Universitat Autònoma de Barcelona

2018/2019

Nanoelectronic Devices

Code: 43430
ECTS Credits: 6

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

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 fabircation and its 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 high-frequnecy, logic and memory applications.

Skills

- 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.- Classcial 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 excercises, the critical reading of ITRS documents and the use of device simulation tools.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Autonomous works and report writting	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	

Evaluation

The final mark will combine the final exam (45%) with careful preparation of homework problems (15%), the reports of device simulations tools (30%) and the reports of state-of-the-art scientific papers (10%). A mark of 5 is needed in all the evaluated activities to make the mentioned average.

If the mark in the final exam is lower than 5 then the student will have a second recuperation exam to pass this evaluated activity. For the rest of evaluated activities (homework problems, device simulations and reports of state-of-the-art scientific papers), if the mark is lower than 5 the student will have to opportunity to repeat them.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Device simulation tools	30	0	0	1, 2, 5, 7
Final exam	45	4	0.16	1, 3, 4, 5, 6, 7
Homework reports	15	0	0	1, 2, 3, 7
Reading on state-of-the-art scientific papers	10	0	0	3, 4, 5, 6, 7

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 anmd J. Bird, Transport in nanostructures, Cambrdigee 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 Mateirals-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 electrònics:

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 complemtaria circuits electronics:

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

Bibliografía complemtaria dispositius optoelectronics:

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