

SYLLABUS

1. Information regarding the program

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| 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

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|---|--|---------------------|---|-------------------------------|---|-----------------------------|----|
| 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)

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|---|-----|-------------------------------|----|--------------------------------------|-----------|
| 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)

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| 4.1 Curriculum | |
| 4.2 Competences | |

5. Conditions (where applicable)

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| 5.1 Conducting lectures | Course hall, appropriate board, projector, dedicated software, computer |
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|---|---|
| 5.2 Conducting seminars/laboratory classes | Course hall, appropriate board, projector, dedicated software, computer network |
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6. Specific competences acquired

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| Professional competences | <ul style="list-style-type: none"> - 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 | <ul style="list-style-type: none"> - 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)

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| 7.1 The general objective of the discipline | <ol style="list-style-type: none"> 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 | <ol style="list-style-type: none"> 1. To increase the doctoral student's ability to identify new procedures and complementary solutions in nanoscale research. |

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| | <p>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.</p> <p>3. To master and use the research laboratory equipment for conducting experiments in the field of plasmonic nanomaterials.</p> <p>4. To master and use of research laboratory equipment for conducting experiments in the field of plasmonic nanomaterials and their applications.</p> <p>5. To master and use of theoretical models for the characterization of some local properties of polymers (segmental dynamics, viscoelasticity, thermal and electrical behavior).</p> <p>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.).</p> <p>7. Training of scientific communication skills in the field of nanostructures and macromolecules.</p> |
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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 |

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| 1. Analysis of the frequency-dependent dielectric function $\epsilon(\omega)$ 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.
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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.
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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% |
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| 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

Prof. dr. Simion Astilean

Prof. dr. Lucian Baia

Lector. dr. Ioan Botiz

Signature of seminar coordinator

Prof. dr. Simion Astilean

Prof. dr. Lucian Baia

Lector. dr. Ioan Botiz

Date

21.09.2025

Signature

Head of department
Prof. dr. Vasile Chiş