Nanoelectromechanical Sytems (NEMS)

Code: 43432
ECTS Credits: 6

<table>
<thead>
<tr>
<th>Degree</th>
<th>Type</th>
<th>Year</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>4314939 Advanced Nanoscience and Nanotechnology</td>
<td>OT</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Contact

Name: Núria Barniol Beumala
Email: Nuria.Bamiol@uab.cat

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

2. NEMS fabrication and system integration (NEMS engineering)
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

<table>
<thead>
<tr>
<th>Title</th>
<th>Hours</th>
<th>ECTS</th>
<th>Learning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type: Directed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>10</td>
<td>0.4</td>
<td>2, 12</td>
</tr>
<tr>
<td>Theory</td>
<td>25</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Type: Autonomous</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of reports and oral expositions</td>
<td>50</td>
<td>2</td>
<td>2, 12</td>
</tr>
<tr>
<td>Study to assimilate concepts</td>
<td>55</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>
Evaluation

There will be one final written exam (with qualification higher than 4 for averaging).

Additionally there will be 1 additional homeworks which will be evaluated as oral exposition 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

<table>
<thead>
<tr>
<th>Title</th>
<th>Weighting</th>
<th>Hours</th>
<th>ECTS</th>
<th>Learning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral presentation</td>
<td>50%</td>
<td>6</td>
<td>0.24</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14</td>
</tr>
<tr>
<td>Synthesis Test</td>
<td>30%</td>
<td>2</td>
<td>0.08</td>
<td>1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14</td>
</tr>
<tr>
<td>Written report on practical work</td>
<td>20%</td>
<td>2</td>
<td>0.08</td>
<td>1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14</td>
</tr>
</tbody>
</table>

Bibliography