

Nanoelectronic Devices

Code: 43430
ECTS Credits: 6

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

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: english (eng)

Teachers

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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 1.- Nanoelectronic FET devices

- 1.1- MOS structure.
- 1.2- Long channel MOSFETs.
- 1.3- Short channel MOSFETs.
- 1.4.- Scaling and design of MOSFET.
- 1.5.- Advanced CMOS (SiNWs FET, CNT-FETs, GFETs,...).

Tema 2.- Fabrication technologies for nanoelectronic devices

- 2.1- Crystal and film growth.
- 2.2.- Oxidation, Etching, and Lithography.
- 2.4.- IC fabrication. Advanced techniques.

Tema 3.- Physics and simulation of nanoelectronic devices

- 3.1.- Overview of simulation techniques and physical modelling
- 3.2.- Classical and quantum mechanical considerations: band-structure
- 3.3.- Thermodynamical considerations: Fermi statistics
- 3.4.- Landauer model: time-dependent and time independent models
- 3.5.- Semi-classical and quantum Monte Carlo simulations.
- 3.6.- Noise in nanoelectronic devices.

Tema 4.- Advanced nanoelectronic devices for logic and memory

- 4.1.- Overview on More Moore and beyond CMOS nanoelectronic devices.

- 4.2.- Single electron devices and molecular electronics.
- 4.3.- Storage Class memories (FeRAM, MRAM, RRAM,...).
- 4.4- Memristors and Memristive Devices.
- 4.5.- Electronic devices based on graphene and related materials.

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
Device simulation tools	30	0	0	5, 7, 1, 2
Final exam	45	4	0.16	6, 4, 5, 3, 7, 1

Reading on state-of-the-art scientific papers	10	0	0	6, 4, 5, 3, 7
Solution of problems	15	0	0	3, 7, 1, 2

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 Willey 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)

Bibliografia complementaria dispositius optoelectronics:

B.E.A. Salech and M.C. Teich Fundamentals of Photonics Editorial John Wiley & Sons

Software

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