SYLLABUS

1. Information regarding the program

1.1 Higher education institution	Babeş-Bolyai University
1.2 Faculty	Faculty of Physics
1.3 Department	Doctoral School of Physics
1.4 Field of study	Physics
1.5 Study cycle	Doctorate
1.6 Study program / Qualification	Doctoral training/PhD in Physics

2. Course data

2.1 Name of discipline			Nanostructures and macromolecular systems				
2.2 Teacher responsible for lectures			Prof. dr. Simion Astilean, Prof. dr. Lucian Baia, Lector. dr. Ioan Botiz				
2.3 Teacher responsible for seminars			Prof. dr. Simion Astilean, Prof. dr. Lucian Baia, Lector. dr. Ioan Botiz				
2.4 Year of study	I	**2.5 Semester**	I	**2.6 Type of evaluation**	E	**2.7 Course framework**	DS

3. Estimated total time of teaching activities (hours per semester)

3.1 Hours per week	3	Out of which: 3.2 Lectures	2	3.3 Seminars / Laboratory classes	1
3.4 Total hours in the curriculum	36	Out of which: 3.5 Lectures	24	3.6 Seminars / Laboratory classes	12
Allocation of study time:					**89**
Study supported by textbooks, other course materials, recommended bibliography and personal student notes					40
Additional learning activities in the library, on specialized online platforms and in the field					14
Preparation of seminars/laboratory classes, topics, papers, portfolios and essays					15
Tutoring					15
Examinations					5
Other activities: -					–

3.9 Total individual study hours	89
3.10 Total hours per semester	125
3.11 Number of ECTS credits	10

4. Prerequisites (if necessary)

4.1 Curriculum	
4.2 Competences	

5. Conditions (where applicable)

5.1 Conducting lectures	Course hall, appropriate board, projector, dedicated software, computer

5.2 Conducting seminars/laboratory classes	Course hall, appropriate board, projector, dedicated software, computer network

6. Specific competences acquired

Professional competences	- Acquiring competences to formulate hypotheses and scientific concepts. - Abilities to perform measurements and data analysis in the field of nanoscience and nanotechnology. - Abilities to learn concepts, models, theories and advanced achievements in the field of nanostructures. - Ability to conduct experiments independently and to process the information provided by these experiments. - Ability to correlate the structural and morphological information provided by the experiment with the physico-chemical properties of nanomaterials. - Practical skills in using high performance equipment. - Ability to communicate scientific ideas and develop scientific papers. - Formation of a critical, multi- and interdisciplinary way of thinking.
Transversal competencies	- Carrying out professional tasks efficiently and responsibly, in compliance with the legislation and deontology specific to the field. - Application, in the context of compliance with the legislation, of intellectual property rights (including technology transfer), of the product certification methodology, of the principles, norms and values of the code of professional ethics within the framework of one's own rigorous, efficient and responsible work strategy. - Application of effective work techniques in multidisciplinary teams on various hierarchical levels. Identifying roles and responsibilities in a team and applying effective communication and work techniques within the team. - Effective use of information sources and communication and professional training resources, both in Romanian and in an international language. - To demonstrate involvement in scientific activities, such as the elaboration of specialized articles and studies. - To participate in scientific projects, compatible with the requirements of integration in European education and research.

7. Course objectives (based on the acquired competencies grid)

7.1 The general objective of the discipline	1. Acquisition of advanced theoretical knowledge in the field of solid physics, material science and macromolecular structures. 2. Acquisition of advanced experimental and theoretical research methodologies used in the characterization of nanostructured materials and macromolecular structures. 3. Basing the physics of the methods and tools used in specific research, expertise and monitoring activities in the field of nanomaterials.
7.2 Specific objectives	1. To increase the doctoral student's ability to identify new procedures and complementary solutions in nanoscale research.

	2. To master the existing advanced research methods and techniques at the doctoral school level to help the doctoral student develop his own research topic. 3. To master and use the research laboratory equipment for conducting experiments in the field of plasmonic nanomaterials. 4. To master and use of research laboratory equipment for conducting experiments in the field of plasmonic nanomaterials and their applications. 5. To master and use of theoretical models for the characterization of some local properties of polymers (segmental dynamics, viscoelasticity, thermal and electrical behavior). 6. To acquire necessary knowledge in the characterization of advanced organic (flexible) devices that are the basis of modern applications (OLED, solar panels, sensors, etc.). 7. Training of scientific communication skills in the field of nanostructures and macromolecules.

8. Content

8.1 Lectures	Teaching methods	Comments
1. Introduction in Plasmonics. Localized surface plasmon resonances (LSPR) in noble-metal nanoparticles.	Lecture, problem solving, case studies	2 hours
2. Fabrication, synthesis, and functionalization of plasmonic nanoparticles.		2 hours
3. Selected applications of plasmonics in biomedical field. Photodynamic and photothermal therapies.		2 hours
4. Selected applications of plasmonics in nanotechnology, communications and energetics. New generation of sensors, catalyst, lasers and photothermal devices.		2 hours
5. Characterization of nanostructures and nanocomposites used in biomedical applications by complementary morphological, structural, and surface investigations.		2 hours
6. Comprehensive study of nanomaterials used in photocatalytic applications by correlating the pollutant degradation results with structural data achieved.		2 hours
7. Investigating nanoscale effects by applying complementary characterization techniques.		2 hours
8. Structural investigations of graphene materials for technological applications.		2 hours
9. Introduction to polymers, their classification and properties.		2 hours
10. Conjugated macromolecular systems and their utilization in various organic energy devices, including photovoltaic cells, field-effect transistors, light-emitting diodes.		2 hours
11. Processing of polymers in solutions, thin films and solid state – towards highly ordered nanostructures.		2 hours
12. Patterning of polymers in thin films and fabrication of multifunctional structured platforms.		2 hours
8.2 Seminars / laboratory classes	**Teaching methods**	**Comments**

1. Analysis of the frequency-dependent dielectric function ε(ω) for metals within different approximations.	Projection, experimental demonstration, modeling, debate	1 hour
2. Analytical calculation of plasmonic resonances based on Mie theory.		1 hour
3. Discussion on SERS vs thermal effect in plasmonic nanoparticles (Faraday effect vs Joule Effect).		1 hour
4. Determination of light-to-heat conversion efficiency in the case of colloidal nanoparticle under laser irradiation.		1 hour
5. Structural and morphological investigations (experimental and theoretical) of phosphate glasses containing silver oxide.		2 hours
6. Correlating the bioactivity and biocompatibility properties of nanostructures with their structural data achieved.		2 hours
7. Fabrication of single crystals of polymers and small molecules for optoelectronics using a customized space confined solvent vapor annealing technique.		1 hour
8. Patterning of polymer films using hot embossing method.		1 hour
9. Structuring semiconducting molecules into highly ordered nanostructures using convective self-assembly method.		1 hour
10. Crystallization of conjugated polymers from solutions using self-seeding technique.		1 hour

Bibliography

1. A. I. Kirkland, J. L. Hutchison, *Nanocharacterisation*, RSC Publishing, Cambridge, 2007.
2. Renat R. Letfullin and Thomas F. George. *Plasmonic Nanomaterials for Nanomedicine,* Springer, 2013.
3. Stefan Alexander Maier, *Plasmonics. Fundamental and Applications. Springer, 2007*.
4. Andreea Campu, Ana-Maria Craciun, Monica Focsan, and Simion Astilean, *Assessment of the photothermal conversion efficiencies of tunable gold bipyramids under irradiation by two laser lines in a NIR biological window, Nanotechnology 30 (2019) 405701 (8pp)*.
5. R. A. Popescu, F. A. Tăbăran, S. Bogdan, A. Fărcășanu, R. Purdoiu, K. Magyari, A. Vulpoi, A. Dreancă, B. Sevastre, S. Simon, I. Papuc, L. Baia, Bone regeneration response in an experimental long bone defect orthotopically implanted with alginate-pullulan-glass-ceramic composite scaffolds, *Journal of Biomedical Materials Research - Part B Applied Biomaterials*, **108**(3), 1129, 2020.
6. L. C. Cotet, K. Magyari, M. Todea, M. C. Dudescu, V. Danciu, L. Baia, Versatile self-assembled graphene oxide membranes obtained under ambient conditions by using a water-ethanol suspension, *Journal of Materials Chemistry A*, **5**(5), 2132, 2017.
7. L. Baia, Zs. Pap, K. Hernadi, M. Baia, Advanced nanostructures for environmental health: ISBN: 0128158832 Publisher: Elsevier: Amsterdam, Netherlands; Kidlington, Oxford, England; Cambridge, Massachusetts, 2019, 584 pages.
8. Christine Luscombe Ed., *Semiconducting Polymers: Controlled Synthesis and Microstructure*, Royal Society of Chemistry, 2016.
9. I. M. Handrea-Dragan, I. Botiz. Multifunctional Structured Platforms: From Patterning of Polymer-Based Films to Their Subsequent Filling with Various Nanomaterials. *Polymers* **13**, 445, 2021.

10. I. Botiz. Prominent processing techniques to manipulate semiconducting polymer microstructure. *Journal of Materials Chemistry C* **11**, 364, 2023.
11. I. Botiz. Single Crystals of Established Semiconducting Polymers. *Polymers* **16**, 761, 2024.
12. I. Botiz, M. M. Durbin, N. Stingelin. Providing a Window into the Phase Behavior of Semiconducting Polymers. *Macromolecules* **54**, 5304, 2021.

9. Aligning the contents of the discipline with the expectations of the epistemic community, representatives, professional associations and standard employers operating in the program field

The content of the discipline is in line with what is studied in other university centers in the country and abroad. In order to adapt to the requirements imposed by the labor market, the content of the discipline was harmonized with the requirements imposed by the specifics of postgraduate education, research institutes and the business environment.

10. Examination

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Weight in the final grade
10.4 Lectures	Assessment of knowledge	Exam	50%
10.5 Seminars / laboratory classes	Activity during seminars	Discussions, answers to questions	50%
10.6 Minimum performance standard			
- Correct identification of the experimental methods of structural and morphological analysis of nanomaterials. - Correct identification of the physical properties of a material that depend on its dimensionality.			

Signature of course coordinator	Signature of seminar coordinator
Prof. dr. Simion Astilean	Prof. dr. Simion Astilean
Prof. dr. Lucian Baia	Prof. dr. Lucian Baia
Lector. dr. Ioan Botiz	Lector. dr. Ioan Botiz

Date	Signature Head of department
21.09.2024	Prof. dr. Vasile Chiș