



# **Fundamentals of Biosensors and Electronic Biochips. EE515 EPFL Master**

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# Introducing myself

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Office hours: by appointment

# Rational of the course (1/2)

- The field of biosensors and biochips covers a wide range of applications such as
  - the detection and analysis of **molecular interactions**, **membrane interactions** and **cells properties**.
  - the sample preparation though separation of biological species and enrichment or amplification of specific targets.
  - the manipulation of biological material at the microscopic and nanoscopic scale.

We will discuss the drivers in these fields and the existing limitations.

- The course is intended to present a number of relevant (consolidated or emerging) **biosensing techniques** employed in commercial and research fields and to give insights of the **underlying physical and chemical phenomena**.

# Rational of the course (2/2)

- We will discuss specific issue related to the packaging and interfacing techniques to make the sensors compatible with different application environments.
- We want to
  - support you in acquiring the capability of evaluating new biosensors and biochip discoveries and technologies both in terms of the innovative content and their compliance with the application needs.
  - provide you with tools (knowledge/models/math) for the design of experiments and devices.

# Structure

- 3 credits
- 2/3 Frontal lecture. 1/3 exercises (Prepare the exercises in advance and discuss them at the exercise session).

# Teaching material

- Handouts discussed during the course (available on moodle).
- Exercises text and solutions
- Scientific papers
- Selected material from the following books (available on moodle and at the library):
  - *Intermolecular and Surface Forces*, J. Israelachvili, Academic press
  - *Surface Plasmon resonance Based Sensors*, J.Homola et al., Springer
  - *Surface Design: Applications in Bioscience and Nanotechnology*, R. Forch, H. Schonherr, A.T. Jenkins, Wiley
  - *Bioelectronics: From Theory to Applications*, I. Willner, E. Katz, Wiley

# Evaluation

- Written exam (winter session). 3/4 of the grade. Open book.
- Report and presentation (groups of 4 students). 12-minute presentation per group, 5 minutes questions: Final part of the semester. (1/4 of the grade)

# Organization of the lectures

- **Lectures:** Wednesday 1:15 pm – 3 pm.
- **Exercises:** Wednesday at 3:15 pm
- We will schedule **group presentations** on the last 2-3 weeks of the course on projects assigned.

**(1) Introduction and syllabus**

**Analytical Biosensors**

**(2) Analytical performance of biosensors**

Definition of biosensor and biochips. Examples.

Definitions of performance parameters of a biosensors such as sensitivity, selectivity and limit of detection.

**(3) Surface ligand binding biosensors**

Fundamental mechanisms and laws that regulate the binding of target molecules to ligands arranged on a surface.

Miniaturization of the sensing area

Peculiarities and effects of scaling the surface size

**(4) Assay configurations, matrix-dependent performance**

Classifications and configurations of molecular assays

Homogenous and heterogeneous

Direct, sandwich, competition, inhibition assays

Main issues and performance-limiting factors in surface sensing

Techniques for the creation of patterns of molecular ligands on the surface of a sensor- Biosensors arrays

**Microfluidics systems**

**(5) Sensor performance in presence of convection**

Physical and biochemical phenomena predominant in microfluidic sensing devices.

How to evaluate the sensing speed and performance of a sensor working in flow conditions.

## Applications in Diagnostics

(6) **Binary Diagnostic tests (screening assays) and quantitative test**

(7) **Lab-on-a-chip systems**

## Micro and nanodevices

(8) **Solid-liquid interfaces: Electrodes**

Bioanalytics with Electrodes

Cell-electrode interface

Electrical impedance spectroscopy and other electrochemical techniques

(9) **Field-effect transistors**

Oxide/liquid interfaces

Chemical and biological sensing

Complex systems for Nucleic acid sequencing

## **Prototyping, packaging and commercialization**

### **(10) Translation and Commercialization of biosensors.**

Dr. Fabien Rebeaud. Director Biomedical Sciences @ [Liom](#)

### **(11) Certification for biomedical devices**

Dr. Pierre-Emmanuel Thiriet @Rea Diagnostics

### **(12) Microfluidics, electronics and packaging interfaces to bring a biosensor to the end-user**

Dr. Erick Garcia Cordero @Rea Diagnostics