GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Materials for energy storage and conversion devices , PG_00043556						
Field of study	Green Technologies						
Date of commencement of studies	October 2024		Academic year of realisation of subject		2024/2025		
Education level	second-cycle studies		Subject group		Obligatory subject group in the field of study		
Mode of study	Full-time studies		Mode of delivery		at the university		
Year of study	1		Language of instruction		Polish		
Semester of study	1		ECTS credits		2.0		
Learning profile	general academic profile		Assessment form		assessment		
Conducting unit	Department of Energy Conversion and Storage -> Faculty of Chemistry						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Monika Wilamowska-Zawłocka				
	Teachers						
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	0.0	15.0	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		5.0	15.0		50
Subject objectives	The subject is focused on electrode materials for devices, i.e. galvanic cells, electrochemical capacitors, hybrid devices, redox flow cells, photochemical cells, fuel cells. Physicochemical and electrochemical properties of the materials, including carbonaceous materials (3D, 2D, 1D), semiconductors (e.g. metal oxides, sulfides, selenium), conductive polymers (so-called synthetic metals), will be discussed. Moreover, various types of electrolytes (water electrolytes, aprotic, ionic liquids, gel electrolytes, solid electrolytes) used in energy storage and conversion devices will be presented.						

Learning outcomes			
	Course outcome	Subject outcome	Method of verification
	[K7_W03] will have a detailed knowledge of the theoretical basis of methods and types of apparatus used in chemical analysis of environmental pollutants and the technology of cleaning and neutralization of industrial waste and wastewater management and the design and supervision of environmentally friendly technologies	A student knows problems related to the generation and distribution of energy and energy losses connected with it. A student can propose solutions for the sustainable use of energy and make a project of technological installation for energy conversion and storage.	[SW1] Assessment of factual knowledge
	[K7_K05] is ready to explain the basic concepts of the protection of industry property and copyright and the need for management of intelectual property, it turns the attention to the prestige associated with the profession and profession solidarity properly understaning, shows respect for others and concern for their welfare, understands the need to promote, formulate and provide the public with information and opinions concerning the activities of the profession of Engineer, is aware of the social role of a technical college graduate	A student knows materials used in energy storage and conversion devices. Based on calculations and assumptions, he can choose the appropriate materials and estimate the energy density and power density needed for a particular renewable energy source, e.g., wind farm or photovoltaic cell.	[SK2] Assessment of progress of work [SK5] Assessment of ability to solve problems that arise in practice
	[K7_W01] a broader and deeper knowledge of certain branches of mathematics, including elements of applied mathematics and optimization methods including mathematical methods, useful to formulate and solve complex tasks in the field of environmental technologies and modern analytical methods	Students, based on calculations, can design energy storage systems coupled with renewable energy sources and estimate the cost of their construction.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge

Subject contents	Electrode materials for energy conversion and storage devices (i.e. galvanic cells, electrochemical capacitors, hybrid devices, redox flow cells, photochemical cells, fuel cells) are discussed. The discussed electrode materials include various types of carbon materials (3D, 2D, 1D), semiconductors (including transition metal oxides, sulphides, selenides), and conducting polymers (so-called synthetic metals). Moreover, electrolytes and separators used in energy storage and conversion are presented. The relationships between the physicochemical properties of the discussed materials and their electrochemical activity and suitability for a particular type of device are discussed. Students learn to plan, calculate and design energy storage systems cooperating with renewable energy sources as well as batteries for electric cars, electric bikes, and similar devices.
Prerequisites and co-requisites	Knowledge of the basics of electrochemistry, including knowledge of: - processes occurring on electrodes: Faradaic reactions, electric double layer - basics of the kinetics of electrode reactions - construction of a galvanic cell, an electrochemical capacitor - basic measurement techniques, i.e., cyclic voltammetry, chronopotentiometry, chronoamperometry

Assessment methods and criteria			
	Subject passing criteria	Passing threshold	Percentage of the final grade
	project	60.0%	45.0%
	writing exam	60.0%	55.0%

Recommended reading	Basic literature	[1] M. Armand, P. Axmann, D. Bresser, M. Copley, K. Edström, C. Ekberg, D. Guyomard, B. Lestriez, P. Novák, M. Petranikova, W. Porcher, S. Trabesinger, M. Wohlfahrt-Mehrens, H. Zhang, Lithium-ion batteries Current state of the art and anticipated developments, J. Power Sources. 479 (2020) 228708. doi:10.1016/j.jpowsour.2020.228708. [2] I. Hasa, S. Mariyappan, D. Saurel, P. Adelhelm, A.Y. Koposov, C. Masquelier, L. Croguennec, M. Casas-Cabanas, Challenges of today for Na-based batteries of the future: From materials to cell metrics, J. Power Sources. 482 (2021) 228872. doi:10.1016/j.jpowsour.2020.228872. [3] B. Scrosati, J. Hassoun, Y.-K. Sun, Lithium-ion batteries. A look into the future, Energy Environ. Sci. 4 (2011) 32873295. doi:10.1039/c1ee01388b. [4] M. Armand, J.-M. Tarascon, Building better batteries., Nature. 451 (2008) 652657. doi:10.1038/451652a. [5] A Yolk-Shell Design for Stabilized and Scalable, Nano Lett. (2012). doi:10.1021/nl3014814. [6] D. Lin, Y. Liu, Y. Cui, Reviving the lithium metal anode for high-energy batteries, Nat. Nanotechnol. 12 (2017) 194206. doi:10.1038/nnano.2017.16. [7] M.A. Hannan, M.M. Hoque, A. Mohamed, A. Ayob, Review of energy storage systems for electric vehicle applications: Issues and challenges, Renew. Sustain. Energy Rev. 69 (2017) 771789. doi:10.1016/j.rser.2016.11.171. [8] J. Ajuria, E. Redondo, M. Arnaiz, R. Mysyk, T. Rojo, E. Goikolea, Lithium and sodium ion capacitors with high energy and power densities based on carbons from recycled olive pits, J. Power Sources. 359 (2017) 1726. doi:10.1016/j.jpowsour.2017.04.107. [9] T. Brousse, D. Belanger, J.W. Long, To Be or Not To Be Pseudocapacitive?, J. Electrochem. Soc. 162 (2015) A5185A5189. doi:10.1149/2.0201505jes.
	Supplementary literature	[1] T. Chen, L. Dai, Flexible supercapacitors based on carbon nanomaterials, J. Mater. Chem. A. 2 (2014) 10756. doi:10.1039/c4ta00567h. [2] K. Fic, G. Lota, M. Meller, E. Frackowiak, Novel insight into neutral medium as electrolyte for high-voltage supercapacitors, Energy Environ. Sci. 5 (2012) 5842. doi:10.1039/c1ee02262h. [3] E. Frackowiak, Carbon materials for supercapacitor application., Phys. Chem. Chem. Phys. 9 (2007) 177485. doi:10.1039/b618139m. [4] S. Nowak, M. Winter, Elemental Analysis of Lithium Ion Batteries, J. Anal. At. Spectrom. 00 (2017) 115. doi:10.1039/C7JA00073A.
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed	1) Name three kinds of electrode materials that can be used in galvanic cells. Give an example of each of them. 2) Explain what a redox flow cell is. How can you increase the power of this device and the amount of energy it stores? 3) Explain what an electrical double layer is. Where is this phenomenon used?	
Work placement	Not applicable	