UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

ELECTRONIC INSTRUMENTATION AND TECHNOLOGIES	
Enrollment year	2021/2022
Academic year	2021/2022
Regulations	DM270
Academic discipline	ING-INF/01 (ELECTRONICS)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	ELECTRONIC ENGINEERING
Curriculum	Microelectronics
Year of study	1°
Period	1st semester (27/09/2021 - 21/01/2022)
ECTS	9
Lesson hours	75 lesson hours
Language	ENGLISH
Activity type	WRITTEN AND ORAL TEST
Teacher	RATTI LODOVICO (titolare) - 3 ECTS RATTI LODOVICO (titolare) - 3 ECTS CABRINI ALESSANDRO - 3 ECTS
Prerequisites	Basics of: physics and thermal sciences; chemistry; electrical networks; electronics (including basics of pn junction, MOS transistor and bipolar junction transistor, fundamental electronic circuits, and the operational amplifier, its basic application principles included). Additional lectures can be agreed with interested students to refresh missing background prerequisites.
Learning outcomes	The main purpose of the course is to provide the student with the basics of silicon monolithic integrated circuit fabrication technology and specialized instrumentation for device and circuit characterization. At the end of the course, the student is expected to know the basics of monolithic integration technology (in particular, of CMOS fabrication processes) and be able to evaluate the impact of integration technology

on the design and the performance of integrated circuits. The student is also expected to be capable of understanding the main specifications of advanced electronic instrumentation and the most critical points in their design as well as of selecting a measuring instrument for a given application. The course is intended for students who will carry on their future professional activity in the areas of design, production, application, and management of integrated circuits and devices, equipments, and systems including such circuits, as well as in those areas which involve the design and/or the use of electronic instrumentation.

Course contents

1) Silicon planar technology
Semiconductors. Silicon. Silicon ingot fabrication and wafer preparation. Basic processing steps for silicon planar technology: thermal oxidation; thermal diffusion; ion implantation; chemical vapour deposition; physical vapour deposition (vacuum evaporation, sputtering); other thin film deposition techniques; epitaxy; annealing; gettering; lithography (selective exposure, exposure techniques, mask making; selective etching); advanced exposure techniques. Planarization. Clean rooms.

2) Integrated circuit packaging
Production flow from fabricated wafer to packaged die. Yield; yield at the wafer level. Testing (parametric testing; wafer sort; final testing). Packages for integrated circuits: metallic, ceramic, and plastic packages. Assembly and packaging process. Use of non encapsulated devices. Multi-chip modules.

3) Monolithic integration technologies
Bipolar fabrication technology. MOS technology; CMOS fabrication process: technology with localized oxidation isolation and aluminum metallization; technology with shallow trench isolation and copper metallization. Mixed bipolar-CMOS fabrication technologies. Electrostatic discharges and snap-back in MOS integrated circuits; latch-up in CMOS integrated circuits.

4) Instrumentation for semiconductor device and passive component characterization
Semiconductor parameter analyzers. Semi-automatic bridges for impedance measurement.

5) Instrumentation for circuit analysis in the time domain
Digital storage oscilloscopes. Digital pattern generators. Logic and timing analyzers.

6) Instrumentation for circuit analysis in the frequency domain
Real-time (multichannel) spectrum analyzers. Signal analyzers. Swept-frequency (tunable filter or superheterodyne) spectrum analyzers.

7) Noise sources in electronics devices

8) Instrumentation for noise measurement in single devices
Noise measurement in single devices. Instrumentation for noise measurement in field-effect transistors. Instrumentation for noise measurements in bipolar transistors.

	9) Instrumentation for charge measurement from capacitive detectors Capacitive detectors. Optimum chain for processing the charge signal from capacitive detectors: charge preamplifier and shaper. Equivalent noise charge (ENC). Equivalent noise charge measurement. Shaping filter optimization. Minimum noise design of charge preamplifiers. 10) Instrumentation for event timing and time interval measurement. Methods for event timing: leading-edge, adaptive threshold, zero-crossing. Walk and jitter errors in event timing. Time interval measurements: direct digitization, time-to-amplitude conversion, time-to-amplitude conversion with time expansion, interpolation (time vernier). Time-to-digital converters.
Teaching methods	Lectures (hours/year in lecture theatre): 61 Practical class (hours/year in lecture theatre): 10 Practicals / Workshops (hours/year in lecture theatre): 5 Classroom lectures are given by means of transparencies, power point presentations and/or at the blackboard. Numerical exercises (regarding the part of the course on electronic instrumentation) are concerned with the analysis of a few case studies, focusing in particular on the subject of noise in electronic circuits. Practical activities aim at demonstrating and discussing electronic parts and components (for the part of the course on electronic technologies) and involving the students in the use of advanced instrumentation for circuit and electronic component characterization (for the part of the course on electronic instrumentation).
Reccomended or required readings	Lecture notes on integrated circuit fabrication technology (items 1, 2, and 3 of the program): G. Torelli and A. Cabrini. Introduction to Silicon Integrated Circuit Technology. 2019. Lecture notes and transparencies on electronic instrumentation (items 4 to 10 of the program). For better details: R. C. Jaeger. Introduction to Microelectronic Fabrication, 2nd Edition. Prentice-Hall, Upper Saddle River, NJ, USA, 2002. For better detail on the part of the program regarding integrated circuit technology. J. D. Plummer, M. D. Deal, P. B. Griffin. Silicon VLSI Technology: Fundamental, Practice and Modeling. Prentice-Hall, Upper Saddle River, NJ, USA, 2000. For more details on integrated circuit technology. C. Y. Chang, S. M. Sze. ULSI Technology. The McGraw-Hill Companies, New York, NY, USA, 1996. For more details on integrated circuit technology, together with the textbook just below. S. M. Sze. VLSI Technology. McGraw-Hill International Editions, 1988. For more details on integrated circuit technology, together with the textbook just above.

	N. Kularatna. Digital and Analogue Instrumentation. The Institution of Electrical Engineers, London, 2003. C. F. Coombs, Jr. Editor. Electronic Instrumentation Handbook. McGraw-Hill, New York, 1999. J. J. Carr. Elements of Electronic Instrumentation and Measurements. McGraw-Hill, Inc, 1996. W. D. Cooper, A. D. Helfrick. Electronic Instrumentation and Measurements Techniques. Prentice-Hall International, Inc., 1985.
Assessment methods	Oral examination, divided in two parts, one regarding the part of the course on electronic technologies, the other regarding the part of the course on electronic instrumentation. For the part concerning electronic technologies, the exam aims at assessing the student skills on the contents illustrated during the course; during the exam, some components and/or electronic parts will also be provided to the student for discussion. For the electronic instrumentation section, the exam aims at testing the student skills, in particular her/his ability to correctly evaluate the characteristic of measurement instrumentation, also with reference to specific applications. The Examination Commission can decide that the oral examination be preceded by a written examination. The two parts of the exam (i.e. the part on electronic technologies and the part on electronic instrumentation) may also be independently taken in different dates. The final mark will result as the weighted average (according to the number of CFUs) of the marks achieved in the two parts of the exam.
Further information	
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile