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:** 2018  
**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></td>
<td>Self study:</td>
<td>81h</td>
<td>64.80%</td>
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</table>
## 1. Physical Chemistry of surfaces

**Description:**
Design, preparation, characterization and applications of solid surfaces.

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

### 1.1 Introduction to surfaces

**Description:**
The surface boundaries. Surfaces at the nanoscale, microscale and macroscale. The importance of defects.

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

### 1.2 Structure of surfaces

**Description:**
Ordered vs. amorphous surfaces. Epitaxial relationships. Surface vacancies

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

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

**Description:**
Surface reconstruction and relaxation. Adsorption and desorption phenomena.

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

### 1.4 Characterization techniques

**Description:**
Surface characterization techniques. Electron microscopy techniques (HRTEM, STEM), scanning probe microscopies (AFM, STM), and spectroscopies (IR, Raman, XPS).

**Learning time:** 3h
**Theory classes:** 3h
### 1.5 Applications in sensors and catalysis


**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:** Introduction to Fluid mechanics. Newtonian, non-Newtonian fluids. Flow over infinite plates, laminar and turbulent flow. Compressible and Incompressible flows. Types of flows. Flow rate calculations.

**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:** Review of sensing principles and micro/nano devices for bio-sensing  
 a. Basic principle of biosensors.  
 b. Bioelectric potentials and typical bio-targets.  
 c. Amperometric, potentiometric and impedimetric biosensors.  
 d. Electrochemical sensors and FET-based biosensors.  
 e. Acoustic and piezoelectric biosensors.  
 f. Optical biosensors

**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

E1: Written exams: 50-60%  
E3: Assignments: 40-50%
Bibliography

Basic:


Others resources:

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