Course guide
2301212 - MS - Microsensors

Last modified: 29/05/2025

Unit in charge:	Barcelona School of Telecommunications Engineering
Teaching unit:	1022 - UAB - (ANG) pendent.
Degree:	MASTER'S DEGREE IN SEMICONDUCTOR ENGINEERING AND MICROELECTRONIC DESIGN (Syllabus 2024). (Optional subject).

Academic year: 2025 **ECTS Credits:** 4.0 **Languages:** English

LECTURER

Coordinating lecturer: GABRIEL ABADAL

Others:
Segon quadrimestre:
GABRIEL ABADAL - 11
ANTONI BALDI COLL - 11
NURIA BARNIOL BEUMALA - 11
JAUME ESTEVE TINTÓ - 11
EDUARD LLOBET VALERO - 11
FRANCESC TORRES CANALS - 11

PRIOR SKILLS

Advanced knowledge of physics and maths

LEARNING RESULTS

Knowledges:
KT01. Identify semiconductor devices, technological processes, the most appropriate microelectronic design tools, and relationships between these elements in order to integrate a given product or system into microelectronic technologies.
KT02. Describe the current state of scientific research and microelectronic industrial technology worldwide and their economic, social and environmental impact.
KT03. Describe the physical principles underlying current semiconductor devices in relation to their application, as well as their emerging trends, modelling and characterisation techniques.
KT04. Identify and describe the different manufacturing and characterisation processes in microelectronics and their applicability according to the functional and cost requirements of the final integrated product.
KT05. Describe the main methods and tools used to design integrated circuits and systems in accordance with the required functional specifications and cost of the final integrated product.
KT06. Identify and describe the main verification and test strategies for integrated circuits and systems according to their application.

Skills:
ST01. Design integrated devices, circuits and systems for new products according to their applications, taking into account sustainability and energy efficiency requirements.
ST02. Apply the manufacturing techniques and processes and design, simulation and characterisation tools of semiconductor engineering and microelectronic design to provide a solution to a specific integrated system proposal.
ST04. Select appropriate sources of information from the scientific and technical literature, using appropriate channels, and integrate this information, demonstrating the ability to synthesise information, analyse alternatives and engage in critical debate.
ST06. Plan the different activities involved in successfully carrying out an assigned task within a team, managing time and resources appropriately.

Competences:
CT01. Design new devices and integrated systems that require the use of manufacturing techniques specific to microelectronic technologies or the use of microelectronic design tools.
CT02. Apply sustainability criteria to projects based on integrated microelectronic products.
CT03. Apply the processes of semiconductor engineering and microelectronic design to fields in diverse areas of science or engineering where integrated systems are required.
CT04. Generate questions and hypotheses, propose methodologies to address new research and innovation challenges, and demonstrate originality in approaching and solving problems requiring integrated solutions in microelectronic technologies.

TEACHING METHODOLOGY

Theory: Oral exposition of the fundamentals concepts.
Laboratory: Hands-on specific tools for MEMS design and analysis. Finite elements simulations

LEARNING OBJECTIVES OF THE SUBJECT

1. To give a global vision of microsensors and MEMS technologies. Terminology and basic concepts.
2. To state the basic equations for the analysis and design of the fundamental mechanical structures.
2. To describe the phenomenology and transduction principles which are the bases of the MEMS structures operation in microsensors.
4. To identify the most relevant examples of state-of-the-art applications of microsensors.
5. To apply the simulation techniques for the analysis and design of microsensors.

STUDY LOAD

Type	Hours	Percentage
Hours large group	18,0	18.00
Hours small group	12,0	12.00
Self study	70,0	70.00

Total learning time: 100 h

CONTENTS

1. Introduction to microsensors

Description:
basic concepts, MEMS, typologies, and applications

Full-or-part-time: 2h
Theory classes: 2h

2. Basic mechanical structures for MEMS systems

Description:
beams and membranes. Elasticity theory. Static and dynamic performance.

Full-or-part-time: 4h
Theory classes: 4h

3. Transducers

Description:
materials, mechanisms and devices. Piezoresistive, piezoelectric, electrostatic, electromagnetic, optical, thermal.

Full-or-part-time: 4h
Theory classes: 4h

4. Microsensors and microactuators

Description:
a. Inertial: accelerometers, gyroscopes, magnetometers, IMUs.
b. Ambient: temperature, pressure, gas, humidity, VOC, particles.
c. Acoustics: microphones, microspeakers, SAW, BAW, PMUTs.
d. Biosensors: chemical sensors, electrochemical sensors.

Full-or-part-time: 8h
Theory classes: 8h

Lab sessions

Description:
Development of a MEMS microsensor to address a specific functionality, including design, simulation (mechanics and transduction), fabrication process proposal to demonstrate its viability.
a. Conceptualization of the proposal and basic design of the solution.
b. FEM simulation of the structure. Modelling and simulation of transducing elements. FEM simulation tools. Simulations domains: mechanical, electromagnetic, thermal, optical, fluidic, acoustic. Modelling and simulation at the system level.
c. Characterization at LAB of a fabricated microsensor.

Specific objectives:
Microsensors course aims to provide a wide overview of the microsensors and MEMS technology, from the most basic concepts of elasticity theory and main transducing mechanisms to their more advanced applications in the fields of physical sensors, ambient sensors and biosensors, through the discussion of state-of-the-art examples

Full-or-part-time: 12h
Laboratory classes: 12h

GRADING SYSTEM

Examination: course work (reports/exposition of laboratory work, exercises/problems) (60%) + written exam (40%).

BIBLIOGRAPHY

Basic:

- Senturia, S.D. Microsystems design [on line]. New York: Springer, 2001 [Consultation: 14/06/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/b117574. ISBN 9780306476013.
- Lobontiu, N.; Garcia, E. Mechanics of microelectromechanical systems [on line]. New York, NY: Springer US, 2005 [Consultation: 14/06/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/b100026. ISBN 9780387230375.
- Göpel, W.; Hesse, J.; Zemel, J.N. Sensors: a comprehensive survey: vol.7: mechanical sensors. Weinheim ; New York: F.R.G. ; VCH, 1993. ISBN 9783527267736.
- Baltes, H.; Göpel, W.; Hesse, J. Sensors update. Wiley-VCH, 1996. ISBN 9783527294336.
- Kaajakari, V. Practical MEMS. 2nd ed. Las Vegas: Small Gear Publishing, 2024. ISBN 9780982299111.
- Vigna, B.; Ferrari, P.; Villa, F.F.; Lasalandra, E.; Zerbini, S. (eds). Silicon sensors and actuators: the Feynman roadmap [on line]. Switzerland: Springer, 2023 [Consultation: 14/06/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-030-80135-9. ISBN 9783030801359.