SYLLABUS

1. Information regarding the programme

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 of study	Chemistry
1.5. Study cycle	Master
1.6. Study programme / Qualification	Advanced Chemistry (AC)/ Master's Degree Advanced Chemical Process Engineering (ACPE) / Master's Degree

2. Information regarding the discipline

2.1. Name of the discipline			Functional Materials (on-line course) – CME6140 (AC) CME6139 (ACPE)				
2.2. Course coordinators			Prof. Dr. Cristian SILVESTRU (BBU) Prof. Dr. Michael MEHRING (TUC)				
2.3. Seminar / practical work coordinator			Lect. Dr. eng. Lucian-Cristian POP (BBU) (including course) Asist. Ionuț-Tudor MORARU (PhD student) (BBU)				
2.4. Year of study	I	2.5. Semester	2	2.6. Type of evaluation	Exam	2.7. Type of discipline	SD

3. Total estimated time (hours/semester of didactic activities)

3.1. Hours per week	4	Of which: 3.2. course	2	3.3. seminar/ practical work	1/1
3.4. Total hours in the curriculum	56	Of which: 3.5. course	28	3.6. seminar/ practical work	14/14

Time allotment	hrs
Learning using manual, course support, bibliography, course notes	54
Additional documentation (in libraries, on electronic platforms, field documentation)	14
Preparation for seminars/labs, homework, papers, portfolios and essays	14
Tutorship	8
Evaluations	4
Other activities: not the case	-

3.7. Total individual study hours	94
3.8. Total hours per semester	150
3.9. Number of ECTS credits	5

4. Prerequisites (if necessary)

4.1. Curriculum	• Not the case
4.2. Competencies	• Estimated personal level of English using *Common European Framework of Reference* for Languages (*CEFR*) should be minimum B1

5. Conditions (if necessary)

5.1. For the course	• 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. For the seminar / practical work activities	• 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. Specific competencies acquired

Professional competencies	• Definition of notions, concepts, theories and advanced models in the field ofmaterial chemistry as well as their proper use within the professional community • Application and interpretation of the properties of inorganic chemistry/organic-inorganic hybrid materials /organometallic chemistry as well as concepts, approaches and phenomena related to material chemistry • Identification and proper usage of concepts, method and theories for solving new complex problems of material chemistry / Functional Materials • Use of advanced knowledge in the field of material chemistry to determine, explain and interpret the structure, properties, and potential application of Functional Materials • Critical analysis and usage of principles, methods and advanced work techniques to solve specific problems of Functional Materials • The ability to establish positive interpersonal relationships in an international team
Transversal competencies	• Analysis, interpretation and communication of scientific information and comply with professional ethics and moral values • Planning, monitoring and assuming professional duties of underline group. Proving the coordination capabilities, analytical thinking, adaptability and flexibility, team work abilities • Self-evaluation of professional performances and establish the needs of continuous learning, documentation in the work fields in correlation to the labor market

7. Objectives of the discipline (outcome of the acquired competencies)

7.1. General objective of the	• Familiarize master students with the basic notions, concepts and

discipline	techniques used in the synthesis, identification, morpho-structural characterization and potential applications of Functional Materials
7.2. Specific objective of the discipline	• Trainingskillsfor dealing with experimental aspects (high-temperature synthesis of solids, synthesis via chemical transport reaction, hydrolytic and non-hydrolytic sol-gel process, hydrothermal process, microwave assisted synthesis, Metal Organic Vapor Deposition process),characterization (e.g.BET analysis, IR spectroscopy, UV-Vis spectroscopy and X-ray diffraction)and potential application (sensors, actuators, medical devices) ofvarious Functional Materials

8. Content

8.1. Course (on-line)	**Teaching methods**	**Remarks**
8.1.1. Introduction (including introduction of lecturers). Phase, phase diagram, solid state reaction *vs* reaction in solution	Presentation; Explanation	1 hour
8.1.2. – 8.1.6. Crystal chemistry I-V		5 hours
8.1.7. Perowskites – structures, polymorphismn, ferroelectricity		1 hour
8.1.8. Hybrid perowskites – structures, perowskites for solar cells		1 hour
8.1.9. Spinel – structures, magnetism		1 hour
8.1.10. Polymorphism – polymorphs, phase transition		1 hour
8.1.11. Coordination polymers I – building blocks, including organometallic linkers and nodes		1 hour
8.1.12. Coordination polymers II – synthesis strategies		1 hour
8.1.13. MOFs – MOFs and related materials; applications		1 hour
8.1.14. 2D-materials I – graphenes (introduction, fundamental research)		1 hour
8.1.15. 2D-materials II – graphenes(production, characterization and applications of graphene and graphene-based materials, including environment aspects)		1 hour
8.1.16. – 8.1.19. Synthetic methods I-IV		4 hours
8.1.20. – 8.1.21. Sol-gel process I-II		2 hours
8.1.22.Twin polymerisation		1 hour
8.1.23. – 8.1.26. Photocatalysis I-IV		4 hours
8.1.27.Nanocatalysis I – introduction; transition metal nanoparticles in catalysis (size, structure, surface composition)		1 hour
8.1.28.Nanocatalysis II – applications; case studies		1 hour

Bibliography

1. Course support notes (pdf) and videos – made available by course coordinator
2. A. R. West, *Solid State Chemistry and its Applications - Student Edition*, 2nd Ed., JohnWiley& Sons, Ltd, Chichester (UK), **2014**.
3. U. Schubert, N. Hüsing, *Synthesis of Inorganic Materials*, 4th Ed., Wiley-VCH, Weinheim (Germany), **2019**.
4. S. Kaskel (Ed), *The Chemistry of Metal–Organic Frameworks - Synthesis, Characterization and Applications* (2 vols.), Wiley-VCH, Weinheim (Germany), **2016**.
5. O. M. Yaghi, M. J. Kalmutzki, C. S. Diercks, *Introduction to Reticular Chemistry - Metal-Organic Frameworks and Covalent Organic Frameworks*, Wiley-VCH, Weinheim (Germany), **2019**.
6. S. R.Batten, S. M. Neville, D. R.Turner, *CoordinationPolymers - Design, AnalysisandApplication*, RSC Publishing, Cambridge (UK), **2009**.
7. O. L.Ortiz, L. D. Ramirez (Eds),*CoordinationPolymersandMetalOrganic Frameworks - Properties, TypesandApplications*, Nova Science Publishers, New York (USA), **2012**.

8. E. Hey-Hawkins, M. Hissler, *Smart Inorganic Polymers - Synthesis, Properties, and Emerging Applications in Materials and Life Sciences*,Wiley-VCH, Weinheim (Germany), **2019**.
9. A. C. Ferrari,*et al.*,*Science and Technology Roadmap for Graphene, Related Two-Dimensional Crystals, and Hybrid Systems (Review Article),Nanoscale,* **2015**, *7*, 4598–4810.
10. P. Serp, K. Philippot (Eds), *Nanomaterials in Catalysis*, Wiley-VCH, Weinheim (Germany), **2012**.
11. Reviews and articles from recent scientific literature (ACS, Wiley, Elsevier, RCS, etc.).

8.2. Seminar (on-line) - organized in 2 blocks of 4 and 2 blocks of 3 hours, respectively	**Teaching methods**	**Remarks**
8.2.1. Block seminar I - crystal chemistry; perowskites; hybrid perowskites; spinel; polymorphism (one topic of each)	Conversation; Learning by discovery; Problem solving	block of 4 hours – 5 seminar topics
8.2.2. Block seminar II - coordination polymers (2 topics); MOFs (2 topics); 2D-materials – graphenes (3 topics)		block of 4 hours – 7 seminar topics
8.2.3. Block seminar III - synthetic methods (2 topics); sol-gel process (1 topic); twin polymerization (1 topic)		block of 3 hours – 4 seminar topics
8.2.4. Block seminar IV - photocatalysis (1 topic); nanocatalysis (3 topics)		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.).

8.3. Practical work (on line) – organized by TUC	**Teaching methods**	**Remarks**
8.3.1. Photocatalytic degradation of a dye solution	Experiments; Learning by discovery; Interpretation of analytical data	1 hour
8.3.2. Synthesis of Bi_2WO_6: solid state reaction		1 hour
8.3.3. Synthesis of Bi_2WO_6: Sol gel process		1 hour
8.3.4. Synthesis of Bi_2WO_6: hydrothermal synthesis		1 hour
8.3.5. Spray coating of Bi_2WO_6 via air brush technique		1 hour
8.3.6. Synthesis of Bi_2WO_6: microwave assisted synthesis		1 hour
8.3.7. Discussion of practical work an analytical data		8 hours

Bibliography

1. Laboratory support notes (pdf) and videos – made available by course coordinators.
2. G. E. J. Poinern, *A Laboratory Course in Nanoscience and Nanotechnology*, Taylor and Francis Group, ISBN: 1482231034, **2014**.

9. Corroborating the content of the discipline with the expectations of the epistemic community,professional associations and representative employers within the field of the program

- By acquiring theoretical / methodological concepts and practical aspects included in *Functional Materials* course, master students acquire a significant amount of knowledge, in accordance with required competencies from Diploma supplement and ANC's qualifications

10. Evaluation

Type of activity	10.1. Evaluation criteria	10.2. Evaluation methods	10.3. Share in the final grade (%)
10.4. Course	Correctness of answers – proper understanding and learning of notions and	Oral / written examination. Proven or intended fraud is punished according to the	50%

	concepts discussed during lectures; correct use of learned concept within new contexts. Correct solving of the problems as part of the examination subjects	ECST rules of BBU	
10.5. Seminar	Quality of the presentation and discussion of the topic	Online Presentation	25%
10.6. Practical Course	Correct interpretation of analytical data and discussion	Laboratory report - delivered at the end of the practical course	25 %
10.7. Minimum performance standards			
• Grade 5 (five) at the oral exam, participation to the final oral exam is conditioned by participation to all practical courses and seminars and minimum grade 5(five) for these two activities • Adequate knowledge and usage of basic concepts on synthesis, identification, morpho-structural characterization and potential applications of Functional Materials			

Date
14.04.2024

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

Signature of seminar / practical work coordinators
Lect. Dr. eng. Lucian-Cristian POP

Asist. Ionuț-Tudor MORARU

Date of approval
14.04.2024

Signature of the head of department
Prof. Dr. Habil. Ing. Monica Toșa