Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și Tehnologia Informației

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)				Caracterizarea microfizică a micro- si nano-structurilor			
2.2 Course Lecturer				Dr.ing. Miron Adrian DINESCU			
2.3 Instructor for practical activities				Dr.ing. Miron Adrian DINESCU			
2.4 Year of studies	2	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DS	2.9 Course code	UPB.04.M3.O.03-17		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	2.00	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	42.00	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.					58
Tutoring					0
Examinations					4
Other activities (if any):					0

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	Physics I and II

4.2 Results of learning	Knowledge of physics (optics, solid state physics, electrodynamics, quantum physics), chemistry, electron devices and circuits, electronic measurements

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 a video projector or on the MSTeams platform
5.2 Seminary/ Laboratory/Project	The project will take place in a room with specific equipment, which must include: computers, INTERNET connection. Attendance in each practical session taking place at National Institute for Research and Development in Microtechnologies – IMT Bucharest is mandatory.

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)*

This discipline is studied within the field of Electronic Engineering, Telecommunications and Information Technologies, specializing in Microsystems, and aims to familiarize students with the main approaches, methods and technologies used in the field of micro and nanostructure characterization. Nanotechnologies are revolutionary technologies that are embedded in products from Romania's modern industry, for example: cars (Renault), aircraft (Airbus), electronics industry (Continental, Honeywell, Infineon). In this way, the graduates are provided with a modern, high-quality and competitive scientific and technical training, which will allow them to become familiar with advanced methods of micro- and nano-structuring.

The general objective of the discipline includes:

- Presentation of the methods and means of microphysical characterization of the structures and component materials of the microsystems.

- Topographical, structural and compositional analysis techniques of structures with dimensions in the micro-nanometric range will be presented.

- An introduction to optical, electron-optical and X-ray characterization techniques will be given. Micron and nanometric structuring methods will also be presented.

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 advanced knowledge of the fundamentals of microphysical properties of structures; Demonstrates the ability to configure and structure at the micro-nano scale using complex equipment; Correlates the knowledge of microphysical properties and methods of characterization of micro and nanostructures; It argues and analyzes coherently and correctly the methods of measuring the microphysical properties of structures; Oral and written communication in Romanian: uses the scientific vocabulary specific to the field. Oral and written communication in a foreign language (English): demonstrates understanding of vocabulary related to the field. Demonstrates advanced knowledge of the fundamentals of microphysical properties of structures;
Transversal (General) Competences	Adaptation to new technologies, professional and personal development through continuous training, using printed documentation sources, specialized software and electronic resources in English.

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.* • Specifies physical properties of microstructures • Defines the characteristics of structures • Describes/classifies the characterization techniques of micro and nanostructures • Highlights the particularities of micro and nanostructure characterization methods
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 classifies relevant information about nanostructures • Reasonably uses specific principles of micro and nanostructuring methods. • Work productively in a team to carry out laboratory work. • Adequately interprets the microphysical properties of structures. • Analyze and compare the value of different micro- and nanostructuring methods. • Identifies solutions and methods for characterizing micro and nanostructures. • Formulates conclusions to the experiments carried out. • Argues the differences between the methods of characterization of structures

Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Selects and analyzes adequate bibliographic sources. • Respects 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 process/context or the problem situation to be solved • Promotes/contributes through new solutions related to the specialized field. • Realizes the value of his contribution in the field of engineering to the identification of viable/sustainable solutions • Applies ethical principles

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 (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct exploration and indirect of reality (experiment, demonstration, modelling), but also on action-based methods, such as exercise, practical activities and problematization method.

In the teaching activity, lectures will be used, based on Power Point presentations or different Internet pages 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 designed to support students in their learning efforts and the development of optimal collaborative and communicative relationships in a climate conducive to discovery learning.

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.

Teamwork skills will be practiced to solve different learning tasks.

Students' attention will be checked through quick tests (quiz type) during or at the end of the course in certain courses.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**

1	Chapter 1. Introduction 1.1. The importance of microphysical characterization in the process of making structures for microsystems 1.2. Peculiarities of physical phenomena on a submicron scale	2
2	Chapter 2. Optical methods of physical characterization of microstructures 2.1. Optical microscopy (UV, visible, IR). Working in polarized, fluorescent, phase contrast light. 2.2 Confocal microscopy 2.3 Optical Profilometry (WLI) 2.4 Determination of optical properties of microstructures by SNOM	8
3	Chapter 3. Structural analysis methods by X-ray diffraction3.1 3.1. Physical principles of X-ray diffraction 3.2 X-ray diffraction methods 3.3 Modern diffractrometers: principles and construction	4
4	Chapter 4. Electron beam characterization techniques 4.1 The use of scanning electron microscopy (SEM) in the characterization of microstructures 4.2 Field emission electron microscopes (FEG-SEM) 4.3 Transmission electron microscopy (TEM): principles and applications 4.4 Auger Spectroscopy (AEM) 4.5 Electrovoltaic characterization (EBIC) 4.6 Cathodoluminescence (CL)	8
5	Chapter 5. Compositional determinations by spectrometric methods in SEM 5.1 Qualitative and quantitative compositional analyzes by EDX 5.2 Qualitative and quantitative compositional analyzes by WDX	2
6	Chapter 6. Lithographic techniques for configuring micro and nanostructures	4
	Total:	

Bibliography:

1. M.A. Dinescu, Microphisical characterization of micro and nanostructures,
2. Peter W. Hawkes, John C.H. Spence, Science of Microscopy, Springer, 2007
3. Daniel Courjon, Near Field Microscopy and Near Field Optics, Imperial College Press, 2003
4. Heinrich, K. F. J., D. E. Newbury Electron Probe Quantitation, Plenum Press, New York, 1991
5. W. B. Glendinning, J. N. Helbert, editors, Handbook of VLSI Microlithography (1991)

LABORATORY

Crt. no.	Content	No. hours
1	1. Optical characterization techniques (1) - Optical microscopy - WLI	2
2	2. Optical characterization techniques (2) - SNOM	2
3	3. X - Ray X-Ray diffractometer and its applications to the determination of lattice constants for various materials.	2

4	4. SEM Scanning electron microscopy (SEM)	2
5	5. EDX Energy-dispersive X-ray spectroscopy - EDX	2
6	6. EBL - Electron beam lithography - EBID technique and pattern transfer into the substrate (etching and lift-off)	4
	Total:	14

Bibliography:

1. M.A.Dinescu,Curs Caracterizarea microfizica a micro si nanostructurilor
2. Dieter K. Schroder, Semiconductor Material and Device Characterization, John Wiley & Sons, 2006
3. B.D. Cullity, S.R. Stock, Elements of X-Ray Diffraction, Prentice Hall, 2001

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Basic knowledge regarding the methods and means of microphysical characterization of the structures and component materials of microsystems	Test	30%
	Knowledge of the theoretical notions regarding physical phenomena on a submicron scale and identification of the basic means regarding the methods of microphysical characterization of the structures and component materials of microsystems	Exam	50%
11.5 Seminary/laboratory/project	Basic knowledge regarding the methods and means of microphysical characterization of the structures and component materials of microsystems	Laboratory colloquium	20%
11.6 Passing conditions			
- Obtaining 50% of the total score. - Obtaining 50% of the score related to the activity during the semester. - Compliance with the UNSTPB regulation regarding promotion conditions.			

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)

- Through the activities carried out, students will develop skills to offer solutions to problems and to propose ideas to improve the situation in the field of nanofabrication of nanoelectronic devices

– In the development of the content of the discipline, knowledge, phenomena described by specialized literature and own published research were taken into account.

- Through activities related to the presentation of the main technologies in the field of nanofabrication and the manufacturing of nanoelectronic devices, it was considered the development of the graduate's skills to manage practical situations that he may face in real life in order to increase his contribution to the improvement of the socio-economic environment.

Date	Course lecturer	Instructor(s) for practical activities
17.10.2024	Dr.ing. Miron Adrian DINESCU	Dr.ing. Miron Adrian DINESCU

Date of department approval	Head of department
31.10.2024	Prof. Dr. Claudius DAN

Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea