Functional materials

Basic information

Field of study Materials Science	**Didactic cycle** 2021/2022
Speciality All	**Subject code** CIMA00S.II4S.b391c93ccfecaacfa35a41dac771fd4e.21
Department Faculty of Materials Science and Ceramics	**Lecture languages** English
Study level Second-cycle studies	**Mandatory** Elective
Study form Full-time studies	**Block** Major Modules
Education profile General academic	**Subject related to scientific research** Yes

Subject coordinator	Karol Kyzioł, Jerzy Jedliński
Lecturer	Zbigniew Grzesik, Karol Kyzioł, Tomasz Brylewski, Robert Filipek, Juliusz Dąbrowa, Agata Sawka, Stanisława Kluska, Mirosław Stygar, Grzegorz Smoła, Marek Zajusz

Period Semester 3	**Examination** Exam **Activities and hours** Lecture: 30, Laboratory classes: 75, Seminars: 30	**Number of ECTS points** 8.0

Goals

C1	Making students familiar with classificon of materials in terms of their application and functionality.
C2	Making students familiar with specific groups of functional materials.
C3	Making students familiar with methodology for using the physical and chemical properties of materials to design functional materials.
C4	Transfer of knowledge in the field of specific methods of material design and problem solving related to providing them with the required properties.

Subject learning outcomes

Code	Outcomes in terms of	Directional learning outcomes	Examination methods
Knowledge – Student knows and understands:			
W1	Student has detailed knowledge of the methods of synthesis of nanomaterials, biomaterials and functional materials.	IMT2A_W03	Activity during classes, Participation in a discussion, Examination, Presentation
W2	Has extensive knowledge in the field of computational methods and IT tools necessary to analyze the results of experiments and material design and process modeling.	IMT2A_W02	Execution of laboratory classes, Report, Completion of laboratory classes
W3	Student has in-depth knowledge of materials specific to his specialty, their properties, methods of obtaining, testing methods.	IMT2A_W03	Execution of laboratory classes, Examination, Completion of laboratory classes
Skills – Student can:			
U1	Student is able to use well-chosen methods and devices to measure the size of advanced materials.	IMT2A_U04	Activity during classes, Execution of laboratory classes, Completion of laboratory classes
Social competences – Student is ready to:			
K1	Student is aware of the responsibility for the tasks carried out independently and collectively, he/she is able to manage the team.	IMT2A_K02	Activity during classes, Execution of laboratory classes, Involvement in teamwork, Completion of laboratory classes
K2	Student understands the importance of the impact of materials science on the development of modern technologies.	IMT2A_K03	Activity during classes, Participation in a discussion, Presentation, Completion of laboratory classes

Programme content that ensure achieving learning outcomes for the module

The module allows you to acquire knowledge about the design, manufacture and testing of the properties of materials intended for use in modern technology (energy, electronics, transport, etc.).

Calculation of ECTS points

Activity form	Average amount of hours* needed to complete each activity form
Lecture	30
Laboratory classes	75
Seminars	30
Preparation for classes	25

Realization of independently performed tasks	30
Examination or Final test	2
Contact hours	5
Preparation of project, presentation, essay, report	30
Student workload	**Hours** 227
Workload involving teacher	**Hours** 135

* hour means 45 minutes

Study content

No.	Course content	Subject learning outcomes	Activities
1.	General programme: - Electronic, ionic and mixed electron-ion conductors - Fuel cells - Sensors - Materials for waste heat recovery - Materials for Li ion batteries - Materials for solar energy harvesting - Nanostructures and their properties - Sintering of nanoceramics - Biofuels and corrosion - Materials for corrosion-resistant coatings - Multiferroic and magnetoelectric materials and applications - Materials for soldering and brazing - Modeling in materials science and engineering, computer aided design	W1, W2, W3, K2	Lecture
2.	Functional materials for specific applications, including: - Materials for fuel cells - Materials for optoelectronics - Thermoelectric and pyroelectric materials - Photovoltaic cells: properties of silicon, 1st and 2nd generation cells - Semiconductors in heterogeneous catalysis - Magnetocaloric materials - Amorphous materials/coatings - Semiconductor lasers - Functional hybrid systems - Superhard coatings - Materials for hydrogen storage and battery applications - Multiferroic and magnetoelectric materials - Lead-free solders - Nanomaterials - H&S issues - Sensors (semiconductor, electrochemical, ...)	W1, W3, K2	Seminars

3.	- Introduction, H&S issues - Semiconductor sensors (methane sensor, ethanol sensor) - Electrochemical sensors (O2, H2, CO2 and humidity sensors) - PVD: magnetron sputtering - SHS in the manufacturing of functional materials - PA CVD - Sol-gel deposition - Characterization of deposited layers - Measurements of electrical properties by dc methods - Impedance spectroscopy I - Impedance spectroscopy II - Properties of ferroelectric materials - Microgravimetry in corrosion studies - Oxidation kinetics of metals	W1, W2, W3, U1, K1, K2	Laboratory classes

Course advanced

Teaching methods:

Multimedia presentation

Activities	Examination methods	Credit conditions
Lecture	Activity during classes, Participation in a discussion, Execution of laboratory classes, Examination, Report, Presentation, Completion of laboratory classes	
Lab. classes	Activity during classes, Participation in a discussion, Execution of laboratory classes, Examination, Report, Involvement in teamwork, Presentation, Completion of laboratory classes	
Seminar classes	Activity during classes, Participation in a discussion, Execution of laboratory classes, Examination, Presentation, Completion of laboratory classes	

Requirements and method of completing particular forms of classes

1. Individual classes - credited in the standard mode
2. Retake credits - tests or other forms adapted to the type of classes (e.g. for laboratory classes)
3. Exam admission conditions: positive final credit for laboratory and seminar classes, taking into account the final test.

Method of calculating the final grade

FR (Final Rating) = 0.5 EX (Exam Rating) + 0.5 TFRSL (Total Final Rating of Seminar and Lab Classes)
TFRSL = 0.2 SR (Seminar Rating) + 0.3 LR (Lab Rating) + 0.5 FTR (Final Test Rating)
Details of the approach to SR and LR as well as concerning how the attendance will be included in SR an LR will be given by lecturers during their classes.

Method and procedure for compensating for missed coursework resulting from student absence from classes

Depending on the type of classes and the size of the absence - to be fixed individually .

Entry requirements

Knowledge in the field of solid state physical chemistry corresponding to the stage of education

Attendance requirements for particular classes, with indication whether student attendance is compulsory

Lecture (optional, but recommended): Students participate in the classes, learning about the content of the teaching according to the syllabus of the subject. Students should ask questions and explain doubts on a regular basis. Audio-visual recording of the lecture requires the consent of the lecturer.
Laboratory exercises (obligatory presence): Students perform laboratory exercises in accordance with the materials provided by the teacher. The student is obliged to prepare for the subject of the exercise, which can be verified by an oral or written test. Passing the course is based on the presentation of the solution to the given problem, taking into account the result of the test. Passing the module is possible after passing all laboratory classes.
Seminar classes (obligatory attendance): Students present the topic indicated by the teacher in the forum of the group and participate in the discussion on this topic. Both the substantive value of the presentation and the so-called soft skills.
Note: In the case of conducting classes remotely, the conditions may be subject to modification. Moreover: in exceptional cases, especially justified, it is possible to individually modify the approach to the above procedure.

Literature

Obligatory

1. - Coatings Technology, Fundamentals, Testing, and Processing Techniques, Ed. Tracton A.A. CRC Press(2006);
2. - Ceramic matrix composites, Microstructure, properties and Applications, ED. Low I.M. CRC Press (2006);
3. - Composite Materials. Functional Materials for Modern Technologies, Chung D.D.L., Springer (2002);
4. - Engineering Materials for Technological Needs - Vol. 2, Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications, Chung D.D.L, World Scientific Publishing Co. Pte. Ltd. (2010);
5. - current scientific literature
6. - lecture notes
7. Surface and thin film analysis : a compendium of principles, instrumentation, and applications, ed. by G. Friedbacher, H. Bubert, Wiley, 2011

Research and publications

Publications

1. Publications of lecturers available at the AGH Library web-page / Publikacje prowadzących można znaleźć na stronie Biblioteki Głównej AGH: https://www.bpp.agh.edu.pl

Directional learning outcomes

Code	Content
IMT2A_K02	Potrafi myśleć i działać w sposób kreatywny i przedsiębiorczy oraz ma świadomość odpowiedzialności za realizowane samodzielnie i zespołowo zadania, potrafi kierować zespołem
IMT2A_K03	Ma świadomość ważności i zrozumienia pozatechnicznych aspektów i skutków działalności inżynierskiej, w tym jej wpływu na środowisko i związanej z tym odpowiedzialności za podejmowane decyzje, przestrzega zasady etyki zawodowej oraz rozumie znaczenie wpływu inżynierii materiałowej na rozwój nowoczesnych technologii
IMT2A_U04	Potrafi optymalnie dobrać metody i narzędzia służące do rozwiązania zadań typowych dla inżynierii materiałowej uwzględniających kryteria doboru materiału i procesu wytwórczego
IMT2A_W02	Ma poszerzoną wiedzę w zakresie metod obliczeniowych i narzędzi informatycznych niezbędnych do analizy wyników eksperymentów oraz projektowania materiałów i modelowania procesów.
IMT2A_W03	Ma pogłębioną, podbudowaną teoretycznie wiedzę w zakresie inżynierii materiałowej oraz ma poszerzoną wiedzę z zakresu projektowania materiałowego produktów o założonej strukturze i właściwościach użytkowych oraz modelowaniu procesów