA28, KA29, SA37 |

We will combine class lectures with autonomous homework, including the reading of research papers, solution of excercises, 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.

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## Assessment

## Continuous assessment activities

| Title | Weight | Hours | ECTS | Learning outcomes |
|---|---|---|---|---|
| Device simulation tools | 40 | 0 | 0 | CA28 |
| Final exam | 45 | 3 | 0.12 | CA28, KA29, SA37 |
| Characterization in the laboratory | 5 | 0 | 0 | CA28 |
| Solution of problems | 10 | 0 | 0 | CA28 |

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: 10% of the NOTE

- Laboratory work: 5% of the NOTE

The studewnt 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.

## Bibliography

"Campus virtual" (https://cv.uab.cat/portada/ca/index.html) will be used to upload the materials of the course as well as for communication purposes.

### Bibliografy Subject 1:

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 anmd J. Bird, Transport in nanostructures, Cambrdigee University Press

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

### Bibliografy Subject 2:

Y. Taur and T. H. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 2021.

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)

### Bibliografy Subject 3:

Science and technology roadmap for graphene, related two-dimensional crystals, and hybrid Systems, A. C. Ferrari et al., Nanoscale, 2015,7, 4598

http://pubs.rsc.org/en/content/articlelanding/2015/nr/c4nr01600a#!divAbstract

Compact modeling technology for the simulation of integrated circuits based on graphene field effect transistors, F. Pasadas et al., Advanced Materials, 20200, 34 (48), 2201691

https://advanced.onlinelibrary.wiley.com/doi/full/10.1002/adma.202201691

Bibliografy Subject 4:

Rainer Waser Ed. Nanoelectronics and Information Technology.

Editorial WILEY-VCH

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

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

WEB resources

http://nanohub.org/ ; ITRS: http://www.itrs2.net/ ; RDS: http://irds.ieee.org/ IEDM: https://www.ieee-iedm.org/

## Software

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

### Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

| Type of teaching | Group | Language | Semester | Shift |
|---|---|---|---|---|
| (TEm) Theory (master) | 1 | English | first semester | afternoon |