Biomedical Microdevices

Academic Year: (2021 / 2022) **Review date: 09-06-2021**

Department assigned to the subject: Bioengineering and Aeroespace Engineering Department

Coordinating teacher: MUÑOZ BARRUTIA, MARIA ARRATE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is strongly advised to have completed:
- Introduction to the design of biomedical instrumentation; and
- Medical instrumentation and devices.

OBJECTIVES

The goal of this course is to provide the students with a comprehensive understanding of the biophysical and chemical principles of biomedical micro-electro-mechanical systems, also known as BioMEMS, and their applications in multidisciplinary fields as medicine, clinical sciences and surgery, material sciences and engineering.

The study of the basis of microfabrication techniques, micropatterning, microfluidic systems and biosensors, will be completed with examples of real applications of BioMEMS such as: biomechanical, optical and electrochemical transducers used for in vivo and in vitro measurements, microdevices for molecular and cell biology, microfabricated approaches for analysis and diagnosis, hybrid technologies oriented to tissue microengineering and organ development, implantable microdevices based on biomedical microelectronics, microtools for surgery, point-of-care devices and world-to-chip interfacing and packaging processes.

In particular, at the end of the course, each student will be able to:

- Integrate knowledge of life and medical science learned in previous courses to create implementable solutions to microengineering problems.
- Select appropriate materials for the construction of biomedical microdevices.
- Understand the basic principles on the microfabrication and systems integration of BioMEMS devices.
- Design and construct simple microfluidic systems and perform experiments using these devices.
- Describe different biosignal transduction mechanisms and choose the appropiate one for a given application.
- Have an appreciation and understanding of the technical challenges and opportunities that biomedical microdevices brings to life and medical sciences.
- Function effectively as a part of a group on the practical sessions and problem solving sessions.
- Acquire through reading, practice exercises, and self-initiated research technical knowledge related to the course content, including the emerging applications of biomedical microdevices.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction

Part I. BioMEMS fundamentals
2. BioMEMS Materials
3. Microfabrication methods and processes for BioMEMS
4. Microfluidic systems
5. Lab-on-a-Chip or Micro Total Analysis Systems
6. Sensing and detection methods

Part II. BioMEMS applications
7. 'Chips' for or biotechnology and molecular biology
8. BioMEMS for cell biology
9. Clinical monitoring and therapeutic intervention

Part III. Practical sessions

1. Design of a PDMS microdevice
2. PDMS microdevices fabrication and characterization
3. Paper microfluidics design and characterization
4. Glucometer design and calibration
5. Flexible electronics
6. Analysis of flow cytometer data

LEARNING ACTIVITIES AND METHODOLOGY

Teaching methodology will be mainly based on lectures, seminars and practical sessions.

LECTURES:
Due to the large amount of topics covered and their multidisciplinary nature, it is very convenient that the student read the assigned documentation before the lectures and when required, complement it provided with additional information through personal work.

1) Lectures: They will be used by the teachers to stress and clarify some difficult or interesting points from the corresponding lesson, previously prepared by the student.

2) Seminars: They will be mainly dedicated to presentations given by invited speakers related with the course subject and interactive discussions with the students. During the discussion sessions, exercises will be given and solve in small groups of 2-3 students. In some occasions, the exercises will be assigned as homework. All assignments are due by the corresponding deadline through the course platform.

3) Oral presentations: At least once during the course each student will have the chance to do a short oral presentation on a topic related to the course. These oral presentations will be prepared either individually or in groups of two and have a duration of approximately 15 minutes per student.

Help sessions and tutorial classes will be held prior to the final exam. Attendance to lectures, short-exams or submission of possible homework is not compulsory.

PRACTICAL SESSIONS:
The practical sessions may consist on visits to research or clinical centers or laboratory work.

1) Visits to research or clinical centers: These visits to centers designing, fabricating or using bioMEMS will aim to expose the students to the practicalities of the subject. To consolidate the learned concepts, the students will prepare a short report about the visit.

2) Laboratory practices: For these sessions, each experiment will be performed in groups of no more than three students. During these sessions simple experiments will be done to familiarize the students with simple BioMEMS devices. Experimental data will be obtained, analyzed and presented as a scientific report.

The attendance to practical sessions is mandatory.

Tutorship sessions and schedule will be announced in Aula Global.

ASSESSMENT SYSTEM

Grading will be based on continuous evaluation (including short-exams, practical sessions, and student participation in class and Aula Global) and a final exam covering the whole subject. In particular,

CONTINUOUS EVALUATION:
It accounts for up to 60% of the final score of the subject, and includes three components:

1) Short-exams (20% of the continuous evaluation mark): These exams will take place mostly during seminars, and will be announced at least one week in advance. Results of these exams will constitute the core of the continuous evaluation. Failure to attend the exams will result in a mark of zero in the corresponding continuous evaluation block.

2) Practical sessions (30% of the continuous evaluation mark): They will be assessed through a laboratory notebook, laboratory reports and/or questionnaires that will be handed in at the end of each practical session. Attendance to at least 80% of the practical sessions is mandatory and it is the handling of the laboratory reports on time; otherwise the score will be zero in this item.

3) Student participation (50% of the continuous evaluation mark): Within this category, we will have grades for the Oral Presentation each student will make and homework assignments (quizzes or

exercises to be solved in groups or individually). It will also be included the contribution to seminars and the fórum in Aula Global. The student¿s attitude and the participation to other activities proposed by the teachers will be also taken into account in this continuous evaluation block.

FINAL EXAM:
The final exam will cover the whole subject and will account 40 % of the final score. The minimum score in the final exam to pass the subject is 4.0 over 10, notwithstanding the mark obtained in continuous evaluation.

EXTRAORDINARY EXAMS:
The mark for students attending any extraordinary examination will be the maximum between:
a) 100% extraordinary exam mark, or
b) 40% extraordinary exam mark and 60% continuous evaluation if it is available in the same course.

ACADEMIC CONDUCT:
Unless specified, all exams will be closed-book, closed-notes, no PC or mobile phone, or anything else other than a writing implement and the exam itself. Plagiarism, cheating or other acts of academic dishonesty will not be tolerated. Any infractions whatever will result in a failing grade.

% end-of-term-examination:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

BASIC BIBLIOGRAPHY

- Albert Folch Introduction to BioMEMS, CRC Press, 2013
- Ellis Meng Biomedical Microsystems, CRC Press, 2011

ADDITIONAL BIBLIOGRAPHY

- Simona Badilescu, Muthukumaran Packirisamy BioMEMS: Science and Engineering Perspectives, CRC Press, 2016
- Stephen D. Senturia Microsystems Design, Kluwer Academic Publishers, 2001