



Subject card

Subject name and code	Modern functional materials, PG_00068811						
Field of study	Biomedical Engineering, Biomedical Engineering, Biomedical Engineering						
Date of commencement of studies	February 2026		Academic year of realisation of subject			2026/2027	
Education level	second-cycle studies		Subject group			Optional subject group Specialty subject group Subject group related to scientific research in the field of study	
Mode of study	Full-time studies		Mode of delivery			at the university	
Year of study	2		Language of instruction			Polish	
Semester of study	3		ECTS credits			2.0	
Learning profile	general academic profile		Assessment form			assessment	
Conducting unit	Department of Chemistry and Technology of Functional Materials -> Faculty of Chemistry -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		prof. dr hab. inż. Ewa Wagner-Wysiecka				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	0.0	0.0	30
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	30		3.0		17.0	50
Subject objectives	The aim of the course is to present the relationship between the properties of functional materials, their chemical structure and production methods leading to functional materials with different properties and application areas: energy storage and conversion devices, electronics, photonics, medicine.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	<p>[K7_K01] is ready to create and develop models of proper behaviour in the work and life environment; undertake initiatives; critically evaluate actions of their own, teams and organisations they are part of; lead a group and take responsibility for its actions; responsibly perform professional roles taking into account changing social needs, including: - developing the achievements of the profession, - observing and developing rules of professional ethics and acting to comply to these rules</p>	<p>Student is aware of the responsibility of professional work, understands the importance of making decisions in accordance with ethical and social standards</p>	<p>[SK1] Assessment of group work skills</p>
	<p>[K7_W54] knows and understands in-depth selected aspects of biomedical engineering, in particular chemistry, biochemistry, biomaterials and materials science, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences</p>	<p>The student has advanced knowledge in the field of chemistry of functional materials, including their structure, properties and synthesis methods, and understands the complex relationships between chemical composition, structure, and applications in biomedical engineering.</p>	<p>[SW1] Assessment of factual knowledge</p>
	<p>[K7_U12] is able, to an increased extent, to analyze the operation of components and systems related to the field of study, as well as to measure their parameters and study their technical characteristics, and to plan and carry out experiments related to the field of study, including computer simulations, interpret the obtained results and draw conclusions</p>	<p>The student is able to plan and carry out experiments and analyse the parameters of functional materials using appropriate research techniques, and to interpret the obtained results taking into account their applications in technical and biomedical systems.</p>	<p>[SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools</p>
	<p>[K7_U08] while identifying and formulating engineering tasks specifications and solving these tasks, can: - apply analytical, simulation and experimental methods, - notice their systemic and non-technical aspects, - make a preliminary economic assessment of suggested solutions and engineering work</p>	<p>The student is able to identify an engineering problem in the field of functional material applications and propose a solution using analytical, experimental or simulation methods, taking into account system-level, non-technical aspects and a preliminary economic evaluation of the proposed solution.</p>	<p>[SU2] Assessment of ability to analyse information</p>

Subject contents	<p>Course content – lecture Electrode materials: synthesis, characterization and applications in energy storage devices for technical, medical, and biomedical engineering purposes. Functional polymers: synthesis methods, properties, and their use in medicine, pharmacy, and in ultrafiltration and nanofiltration processes. Materials with magnetic properties and optically active materials synthesis, characterization, and selected areas of application in technology, medicine, and biomedical engineering.</p> <p>The project classes involve the development of a design solution for a biomedical device based on a selected group of functional materials. The laboratory classes aim to familiarise students with the synthesis methods of selected groups of functional materials and the methods of their characterization.</p> <p>Lecture</p> <ol style="list-style-type: none"> 1. Definition and types of functional materials 2. Metals (groups I, II, transition metals) - bulk phases, metal nanoparticles - a redox activity series in aqueous and non-aqueous electrolytes for bulk metals and nanometals. 3. Semiconductors from the group of transition metal chalcogenides - characteristics of the bulk phase and 2-D nanomaterials. 4. Carbon materials - natural graphite, synthetic graphite, carbon nanomaterials, doped diamond, biomass derived pyrolytic carbons, graphene-like g-C₃N₄. 5. Methods of producing electrode layers from functional materials. Types of substrate, types of binder 6. Application of electrodes in electrochemical devices for energy storage and conversion 7. Macromolecules as functional materials. 8. Biomedical polymers: synthesis and their application areas. 9. Formulation, development & manufacturing of drug delivery systems. 10. Shape-memory and self-organization of functional materials. 11. Application of macromolecules in ultra- and nanofiltration. 12. Materials based on classical dyes and pigments vs. plasmon nanomaterials 13. Multifunctional photochromic materials and photoswitches. 14. Materials with magnetic properties 15. Surface functionalized materials 16. Applications of selected optical active materials: sensors, actuators, fotovoltaic cells, optoelectronic devices 17. Bioinspired functional materials <p>Project</p> <p>Design of device for biomedical applications based on a selected group of functional materials. Two presentations: 1. literature review and design assumptions 2. overview of the proposed design solution, discussion of the results</p> <p>Laboratories</p> <ol style="list-style-type: none"> 1. Preparation, characterization and applications of optical active materials - carbon dots 2. Gas sorption and detection with the use of organometallic porous materials MOFs 3. Synthesis and properties analysis of polymers for biomedical applications 4. Methods of obtaining and potential application of polymer membranes and nanomembranes 5. Synthesis and characterization of materials for dye solar cells 														
Prerequisites and co-requisites	Knowledge of chemistry, biochemistry, basic analytical methods. Ability to use basic laboratory equipment.														
Assessment methods and criteria	<table border="1"> <thead> <tr> <th data-bbox="456 1767 794 1794">Subject passing criteria</th> <th data-bbox="799 1767 1137 1794">Passing threshold</th> <th data-bbox="1142 1767 1469 1794">Percentage of the final grade</th> </tr> </thead> <tbody> <tr> <td data-bbox="456 1800 794 1872">Lecture - written colloquium covering the issues discussed during the lecture</td> <td data-bbox="799 1800 1137 1872">51.0%</td> <td data-bbox="1142 1800 1469 1872">40.0%</td> </tr> <tr> <td data-bbox="456 1879 794 1951">Laboratory -participation in all laboratory exercises and passing appropriate tests</td> <td data-bbox="799 1879 1137 1951">100.0%</td> <td data-bbox="1142 1879 1469 1951">30.0%</td> </tr> <tr> <td data-bbox="456 1957 794 2069">Project - two presentations: 1. literature review and design assumptions 2. discussion of the proposed design solution, discussion of the results</td> <td data-bbox="799 1957 1137 2069">51.0%</td> <td data-bbox="1142 1957 1469 2069">30.0%</td> </tr> </tbody> </table>			Subject passing criteria	Passing threshold	Percentage of the final grade	Lecture - written colloquium covering the issues discussed during the lecture	51.0%	40.0%	Laboratory -participation in all laboratory exercises and passing appropriate tests	100.0%	30.0%	Project - two presentations: 1. literature review and design assumptions 2. discussion of the proposed design solution, discussion of the results	51.0%	30.0%
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Recommended reading	Basic literature	<ol style="list-style-type: none"> Recent Advances in Complex Functional Materials. From Design to Application, E. Longo, F. de Almeida La Porta (Eds.), Springer International Publishing AG 2017, ISBN 978-3-319-53898-3 (eBook), DOI 10.1007/978-3-319-53898-3 X. D. Liu, A. R. Esker, M. Häußler, Ch. Kim, P. Lucas, M. Matsunaga, N. Nishi, J.-J. Robin, B. Z. Tang, D. A. Wang, M. Yamada, H. Yu, Functional Materials and Biomaterials, Springer-Verlag Berlin Heidelberg 2007, DOI 10.1007/978-3-540-71509-2 Magnetism and Structure in Functional Materials, A. Planes, L. Mañosa, A. Saxena (Eds.), Springer-Verlag Berlin Heidelberg 2005, 978-3-540-31631-2 (eBook), DOI 10.1007/3-540-31631-0 R. D. Munje, S. Prasad, E. Graef, Functional Materials: For Sensing/Diagnostics, w: Handbook of Solid State Chemistry, R. Dronskowski, S. Kikkawa, A. Stein (Eds.), WileyVCH Verlag GmbH & Co. KGaA 2017, DOI: 10.1002/9783527691036 V. Sudarsan, Optical Materials: Fundamentals and Applications, w: Functional Materials. Preparation, Processing and Applications, str. 285-322, Elsevier Inc. 2012, DOI 10.1016/C2010-0-65659-8 Handbook of Smart Materials in Analytical Chemistry, M. de la Guardia, F. A. EsteveTurrillas (Eds.), John Wiley & Sons Ltd, 2019 S.O. Kasap, K. Koughia, Jai Singh, Harry E. Ruda, Asim K. Ray, Fundamental Optical Properties of Materials I, w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 1-36. DOI 10.1002/9781119506003.ch1 S.O. Kasap, K. Koughia, Jai Singh, Harry E. Ruda, Asim K. Ray, Fundamental Optical Properties of Materials II, w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 37-65. DOI 10.1002/9781119506003.ch2 J. M. Hvam, Optoelectronic Properties and Applications of Quantum Dots, w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 503-536. DOI 0.1002/9781119506003.ch17 M. A. J. Mazumder, H. Sheardown, A. Al-Ahmed, Functional Polymers, Springer, Cham 2019, ISBN 978-3-319-95987-0, DOI: 10.1007/978-3-319-95987-0 Instrukcje do ćwiczeń laboratoryjnych
	Supplementary literature	<ol style="list-style-type: none"> M. Chen, X. Fu, Z. Chen, J. Liu, W. H. Zhong, Protein-Engineered Functional Materials for Bioelectronics, <i>Advanced Functional Materials</i>, 31, (2021), 2006744. DOI 10.1002/adfm.202006744 A. Edgar, Optical Properties of Glasses w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 83-128. DOI 0.1002/9781119506003.ch4 T. Aoki, Photoluminescence w: Optical Properties of Materials and Their Applications, J. Singh (Ed.), John Wiley & Sons Ltd, 2020, str. 157-202. DOI 10.1002/9781119506003.ch6 D. Xiao, L. Gu, Origin of functionality for functional materials at atomic scale, <i>NanoSelect</i>, 1, (2020) 183-199. DOI 10.1002/nano.202000020 A. Moores, F. Hajiali, T. Jin, G. Yang, M. Santos, E. Lam, Mechanochemical Transformations of Biomass into Functional Materials, <i>ChemSusChem</i>, w druku, (2022) DOI 10.1002/cssc.202102535 J. Kawamata, Y. Suzuki, M. Tominaga, From Adsorbed Dyes to Optical Materials, <i>Developments in Clay Science</i>, 9 (2018) 361-375. DOI 10.1016/B978-0-08-102432-4.00011-1 L.Y. Chu, R. Xie, X. J. Ju, W. Wang, Smart Hydrogel Functional Materials, Chemical Industry Press, Beijing and Springer Berlin Heidelberg 2013, ISBN 978-3-642-39538-3 (eBook), DOI 10.1007/978-3-642-39538-3 M. Jenkins, Biomedical polymers, Woodhead Publishing Series in Biomaterials 2007, ISBN-10:1845690702 T. A. Saleh, V. K. Gupta, Nanomaterial and Polymer Membranes: Synthesis, Characterization, and Applications, Elsevier 2016, ISBN: 0128047038 Cornelia Breilkopf; Karen Swider-Lyons, Springer Handbook on Electrochemical Energy, Springer 2016. A. S. Aricò, P. Bruce, B. Scrosati, J. M. Tarascon, and W. Van Schalkwijk, Nanostructured materials for advanced energy conversion and storage devices, <i>Nature Materials</i>, vol. 4, no. 5, pp. 366377, 2005.
	eResources addresses	
Example issues/ example questions/ tasks being completed	j.w.	
Practical activities within the subject	Not applicable	