COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Microsystems

2. Date despre disciplină

2.1 Course name (ro) (en)				Simularea dispozitivelor şi proceselor electronice în microsisteme integrate Simulation of electronic devices and processes in integrated microsystems			
2.2 Course Lecturer				Prof. Dr. Babarada Florin			
2.3 Instructor for practical activities							
2.4 Year of studies	1	2.5 Semester	1	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type	S	2.9 Course code		4		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	3	Out of which: 3.2 course	2	3.3 seminary/laboratory		1
3.4 Total hours in the curricula	42	Out of which: 3.5 course	28	3.6 seminary/laboratory		14
Distribution of time:						hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.						42
Tutoring						10
Examinations						4
Other activities (if any):						2

3.7 Total hours of individual study	58.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	· Completion and/or promotion of the following subjects: Electronic Devices, Fundamental Electronic Circuits, Microelectronic Technologies, Spice Device Modeling, MCMA, Advanced Modeling of MOS Transistors, Sensors and Microsensors Courses, Modeling and Experimental Characterization of Integrated Microstructures.

4.2 Results of learning	Accumulation of the following knowledge: General knowledge of physics, microelectronic technologies, electronic sensors and modeling of advanced active electronic devices, as well as simulation software packages such as Spice and Silvaco.

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	The course will take place in a room equipped with video projector and computer.
5.2 Seminary/ Laboratory/Project	• The project will take place in a room with specific equipment, which must include: Computer room with specific TCAD software.

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

The discipline familiarizes students with the manufacturing technologies of integrated circuits adapted to the manufacturing of microsystems, respectively the microprocessing techniques on the surface and in volume, extending the techniques and software tools they learned in microelectronics to the development methods of new technologies, devices and microsystems such as experiment design and modeling response surface.

Creating skills to apply knowledge of modeling, simulation, optimization and design of a wide range of integrated microsystems. Creating the skills to apply general knowledge in modeling, simulation, optimization and design of specific applications using integrated software environments such as Silvaco's TCAD-Omni.

Extending the understanding of electrical phenomena from the level of devices and electronic circuits to integrated microsystems. Knowledge of microelectronics is expanded by approaching electromechanical-MEMS microsystems, microfluidics, bio-nano-electronics, solar cells, bolometers, microsensors and transparent electronics.

Familiarization with the current products in the field of microsystems, including the specialized literature and journals.

Acquiring the practical skills of modeling, simulation, optimization and designing a wide range of microsystems using integrated environments, investigation with optical techniques, maturators and parameter extraction, generation of design rules.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	Demonstrates basic and advanced knowledge of abc Correlates modeling, simulation, design and characterization knowledge Apply knowledge in practice It applies standardized methods and tools, specific to the field, to carry out the evaluation and diagnosis process of a situation, depending on the reported problems, and identifies solutions. It argues and analyzes coherently and correctly the context of application of the basic knowledge of the field, using key concepts of the discipline and the specific methodology. Oral and written communication in Romanian: uses the scientific vocabulary specific to the field, in order to communicate effectively, in writing and orally. Oral and written communication in a foreign language (English): demonstrates understanding of subject-related vocabulary in a foreign language.
Transversal (General) Competences	Works in a team and communicates effectively, coordinating efforts with others to solve problem situations of medium complexity. Autonomy and critical thinking: the ability to think in scientific terms, search and analyze data independently, and draw and present conclusions / identify solutions. Ability to analyze and synthesize: presents the acquired knowledge in a synthetic way, as a result of a process of systematic analysis. Respect the principles of academic ethics: correctly cite the bibliographic sources used in the documentation activity. Puts elements of emotional intelligence into practice in the appropriate social-emotional management of real-life/academic/professional situations, demonstrating self-control and objectivity in decision-making or stressful situations.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* • Modeling, Simulation, Optimization, Design, Manufacturing, Characterization, Calibration of models. • Defines domain-specific notions. • Describes/classifies notions/processes/phenomena/structures • Highlights consequences and relationships.

Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* Selects and groups relevant information in a given context. • Reasonably uses specific principles in order to abc. • Work productively in a team. • Elaborate a scientific text. • Experimentally verifies identified solutions. • Solve practical applications. • Adequately interpret causal relationships. • Analyze and compare abc. • Identifies solutions and develops solution/project plans. • Formulates conclusions to the experiments carried out. • Argue the identified solutions/solutions.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Select appropriate bibliographic sources and analyze them. • Respect the principles of academic ethics, correctly citing the bibliographic sources used. • Demonstrates responsiveness to new learning contexts. • Demonstrates collaboration with other colleagues and teaching staff in carrying out teaching activities • Demonstrates autonomy in organizing the learning situation/context or the problem situation to be solved • Demonstrates social responsibility through active involvement in student social life/involvement in academic community events • Promotes/contributes through new solutions related to the specialized field to improve the quality of social life. • Realizes the value of his contribution in the field of engineering to the identification of viable/sustainable solutions to solve problems in social and economic life (social responsibility). • Apply principles of professional ethics/deontology in the analysis of the technological impact of the proposed solutions in the specialized field on the environment. • Analyzes and capitalizes on business/entrepreneurial development opportunities in the specialized field. • Demonstrates real-life situation management skills (collaborative vs. conflict time management).

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

Starting from the analysis of students' learning characteristics and their specific needs, the teaching process will explore both expository teaching methods such as lecture, exposition, and conversational-interactive, based on discovery learning models facilitated by direct and indirect exploration of reality such as experiment, demonstration, modelling, but also on action-based methods such as exercise, practical activities and problem solving.

In the teaching activity, lectures will be used, based on Power Point presentations or different videos that will be made available to the students. Each course will start with a recap of the chapters already covered, with an emphasis on the concepts covered in the last course.

Presentations use images and diagrams so that the information presented is easy to understand and assimilate.

This discipline covers information and practical activities intended to support students in their learning efforts and the development of optimal collaboration and communication relationships in a climate favorable to learning through discovery, similar to the activity in a company.

It will be considered the practice of active listening and assertive communication skills, as well as feedback construction mechanisms, as ways of regulating behavior in various situations and adapting the pedagogical approach to the students' learning needs.

The ability to work in a team will be practiced to solve different learning tasks, similar to the activity in a company.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction: Carrier transport in semiconductors, Semiconductor devices, Manufacture of integrated circuits.	2
2	Basic technological processes: Lithography, Oxidation, Corrosion, Diffusion, Implantation, Epitaxy.	4
3	Specific technological processes: surface micromachining, volume micromachining, LIGA, SLIGA, DEM, sacrificial layers, anodic bonding, fusion, reactive metal, direct or with an intermediate layer, laser micromachining, electrochemical corrosion arrest, assembly and encapsulation of microsystems.	6
4	Modele de proces şi dispozitiv: Proiectarea experimentului, Modelul suprafeței de răspuns, modele fizice si empirice, modelarea neliniarităților si a efectelor de ordinul doi ale dispozitivelor active.	4
5	Simularea dispozitivelor, circuitelor si microsistemelor: metode numerice, metoda diferențelor finite, metoda elementului finit, drift-difuzie, hidrodinamic, Monte Carlo.	2
6	Modelarea simularea optimizare si proiectarea microsistemelor electromecanice MEMS, microfluidice, bio-nano-electronice, celulelor solare, actuatoarelor, bolometrelor, microsenzorilor si electronica transparenta.	8
7	Tehnici de caracterizare a tehnologiilor pentru microsisteme si a microsistemelor: structuri potențiometru, grinda, vernier, punte, serie si arie de elemente, Inele Gukel, Van der Paw, Kelvin.	2
	Total:	28

Bibliography:
1) Florin Babarada, guest chapter: Semiconductor Processes and Devices Modelling, from the book Semiconductor Technologies, edited by Jan Grym, InTech publishing house, ISBN 978-953-307-080-3, April 2010; DOI: 10.5772/8562.
http://www.intechopen.com/books/semiconductor-technologies
2) Florin Babarada, Camelia Dunăre, Microsensors made on silicon, MATRIX ROM Publishing House, ISBN 978-973-755-376-8, 364pg., 2008.
3) Florin Babarada, Marcel Profirescu, Simulation of semiconductor processes and devices, Printech Publishing House, ISBN 973-718-389-4, 478pg., 2006.
4) Florin Babarada, Cristian Ravariu, Technologies for microsensors and biosensors, Printech Publishing House, ISBN 973-718-119-0, 258pg., 2004.
5) Florin Babarada, Characterization of Electromechanical Microsensors, Cartea Universitară Publishing House, ISBN 973-86042-4-9, 136pg., 2002.
6) https://silvaco.com/examples/tcad/index.html
7) www.library.pub.ro
8) http://curs.upb.ro
9) https://teams.microsoft.com/l/team/MasterMS

PROJECT

Crt. no.	Content	No. hours
1	MOS transistor simulation regarding transfer and external characteristics, threshold voltage extraction, drain-induced barrier drop, substrate effects, breakdown voltage, Light Doped Drain-LDD structure and CMOS latchup.	3
2	Simulation of devices in SOI technology, regarding the transfer and external characteristics, the Kink effect in partially depleted SOIMOSFET structures.	3
3	Examples of applications of high-k dielectrics regarding the dependence of mobility on phonon and Columb scattering.	3
4	Simulation of solar cells on monocrystalline silicon, amorphous silicon with defects and on germanium to increase efficiency.	3
5	Final colloquium.	2
	Total:	14

Bibliography:
1) Florin Babarada, capitol invitat: Semiconductor Processes and Devices Modelling, din cartea Semiconductor Technologies, editata de Jan Grym, editura InTech, ISBN 978-953-307-080-3, Aprilie 2010; DOI: 10.5772/8562.
http://www.intechopen.com/books/semiconductor-technologies
2) Florin Babarada, Camelia Dunăre, Microsenzori realizaţi pe siliciu, Editura MATRIX ROM, ISBN 978-973-755-376-8, 364pg., 2008.
3) Florin Babarada, Marcel Profirescu, Simularea proceselor şi dispozitivelor semiconductoare, Editura Printech, ISBN 973-718-389-4, 478pg., 2006.
4) www.silvaco.com
5) www.library.pub.ro
6) https://curs.upb.ro/2022/enrol/index.php?id=10228
7) https://teams.microsoft.com/l/team/MasterMS

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of fundamental and specific theoretical notions	A written exam in the session ensures a maximum of 30 points.	30
	Knowing how to apply the theory to specific problems	Homework in the form of a report, given individually to each student, to refer them to literature and international products on the market.	20
	Analysis of synthesis capacity in the documentation and presentation of a subject	Homework is developed and presented during the semester	20
11.5 Seminary/laboratory/project	Knowledge of the discussed topics and the writing language of the input file in the TCAD-Omni simulator from Silvaco	Assessment of individual abilities for each activity	15
	The ability to understand the requirements of each presented topic and the ability to interpret the results	Final colloquium with a practical application	15
11.6 Passing conditions			
Obtaining 50% of the total score. Obtaining 50% of the score related to the activity during the semester.			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

The modeling, simulation, optimization and design of new technological processes, devices, circuits and electronic systems has experienced a development dependent on computing power and has the effect of increasing the computing power of computers. Through TCAD, the process variables that have the greatest influence on electronic devices, circuits or microsystems can be identified. Thus, virtual manufacturing can reduce up to 40% of the costs of developing a new technology, device or microsystem.

The course program responds concretely to these current requirements of development and evolution, subscribed to the national and European economy, offering the extension of microelectronic technologies to microsystems, the area of intersection of microtechnologies and computing techniques that have a high degree of specialization and are requested by the branches in the country of some well-known companies at the international level and recently also by domestic companies, large international companies are beneficiaries.

In this way, the graduates are provided with adequate competences with the needs of the current qualifications and a modern, quality and competitive scientific and technical training, which will allow them to be employed quickly after graduation, the course being perfectly framed in the policy of the Politehnica University of Bucharest, both from the point of view of the content and structure, as well as from the point of view of the skills and international openness offered to students.

Date	Course lecturer	Instructor(s) for practical activities
20.09.2025	Prof. Dr. Babarada Florin	
Date of department approval	Head of department	
22.10.2025	Prof. Dr. Claudius Dan	
Date of approval in the Faculty Council	Dean	