230852 - SEM - Surface Engineering and Microdevices

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2019
Degree: MASTER'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2018). (Teaching unit Compulsory)
ECTS credits: 5
Teaching languages: English

Teaching staff
Coordinator: Pradell Cara, Lluis
Others: Llorca Pique, Jordi
Casals Terre, Jasmina
Pradell Cara, Lluis

Prior skills
- Electromagnetic wave propagation. Guided waves. Transmission lines (input impedance, reflection coefficient, voltage standing-wave ratio, transmitted power, Smith chart). Impedance matching

Requirements
- Course on Electromagnetic Waves

Teaching methodology
MD1 - Master classes
MD5 - Individual assignments (written document)
MD7 - Practical exercises both theoretical resolution and using software tools (circuit/electromagnetic and electromechanical)
MD10 - Laboratory practice performed by teams

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:</th>
<th>44h</th>
<th>35.20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study:</td>
<td>81h</td>
<td></td>
<td>64.80%</td>
</tr>
</tbody>
</table>
# Content

| 1. Physical Chemistry of surfaces | **Learning time:** 15h  
<table>
<thead>
<tr>
<th></th>
<th><strong>Theory classes:</strong> 15h</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  
<table>
<thead>
<tr>
<th></th>
<th><strong>Theory classes:</strong> 2h</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  
<table>
<thead>
<tr>
<th></th>
<th><strong>Theory classes:</strong> 3h</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  
<table>
<thead>
<tr>
<th></th>
<th><strong>Theory classes:</strong> 2h</th>
</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  
<table>
<thead>
<tr>
<th></th>
<th><strong>Theory classes:</strong> 3h</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

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

**Description:**

## 1.6 Functionalization of nano- and microreactors

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

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

## 2. Mechanics and Fluid mechanics at micron scale

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

**Description:**

### 2.1 Introduction to micromechanic and microfluidic behavior

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

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

### 2.2 Biosensor structure

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

**Description:**
### 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
### Qualification system

<table>
<thead>
<tr>
<th>Exam</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>

### 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
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Bibliography

Basic:


Others resources:

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