GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Micro-electronics for electromobility, PG_00069110		
Field of study	MIKRO-ELEKTRONIKA DLA ELEKTROMOBILNOŚCI		
Date of commencement of studies	October 2022	Academic year of realisation of subject	2025/2026
Education level	first-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	4	Language of instruction	Polish
Semester of study	7	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Functional Materials Engineering -> Faculty of Electronics Telecommunications and Informatics -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Maciej Haras	
	Teachers	dr inż. Maciej Haras	

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

eNauczanie source addresses:

Moodle ID: 792 MIKRO-ELEKTRONIKA DLA ELEKTROMOBILNOŚCI [TWiE][2025/26]
https://enauczanie.pg.edu.pl/2025/course/view.php?id=792

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	0.0	0.0	30

Subject objectives

Course aims at students' familiarization with the fundamentals of µelectronics, manufacturing processes of electronic devices, and their applications in electromobility. Students will gain knowledge of current technological trends, focusing on miniaturization, its impact on devices, and the growing use of low- and zero-power solutions. The program introduces the basics of ***I***nternet ***o***f ***T***hings (***IoT***) systems and nodes, highlighting their role in smart and sustainable transportation. A key component is the analysis of energy consumption in µelectronic systems and alternative power sources using energy harvesting, reducing dependence on traditional supplies like batteries and cables. The final objective is to present the wide spectrum of µelectronics applications in electromobility and prepare students for creative, innovative use of knowledge in practice

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_U05] can use analytical and simulation methods, prepare and for the formulation and solution of tasks in the field of hydrogen technologies, automation and robotics, electrical engineering, use various techniques to carry out engineering tasks related to electrical devices, hydrogen installations, control and robotics systems	Is able to use analytical methods to analyze the operation of basic μ-electronic circuits and devices. Is able to prepare and carry out laboratory exercises related to testing the parameters and performance of μ-electronic circuits, and subsequently calculate, analyze, and interpret the obtained results. Is able to apply various engineering techniques and tools to solve practical problems concerning low-power μ-electronic circuits.	[SU1] Ocena realizacji zadania
[K6_K02] can work in a group taking on different roles in it	Is able to cooperate within a team during the implementation of laboratory tasks, demonstrating responsibility for the assigned scope of work. Is able to assume different roles within a group (e.g. leader, executor, person responsible for documentation or presentation of results).	[SK1] Ocena umiejętności pracy w grupie
[K6_W13] knows the properties of materials used in the field of hydrogen energy and electromobility	Knows the properties of materials used in the manufacturing of μ-electronic circuits and devices. Knows the material properties affecting the performance and energy capabilities of micro energy generators. Knows the relationships between material properties and their impact on the operating parameters of modern μ-electronic systems.	[SW1] Ocena wiedzy faktograficznej

Subject contents

1. **Introduction** general overview of the course, grading rules, course content, literature;
2. **Nano- and Microelectronics today** history, industry, and principles;
3. **μ-Electronics vs IoT and electromobility** quantitative and energy analysis, new power supply paradigm;
4. **Thermoelectricity (TEG) heat has power** history, effect, physics, challenges and limitations, applications in electromobility;
5. **Photovoltaics (PV) light does the work** history, effect, physics, challenges and limitations, applications in electromobility;
6. **Vibration energy** piezoelectric, electrostatic, and electromagnetic generators, their design and applications in μ-electronics and electromobility;
7. **Generators from distributed sources producing energy anytime and anywhere** the *Holy Grail* of powering μ-electronics: concept, examples, and performance.

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1. **Photovoltaic generators** operating parameters, effect of light color on performance, output characteristics, searching for the optimal operating point
2. **Thermoelectric generators** output characteristics under different thermal conditions, performance under various electrical loads, thermalization, performance improvement
3. **Piezoelectric generators** performance, optimization of the operating point, IoT system design, methods for improving performance

Prerequisites and co-requisites

1. The student has knowledge of mathematics (*definite integration, differentiation, root mean square and average value*).
2. The student knows and applies basic concepts and laws of electrical engineering (*Ohms law, Kirchhoffs laws, Joules law, Amperes law*).
3. The student knows the definitions and understands the differences between fundamental quantities used in electrical engineering and electronics (*power, energy, current, voltage*).
4. The student can connect simple electrical circuits and understands the principles and operation of basic measuring instruments (*oscilloscope, multimeters*).
5. The student knows the basics of electronics the operating principles of basic electronic devices, types of transistors and semiconductor components along with their typical characteristics.
6. From a materials perspective, the student understands differences in electrical properties knows the concepts of insulator, semiconductor, and conductor, and understands the physical basis for classifying materials by conductivity.
7. The student knows the fundamentals of semiconductor material physics, including the concepts of energy gap, charge carriers, and doping.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
	51.0%	40.0%
	51.0%	60.0%

Recommended reading	Basic literature	1. P. Horowitz i W. Hill, *Sztuka elektroniki. 1-2*, wyd. 12. zmienione. Warszawa: Wydawnictwa Komunikacji i Łączności, 2018. 2. J. Hennel, *Podstawy elektroniki półprzewodnikowej.* Warszawa: Wydawnictwa Naukowo-Techniczne, 2003. 3. A. Chwaleba, B. Moeschke, G. Płoszajski, P. Majdak, i P. Świstak, *Podstawy elektroniki*, 1. wyd. Warszawa: Wydawnictwo WNT, 2021. 4. R. F. Pierret, *Advanced semiconductor fundamentals*. Reading, Mass: Addison-Wesley Pub. Co, 1987. 5. M. Nikowitz, Red., *Advanced hybrid and electric vehicles*. w Lecture Notes in Mobility. New York, NY: Springer Berlin Heidelberg, 2016. 6. S. M. Sze, *Physics of semiconductor devices*, 3. wyd. Hoboken, N.J: Wiley-Interscience, 2007. 7. H. J. Goldsmid, *Introduction to thermoelectricity*, 2. wyd. w Springer series in materials science, no. 121. Berlin Heidelberg: Springer, 2016. 8. J. N. Burghartz, Red., *Guide to state-of-the-art electron devices*. Chichester, West Sussex, United Kingdom: John Wiley & Sons Inc, 2013. 9. L. B. Kong, T. Li, H. H. Hng, F. Boey, T. Zhang, i S. Li, *Waste energy harvesting*, t. 24. w Lecture Notes in Energy, vol. 24. Berlin, Heidelberg: Springer Berlin Heidelberg, 2014. Dostępne na: http://link.springer.com/10.1007/978-3-642-54634-1 10. D. Briand, E. Yeatman, i S. Roundy, Red., *Micro energy harvesting* , 1. wyd. w Advanced micro & nanosystems, no. 12. Weinheim: Wiley-VCH, 2015. 11. N. Bizon, N. M. Tabatabaei, F. Blaabjerg, i E. Kurt, Red., *Energy Harvesting and Energy Efficiency: Technology, Methods, and Applications*. w Lecture Notes in Energy, no. 37. Springer International Publishing, 2017.
	Supplementary literature	1. B. Y. León Ávila, C. A. García Vázquez, O. Pérez Baluja, D. T. Cotfas, and P. A. Cotfas, Energy harvesting techniques for wireless sensor networks: A systematic literature review, Energy Strategy Reviews, vol. 57, p. 101617, Jan. 2025, doi: 10.1016/j.esr.2024.101617. 2. M. R. Sarker, A. Riaz, M. S. H. Lipu, M. H. Md Saad, M. N. Ahmad, R. A. Kadir, and J. L. Olazagoitia, Micro energy harvesting for IoT platform: Review analysis toward future research opportunities, Heliyon, vol. 10, no. 6, 2024, doi: 10.1016/j.heliyon.2024.e27778. 3. K. Bhatt, S. Kumar, S. Kumar, S. Sharma, and V. Singh, A review on energy harvesting technologies: Comparison between non-conventional and conceptual approaches, Energy Reports, vol. 12, pp. 47174740, Dec. 2024, doi: 10.1016/j.egyr.2024.10.019. 4. M. Haras, N. Ahmed, and T. Skotnicki, Further IoT market expansion owing to innovative thermal energy harvesting, in 2022 IEEE 16th International Conference on Solid-State & Integrated Circuit Technology (ICSICT), Nangjing, China, 2022, pp. 14, doi: 10.1109/ICSICT55466.2022.9963142. 5. N. Sezer and M. Koç, A comprehensive review on the state-of-the-art of piezoelectric energy harvesting, Nano Energy, vol. 80, p. 105567, Feb. 2021, doi: 10.1016/j.nanoen.2020.105567. 6. F. K. Shaikh and S. Zeadally, Energy harvesting in wireless sensor networks: A comprehensive review, Renewable and Sustainable Energy Reviews, vol. 55, pp. 10411054, Mar. 2016, doi: 10.1016/j.rser.2015.11.010. 7. M. Haras and T. Skotnicki, Thermoelectricity for IoT A review, Nano Energy, vol. 54, pp. 461476, Dec. 2018, doi: 10.1016/j.nanoen.2018.10.013. 8. R. J. M. Vullers, R. van Schaijk, I. Doms, C. Van Hoof, and R. Mertens, Micropower energy harvesting, Solid-State Electronics, vol. 53, no. 7, pp. 684693, July 2009, doi: 10.1016/j.sse.2008.12.011. 9. A. Harb, Energy harvesting: State-of-the-art, Renewable Energy, vol. 36, no. 10, pp. 26412654, Oct. 2011, doi: 10.1016/j.renene.2010.06.014.
	eResources addresses	

Example issues/ example questions/ tasks being completed	1. Describe the what is the ***I***nternet ***o***f ***T***hings (***IoT***), explain its operating principles, and identify the characteristic features of ***IoT*** systems. Provide examples of applications. 2. List at least two main technologies for manufacturing microelectronic devices and describe the specific characteristics of one selected technology. 3. List at least three techniques or processes used in the production of microelectronic devices and describe one of them in detail. 4. Identify methods of converting mechanical energy into electrical energy that can be applied in electromobility to power microelectronic systems. 5. Explain Moores law and describe its implications for the development of microelectronics. 6. In an electric vehicle, identify at least three energy sources that can be converted into electrical energy. Specify the conversion method or phenomenon for each source. For one selected source, draw or describe the energy recovery system schematic. 7. Describe how thermal energy can be recovered and converted into electrical energy. Provide typical efficiencies and draw the device topology. 8. Explain the Betz limit, provide its value and significance, and indicate in which applications it is relevant. 9. For a given working environment or installation site, indicate the possible energy harvesting methods that can be applied. 10. Draw a typical power consumption diagram for an ***IoT*** node, determine the average energy consumption per operation cycle, describe the operation stages, and identify the most energy-demanding component.
Practical activites within the subject	Not applicable