

COURSE DESCRIPTION
Functional Materials (in English)
 Academic year 2026-2027

1. Programme-related data

1.1. Higher Education Institution	Babeş-Bolyai University (BBU), Cluj-Napoca, Romania, in partnership with Technische Universität Chemnitz (TUC), Chemnitz, Germany
1.2. Faculty	Chemistry and Chemical Engineering
1.3. Department	Chemistry
1.4. Field	Chemistry
1.5. Level of study	Master
1.6. Degree programme / Qualification	Advanced Chemistry / Master's Degree
1.7. Form of education	Full-time education

2. Course-related data

2.1. Course title	Functional Materials (in English)			Course code	CME6140
2.2. Course coordinator	Prof. Dr. Cristian Silvestru (BBU), Lect. Dr. Eng. Lucian-Cristian Pop (BBU) Prof. Dr. Michael Mehring (TUC)				
2.3. Seminar coordinator	Lect. Dr. Eng. Lucian-Cristian Pop (BBU) Lect. Dr. Ionuț-Tudor Moraru (BBU)				
2.4. Year of study	2	2.5. Semester	2	2.6. Type of assessment	Exam
2.7. Course status	Optional			2.8. Course type	Specialisation subject

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	4	of which: 3.2. course	2	3.3. seminar/ laboratory/ project	2
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar/ laboratory	28
Time allocation for individual study (IS) and self-taught activities (ST)					hours
Learning from textbooks, course materials, bibliography, and notes (IS)					30
Additional research in the library, on subject-specific electronic platforms, and on-site					14
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					14
Tutoring (professional guidance)					7
Examinations					4
Other activities					0
3.7. Total hours of individual study (IS) and self-taught activities (ST)				69	
3.8. Total hours per semester				125	
3.9. Number of credits				5	

4. Prerequisites (where applicable)

4.1. curriculum-related	• Not the case.
4.2 skills-related	• Estimated personal level of English using Common European Framework of Reference for Languages (CEFR) should be minimum B1.

5. Specific conditions (where applicable)

5.1. course-related	<ul style="list-style-type: none"> • Students will attend the courses having the materials (e.g. videos) made available prior to each course • During the lecture students are asked to mute their mobile phones
5.2. seminar/laboratory-related	<ul style="list-style-type: none"> • Students will attend the seminar with the course notes referring to the seminar topic • During the seminar/practical work activities students are asked to mute their mobile phones

6.1. Competencies resulting from the completion of the degree programme (as referred to in the curriculum)¹

Professional competencies	
Competency code	Competency
PC1	Demonstrate disciplinary expertise
PC2	Perform scientific research
PC3	Apply scientific methods
PC4	Manage chemical testing procedures
PC5	Interact professionally in research and professional environments
Transversal competencies	
Competency code	Competency
TC1	Work independently
TC2	Work in teams
TC3	Think critically

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)²

Learning outcomes targeted by the subject		
Competency code	Knowledge and comprehension	Specific academic skills
PC1, TC3	The graduate critically evaluates and integrates highly specialised knowledge from physical, inorganic, organic, analytical chemistry and biochemistry, including at disciplinary boundaries, as a basis for advanced reasoning.	The graduate analyses scientific concepts and evidence and synthesises coherent explanations for complex chemical systems, justifying conceptual choices.
PC2, TC1	The graduate demonstrates highly specialised knowledge as a basis for original thinking and/or research, including critical awareness of frontier knowledge.	The graduate formulates research questions/objectives, designs and implements an investigative approach, and critically evaluates the results obtained.
PC3, TC3	The graduate explains principles, limitations and validation criteria for advanced investigation and interpretation methods (experimental and/or computational) relevant to advanced chemistry.	The graduate applies, compares and validates scientific methods to solve research and/or innovation problems, integrating knowledge across different subfields.
PC3, PC4	The graduate understands the criteria for selecting, controlling and optimising chemical testing procedures according to investigation goals, sample type and quality requirements.	The graduate manages and optimises chemical testing procedures for complex investigations by setting parameters, quality criteria and interpretation steps to obtain valid results.
PC5, TC2	The graduate understands norms, roles and working practices specific to academic and professional research environments, including communication and collaboration standards.	The graduate interacts professionally in research and professional environments, gives and uses feedback, and argues scientific decisions within teams.
PC3, TC3	The graduate understands quality criteria and standards of scientific argumentation (coherence, validity, reproducibility, relevance) used to evaluate conclusions.	The graduate critically evaluates results and interpretations and communicates well-argued conclusions and recommendations in

¹ The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

² The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

		<i>academic/professional contexts, adapting the message to audiences and purpose.</i>
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7. Subject-specific learning outcomes

Knowledge and comprehension
The student explains and compares the relationships between structure, composition, and properties in representative classes of functional materials, including perovskites, spinels, coordination polymers, MOFs, and 2D materials, arguing the role of crystal architecture in the emergence of specific material properties.
The student analyses the principles underlying the main strategies for synthesizing functional materials, including solid-state reactions, the sol-gel process, hydrothermal synthesis, microwave-assisted synthesis, and “twin” polymerization, correlating the chosen method with the structure and properties of the resulting material.
The student explains and critically evaluates the mechanisms involved in photocatalysis and nanocatalysis and argues the relevance of the studied functional materials for current applications in energy, the environment, and advanced materials.
Specific academic skills
The student applies and integrates concepts from solid-state chemistry, supramolecular chemistry, and materials science to critically analyse examples of functional materials and to justify the selection of appropriate synthetic strategies.
The student applies specific experimental methods for the preparation and processing of functional materials, including the synthesis of Bi ₂ WO ₆ via solid-state reaction, sol-gel process, hydrothermal or microwave-assisted synthesis, as well as surface deposition techniques, and correctly interprets the resulting analytical data.
The student analyses, compares, and communicates, both orally and in writing, data and case studies regarding the properties, synthesis, and applications of functional materials, appropriately utilizing the specialized literature and presenting coherent scientific conclusions in academic contexts.

8. Contents

8.1. Course	Teaching and learning methods	Remarks³
1. Introduction (including introduction of lecturers). Phase, phase diagram, solid state reaction vs reaction in solution	Presentation; Explanation	1 hour
2-6. Crystal chemistry I-V	Presentation; Explanation	5 hours
7. Perovskites – structures, polymorphism, ferroelectricity	Presentation; Explanation	1 hour
8. Hybrid perovskites – structures, perovskites for solar cells	Presentation; Explanation	1 hour
9. Spinel – structures, magnetism	Presentation; Explanation	1 hour
10. Polymorphism – polymorphs, phase transition	Presentation; Explanation	1 hour
11. Coordination polymers I – building blocks, including organometallic linkers and nodes	Presentation; Explanation	1 hour
12. Coordination polymers II – synthesis strategies	Presentation; Explanation	1 hour
13. MOFs – MOFs and related materials; applications	Presentation; Explanation	1 hour
14. 2D-materials I – graphenes (introduction, fundamental research)	Presentation; Explanation	1 hour
15. 2D-materials II – graphenes (production, characterization and applications of graphene and graphene-based materials, including environment aspects)	Presentation; Explanation	1 hour
16-19. Synthetic methods I-IV	Presentation; Explanation	4 hours
20-21. Sol-gel process I-II	Presentation; Explanation	2 hours
22. Twin polymerisation	Presentation; Explanation	1 hour
23-26. Photocatalysis I-IV	Presentation; Explanation	4 hours




















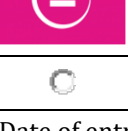




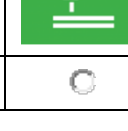

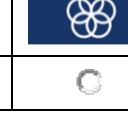
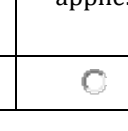
³ For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

27. Nanocatalysis I – introduction; transition metal nanoparticles in catalysis (size, structure, surface composition)	Presentation; Explanation	1 hour
28. Nanocatalysis II – applications; case studies	Presentation; Explanation	1 hour
Bibliography 1. Course support notes (pdf) and videos – made available by course coordinator 2. A. R. West, <i>Solid State Chemistry and its Applications - Student Edition</i> , 2 nd Ed., JohnWiley& Sons, Ltd, Chichester (UK), 2014 . 3. U. Schubert, N. Hüsing, <i>Synthesis of Inorganic Materials</i> , 4 th Ed., Wiley-VCH, Weinheim (Germany), 2019 . 4. S. Kaskel (Ed), <i>The Chemistry of Metal–Organic Frameworks - Synthesis, Characterization and Applications</i> (2 vols.), Wiley-VCH, Weinheim (Germany), 2016 . 5. O. M. Yaghi, M. J. Kalmutzki, C. S. Diercks, <i>Introduction to Reticular Chemistry - Metal-Organic Frameworks and Covalent Organic Frameworks</i> , Wiley-VCH, Weinheim (Germany), 2019 . 6. S. R. Batten, S. M. Neville, D. R. Turner, <i>Coordination Polymers - Design, Analysis and Application</i> , RSC Publishing, Cambridge (UK), 2009 . 7. O. L. Ortiz, L. D. Ramirez (Eds), <i>Coordination Polymers and Metal Organic Frameworks - Properties, Types and Applications</i> , Nova Science Publishers, New York (USA), 2012 . 8. E. Hey-Hawkins, M. Hissler, <i>Smart Inorganic Polymers - Synthesis, Properties, and Emerging Applications in Materials and Life Sciences</i> , Wiley-VCH, Weinheim (Germany), 2019 . 9. A. C. Ferrari, <i>et al.</i> , <i>Science and Technology Roadmap for Graphene, Related Two-Dimensional Crystals, and Hybrid Systems (Review Article)</i> , <i>Nanoscale</i> , 2015 , 7, 4598–4810. 10. P. Serp, K. Philippot (Eds), <i>Nanomaterials in Catalysis</i> , Wiley-VCH, Weinheim (Germany), 2012 . 11. Reviews and articles from recent scientific literature (ACS, Wiley, Elsevier, RCS, etc.).		
8.2.1 Seminar	Teaching and learning methods	Remarks
1. Block seminar I - crystal chemistry; perovskites; hybrid perovskites; spinel; polymorphism (one topic of each)	Conversation; Learning by discovery; Problem solving	block of 4 hours – 5 seminar topics
2. Block seminar II - coordination polymers (2 topics); MOFs (2 topics); 2D-materials – graphenes (3 topics)	Conversation; Learning by discovery; Problem solving	block of 4 hours – 7 seminar topics
3. Block seminar III - synthetic methods (2 topics); sol-gel process (1 topic); twin polymerization (1 topic)	Conversation; Learning by discovery; Problem solving	block of 3 hours – 4 seminar topics
4. Block seminar IV - photocatalysis (1 topic); nanocatalysis (3 topics)	Conversation; Learning by discovery; Problem solving	block of 3 hours – 4 seminar topics
Bibliography 1. Course support notes (pdf) and recorded lectures – made available by course coordinators. 2. Reviews and scientific articles at choice, but no older than 2020 (from ACS, Wiley, Elsevier, RCS journals, etc.).		
8.2.2 Laboratory	Teaching and learning methods	Remarks
1. Photocatalytic degradation of a dye solution	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
2. Synthesis of Bi ₂ WO ₆ : solid state reaction	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
3. Synthesis of Bi ₂ WO ₆ : Sol gel process	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
4. Synthesis of Bi ₂ WO ₆ : hydrothermal synthesis	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
5. Spray coating of Bi ₂ WO ₆ via air brush technique	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
6. Synthesis of Bi ₂ WO ₆ : microwave assisted synthesis	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
7. Discussion of practical work and analytical data	Experiments; Learning by discovery; Interpretation of analytical data	8 hours
Bibliography 1. Laboratory support notes (pdf) and videos – made available by course coordinators. 2. G. E. J. Poinern, <i>A Laboratory Course in Nanoscience and Nanotechnology</i> , Taylor and Francis Group, ISBN: 1482231034, 2014 .		

9. Evaluation

Type of activity	9.1 Evaluation criteria ⁴	9.2 Evaluation methods ⁵	9.3 Percentage in the final grade
9.4. Course	Correctness of answers –proper understanding and learning of notions and concepts discussed during lectures; correct use of learned concept within new contexts. Correct solving of the problems as part of the examination subjects	Oral / written examination. Proven or intended fraud is punished according to the ECST rules of BBU	50%
9.5.1 Seminar	Quality of the presentation and discussion of the topic	On-line presentation	25%
9.5.2. Laboratory	Correct interpretation of analytical data and discussion	Laboratory report - delivered at the end of the practical course	25 %
9.6 Minimum standard for passing			
• Receiving a grade of 5 (five) on the final exam, the seminar presentation, and the lab report.			

10. SDG labels (Sustainable Development Goals)⁶

		Sustainable Development Generic Label						
								
								No label applies
								

Date of entry:
17.04.2026

Signature of course coordinator
Acad. Prof. Dr. Cristian Silvestru

Signature of seminar/laboratory coordinator
Lect. Dr. Eng. Lucian-Cristian Pop

Lect. Dr. Eng. Lucian-Cristian Pop

Lector Dr. Ionuț-Tudor Moraru

Date of approval in the department:
24.04.2026

Signature of the head of department
Prof. Dr. Monica Ioana Toșa

⁴ The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

⁵ Both final evaluation methods and ongoing evaluation strategies should be established.

⁶ Select a single label which, according to the [Implementation of SDG labels in the academic process](#), best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: "No label applies."