Nanoelectromechanical Sytems (NEMS) 2014/2015

Code: 43432
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: anglès (eng)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Teachers

Gabriel Abadal Berini

Francesc Torres Canals

Prerequisites

Basic physics (mechanics, electrostatic, optics....). Fundamentals of electronic devices. Basic knowledge of micro and nanotechnology fabrication processes.

Objectives and Contextualisation

The module aims to give students an overview of nanoelectromechanical systems, their main properties and applications. The physical principles that govern the behavior of the NEMS and the boundaries between classical and quantum models will be also established.

Skills

- Analyse the benefits of nanotechnology products, within one's specialisation, and understand their origins at a basic level
- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- 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)
- Design, plan and carry out a research project in nanoscience and nanotechnology.
- Identify and distinguish the synthesis/manufacture techniques for nanomaterials and nanodevices typically adopted in one's specialisation.
- Identify the characterisation and analysis techniques typically adopted in nanotechnology and know the principles behind these, within 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.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

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. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
3. Continue the learning process, to a large extent autonomously
4. Describe the techniques used for making nanoelectromechanical systems.
5. Design and carry out specific characterisations to determine the physical and chemical properties in nanoelectromechanical systems
6. Design nanoelectromechanical systems based on specifications.
7. Identify the transduction principle needed for the transduction of a specific property.
8. Predict the behaviour of nanoelectromechanical systems taking into account the environment they are operating in.
9. Recognise the characterisation techniques of nanoelectromechanical systems
10. Recognise the opportunities provided by nanoelectromechanical systems for sensing in specific applications.
11. Recognise the transduction mechanisms of nanoelectromechanical systems.
12. 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.
13. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
14. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Content

1. NEMS fundamentals. Nanomechanics. Non-linear dynamics. Modal coupling and collaborative behaviour. Noise
2. NEMS fabrication and system integration (NEMS engineering)
3. NEMS transduction techniques: electrical-optical-thermal-mechanical based techniques. Self-actuation.
4. Carbon-based NEMS
5. Applications and perspectives of NEMS. NEMS for probing mesoscopic effects & quantum properties. NEMS as emerging new devices (switches, oscillators, energy harvesting, sensors)

Methodology

Theory: Oral exposition of the fundamentals concepts. Concepts will be partially introduced as specific-cases which will be discussed during the class

Laboratory: Hands-on specific tools for NEMS design and analysis

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Laboratory	10	0.4	4, 5, 6, 12, 1, 13, 2, 3
Theory	25	1	4, 5, 6, 1, 7, 8, 11, 10, 9, 14
Type: Autonomous			
Preparation of reports and oral expositions	50	2	4, 5, 6, 12, 1, 7, 8, 13, 2, 3, 10, 14

Study to assimilate concepts	55	2.2	4, 5, 6, 1, 7, 8, 13, 3, 11, 10, 9, 14

Evaluation

There will be one final written exam. Additionally there will be 2 additional homeworks which will be evaluated as oral expositions or in a written report related with the design and analysis of a specific NEMS device. Finally the evaluation will be completed with the written report on practical work.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Report and/or oral presentation	50%	8	0.32	4, 5, 6, 12, 1, 7, 8, 13, 2, 3, 11, 10, 9, 14
Synthesis Test	20%	2	0.08	4, 5, 6, 12, 1, 7, 8, 2, 11, 10, 9
Written report on practical work	30%	0	0	4, 5, 6, 12, 1, 7, 8, 2, 11, 10, 9

Bibliography

- Handbook of Nanotechnology. B. Bhushan. Springer-Verlag, (2004)
- Practical MEMS. Ville Kaajakari. Small Gear Publishing. ISBN: 978-0-9822991-0-4 (2009)
- Modeling mems and nems , Pelesko, John A., Boca Raton [etc.] : Chapman & Hall / CRC, cop. 2003
- MEMS/NEMS: handbook techniques and applications. Cornelius T. Leondes. New York : Springer, cop. (2006)
- MEMS and NEMS : systems, devices, and structures. Sergey Edward Lyshevski. Boca Raton CRC Press, cop. (2002)
- Fundamentals of microfabrication and nanotechnology. Marc J. Madou. Boca Raton, Fla. ; London : CRC, cop. (2012)