Course guide
2301204 - SD - Semiconductor Devices

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:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: DAVID JIMÉNEZ JIMÉNEZ

Others: Primer quadrimestre:
ESTEVE AMAT BERTRÁN - 11
BENJAMÍ IÑIGUEZ NICOLAU - 11
NIKOLAOS MAVREDAKIS - 11

PRIOR SKILLS

Basic knowledge of electronic properties of semiconductors and basic buidling blocks made with semiconductors

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.
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

Classroom lectures: 39 h
Lab sessions: 9 h
Places of lab sessions: UAB, CNM, URV - online
Autonomous work of the student: 90 h

LEARNING OBJECTIVES OF THE SUBJECT

1. To be able to recognize and devise potential solutions for the challenges faced by the microelectronic industry in the context of transistor scaling.
2. To be able to design a well-tempered transistor for targeted circuit performance in the digital / analog / RF domain recognizing the common trade-off between power dissipation and performance.
3. To be able to extract transistor model parameters for a given fabrication technology.
4. To acquire hands on practice in device characterization of incumbent transistor technologies.

STUDY LOAD

Type	Hours	Percentage
Self study	102,0	68.00
Hours large group	39,0	26.00
Hours small group	9,0	6.00

Total learning time: 150 h

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CONTENTS

Semiconductor Devices

Description:
*MOSFET physics
Brief review of the long-channel MOSFET physics. Short-channel effect. High-Field Transport. MOSFET Threshold Voltage and Channel Profile Design. MOSFET degradation and breakdown at high fields

*CMOS performance factors
MOSFET scaling. Basic CMOS circuit elements. Parasitic elements: S/D resistance, G resistance, parasitic capacitances, interconnect R and C. CMOS delay and sensitivity to device parameters. Performance factors of FETs in RF circuits.

*Performance factors of FETs in memories
SRAM, DRAM, non-volatile memory: memory speed, memory retention time, memory endurance, power dissipation, power supply voltages, memory cell size, scaling properties.

*Silicon-on-insulator (SOI) and multiple-gate FETs
SOI MOSFETs: Fabrication technology. Key advantages respect to the bulk CMOS technology. Physics and engineering of SOI MOSFETs in the context of scaling. Multiple-gate FETs (FinFETs, Nanosheet FET, Vertical Nanowire FET): Fabrication technology. Key advantages. Physics and engineering of Multiple-gate FETs in the context of scaling.

*FET engineering
Technological innovations to leverage the benefits of scaling: strained materials, high-k dielectrics, metal gate electrodes, ultra-thin body SOI, multiple-gate architectures, III-V materials, low-dimensional materials, low-T CMOS.

*Connecting FET technology with circuit performances
Compact modeling for DC, frequency domain, time domain, and noise analysis. Parameter extraction

*Other advanced transistors and device research directions
HEMTs for RF and power circuits. BiCMOS for analog and mixed-signal applications. Tunnel-FETs for low-power switching applications. Research directions from the device perspective: roadmap for logic / memories / analog / RF.

Full-or-part-time: 48h
Theory classes: 39h
Laboratory classes: 9h

GRADING SYSTEM

Subject evaluation: course work (40%) + exam (60%)

BIBLIOGRAPHY

Basic:
- Tsividis, Y.; McAndrew, C. Operation and modeling of the MOS transistor. 3rd ed. New York : Oxford: Oxford University Press, 2011. ISBN 9780195170153.
- Sze, S.M.; Li, Y.; Ng, K.K. Physics of semiconductor devices. Fourth edition. Hoboken, N.J.: Wiley, 2021. ISBN 9781119429111.
- Taur, Y.; Ning, T.H. Fundamentals of modern VLSI devices. 3rd ed. United Kingdom: Cambridge University Press, 2022. ISBN 9781108480024.

Complementary:
- Gindelblat, G. Compact modeling: principles, techniques and applications [on line]. Springer, 2010 [Consultation: 18/11/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-90-481-8614-3. ISBN 9789048186136.