Degree competences to which the subject contributes

Basic:
- CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.
- CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
- CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Learning objectives of the subject

- To know the structure of the surfaces and the main characterization techniques
- To understand the physical and chemical phenomena that take place on the surfaces of solid materials and their applications
- To develop the ability to modify a solid surface with desired properties
- To know how to apply the knowledge acquired to develop microreactors
- To understand the behavior of fluids at a micro scale
- To know how to design microfluidic circuits
- To know the methods of integration of microfluidic systems with MEMS sensors
- To know the operation and the main configurations of RF-MEMS micro-switches
- To learn how to analyze RF-MEMS micro-switches mechanically and electromagnetically
- To know the applications of RF-MEMS micro-switches to communication circuits
- To understand and to know how to use experimental configurations to characterize MEMS micro-switches

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 44h</th>
<th>35.20%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self study: 81h</td>
<td>64.80%</td>
</tr>
</tbody>
</table>
## Content

| 1. Physical Chemistry of surfaces | Learning time: 15h  
Theory classes: 15h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Design, preparation, characterization and applications of solid surfaces.</td>
</tr>
</tbody>
</table>

### 1.1 Introduction to surfaces

| Learning time: 2h  
Theory classes: 2h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>The surface boundaries. Surfaces at the nanoscale, microscale and macroscale. The importance of defects.</td>
</tr>
</tbody>
</table>

### 1.2 Structure of surfaces

| Learning time: 3h  
Theory classes: 3h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Ordered vs. amorphous surfaces. Epitaxial relationships. Surface vacancies</td>
</tr>
</tbody>
</table>

### 1.3 Solid-liquid and solid-gas interphases

| Learning time: 2h  
Theory classes: 2h |
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Surface reconstruction and relaxation. Adsorption and desorption phenomena.</td>
</tr>
</tbody>
</table>

### 1.4 Characterization techniques

| Learning time: 3h  
Theory classes: 3h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Surface characterization techniques. Electron microscopy techniques (HRTEM, STEM), scanning probe microscopies (AFM, STM), and spectroscopies (IR, Raman, XPS).</td>
</tr>
</tbody>
</table>
**1.5 Applications in sensors and catalysis**

**Description:**

**Learning time:** 3h  
Theory classes: 3h

---

**1.6 Functionalization of nano- and microreactors**

**Description:**
The microreactor concept. Surface activation. Plasma treatment. Surface functionalization

**Learning time:** 2h  
Theory classes: 2h

---

**2. Mechanics and Fluid mechanics at micron scale**

**Description:**

**Learning time:** 15h  
Theory classes: 15h

---

**2.1 Introduction to micromechanic and microfluidic behavior**

**Description:**
Introduction Nanotechnology and MEMS, MEMS design, and fabrication technology – Lithography, Etching, MEMS material, Bulk micromachining, Surface micromachining, Microactuator, electrostatic actuation.

**Learning time:** 3h  
Theory classes: 3h

---

**2.2 Biosensor structure**

**Description:**

**Learning time:** 2h  
Theory classes: 2h
## 2.3 Design and simulation of the biosensor fluidic behavior

**Description:**
Finite element modelling of a microfluidic mixer.

**Learning time:** 3h  
**Theory classes:** 3h

## 2.4 Design and simulation of the biosensor mechanic behavior

**Description:**
Finite element modeling of a mechanical microswitch.

**Learning time:** 3h  
**Theory classes:** 3h

## 2.5 Case studies in bioengineering and communications

**Description:**
Sample preparation microchips: From macro to micro. MEMS-based bio-chip/sensors for Molecules detection

**Learning time:** 2h  
**Theory classes:** 2h

## 3. RF-MEMS micro-devices applied to communication circuits

**Description:**
Micro-devices applied to reconfigurable RF/microwave communication circuits

**Learning time:** 15h  
**Theory classes:** 15h

## 3.1 Introduction to RF-MEMS micro-devices and planar circuits

**Description:**

**Learning time:** 3h  
**Theory classes:** 3h
| 3.2 Design and simulation of planar RF-MEMS micro-switches | **Learning time:** 3h  
**Theory classes:** 3h |
|---|---|
| **Description:**  
Micro-switch structures: ohmic contact and capacitive contact. Mechanical parameters. Equivalent electrical circuit at RF/microwave frequencies. Steady-state analysis. Simulation tools (circuit analysis) |

| 3.3 RF-MEMS micro-switch electromagnetic simulation | **Learning time:** 3h  
**Theory classes:** 3h |
|---|---|
| **Description:**  

| 3.4 Application of RF-MEMS micro-switches to reconfigurable communication circuits. Circuit simulation | **Learning time:** 3h  
**Theory classes:** 3h |
|---|---|
| **Description:**  

| 3.5 Experimental characterization of RF-MEMS micro-switches | **Learning time:** 3h  
**Theory classes:** 3h |
|---|---|
| **Description:**  
Experimental set-up. Laboratory measurement of RF-MEMS micro-switches: pull-in and pull-out voltages. Microwave OFF and ON characteristics |

## Qualification system

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1: Written exams</td>
<td>50-60%</td>
</tr>
<tr>
<td>E3: Assignments</td>
<td>40-50%</td>
</tr>
</tbody>
</table>
Bibliography

Basic:


Others resources:

- Course notes and presentations (through the UPC Atenea digital campus)
- Student license for simulation software tools