GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

| | | | |
|---|---|---|---|
| Subject name and code | , PG_00069394 | | |
| Field of study | Materials Engineering | | |
| Date of commencement of studies | October 2023 | Academic year of realisation of subject | 2025/2026 |
| Education level | first-cycle studies | Subject group | Optional subject group |
| Mode of study | Full-time studies | Mode of delivery | at the university |
| Year of study | 3 | Language of instruction | Polish |
| Semester of study | 5 | ECTS credits | 1.0 |
| Learning profile | general academic profile | Assessment form | assessment |
| Conducting unit | Institute of Nanotechnology and Materials Engineering -> Faculty of Applied Physics and Mathematics -> Wydziały Politechniki Gdańskiej | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | dr inż. Leszek Wicikowski | |
| | Teachers | dr inż. Leszek Wicikowski | |

**Lesson types and methods of instruction**

| Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
|---|---|---|---|---|---|---|
| Number of study hours | 15.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15 |

E-learning hours included: 0.0

eNauczanie source addresses:
Moodle ID: 1327 Materiały amorficzne
https://enauczanie.pg.edu.pl/2025/course/view.php?id=1327

**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 | 15 | 1.0 | 9.0 | 25 |

**Subject objectives**

The aim of the course is to familiarize students with basic information on:
the structure and properties of amorphous materials,
methods of their production, characterization techniques,
main areas of application in materials science and modern technologies.

## Learning outcomes

| Course outcome | Subject outcome | Method of verification |
|---|---|---|
| [K6_W07] Has detailed knowledge of selected problems of materials science. | Knows the structural differences between amorphous and crystalline materials.<br>Characterizes the basic groups of amorphous materials (glasses, metals, polymers).<br>Knows the most important methods for obtaining amorphous materials.<br>Understands the importance of amorphous materials in modern technology. | [SW1] Assessment of factual knowledge |
| [K6_U07] Can obtain information from literature and other properly selected sources, also in English or other foreign language used for international communication in materials engineering. | Identifies techniques for testing and characterizing amorphous materials. Analyzes examples of amorphous materials applications. | [SU2] Assessment of ability to analyse information<br>[SU3] Assessment of ability to use knowledge gained from the subject<br>[SU4] Assessment of ability to use methods and tools |
| [K6_U09] Has the ability to prepare oral presentations in Polish and in a foreign language, concerning detailed issues, using fundamental theoretical approaches, and diverse sources. | uses information obtained during classes and is able to answer questions regarding issues discussed during lecture | [SU3] Assessment of ability to use knowledge gained from the subject |
| [K6_K01] Understands the need to improve professional and personal competencies; is conscious of own limitations and knows when to turn to experts, properly establishes priorities helping to accomplish tasks defined by oneself or others. | Understands the need to continually expand knowledge about new materials.<br>Recognizes the importance of amorphous materials in the development of modern technologies. | [SK5] Assessment of ability to solve problems that arise in practice<br>[SK4] Assessment of communication skills, including language correctness |

## Subject contents

Course Content (Lecture 15 h)
1. Definition of amorphous materials, examples, technological significance.
2. Amorphous structure short- and medium-range order.
3. Glass transition, basic thermodynamics of glass.
4. Methods for manufacturing amorphous materials: rapid cooling, sol-gel, vapor deposition, sputtering.
5. Inorganic glasses composition, optical and mechanical properties.
6. Amorphous metals preparation, magnetic and mechanical properties.
7. Amorphous polymers and thin films.
8. Basic research techniques (XRD, DSC, spectroscopy).
9. Applications of amorphous materials in electronics, optoelectronics, and biomaterials.
10. Prospects for the development of amorphous materials.

Teaching Methods
- Lecture with multimedia presentation.
- Problem-solving discussion.
- Case study (application examples).

## Prerequisites and co-requisites

## Assessment methods and criteria

| Subject passing criteria | Passing threshold | Percentage of the final grade |
|---|---|---|
| Final test | 50.0% | 100.0% |

## Recommended reading

| | |
|---|---|
| Basic literature | 1. A. Varshneya, Fundamentals of Inorganic Glasses<br>2. J. Zarzycki, Glasses and the Vitreous State.<br>3. A. Inoue, Amorphous Materials and Metallic Glasses. |
| Supplementary literature | 1. D.R. Uhlmann, N.J. Kreidl, Glass: Science and Technology.<br>2. A. Makino, T. Bitoh, Soft Magnetic Amorphous and Nanocrystalline Alloys.<br>3. Aktualna literatura naukowa |
| eResources addresses | |

| | |
|---|---|
| Example issues/ example questions/ tasks being completed | **Sample Test Questions and Short Answers**<br>1. Explain the difference between crystalline and amorphous structures.<br>2. What is the glass transition?<br>3. Name three methods for obtaining amorphous materials.<br>4. Why does rapid cooling favor the formation of the amorphous phase?<br>5. Give examples of applications for amorphous metals.<br>6. What technique can be used to confirm the absence of long-range order in a material?<br>7. What is the difference between "short-range order" and "long-range order"?<br>8. Which of the following materials can be amorphous: SiO, Al, Fe, polystyrene?<br>9. Why is glass metastable?<br>10. Indicate the main advantage of metallic glass in mechanical applications.<br>**Open/Descriptive Questions**<br>1. Discuss the conditions for glass formation according to D. Turnbull's concept.<br>2. Explain how the cooling rate affects the ability to avoid crystallization.<br>3. Compare the mechanical properties of silica glass and metallic glass.<br>4. Describe the glass transition process how do specific volume and enthalpy change as a function of temperature?<br>5. Explain the role of glass-forming oxides and modifiers in inorganic glasses.<br>6. Discuss the differences in amorphization methods: rapid cooling vs. vacuum vapor deposition.<br>7. What are the limitations of characterization techniques for amorphous materials compared to crystals?<br>**Calculation/Problem-Solving**<br>1. A material crystallizes at a cooling rate of less than $10^4$ K/s. What minimum cooling rate should be used to obtain glass if the crystallization temperature is 600 K and the melting point is 200 K? (Estimate relaxation time and discuss).<br>2. The DSC curve of the glass sample shows $T_g$ = 450°C, $T_x$ = 520°C. Calculate the thermal stability parameter $S = T_x - T_g$. What does this mean, and can the material be considered thermally stable?<br>3. Draw and discuss the free enthalpy G as a function of temperature for the crystalline and amorphous phases. Where does the difference occur and what significance does this have for the metastability of the glass?<br>4. Explain why sharp reflections are not observed in the diffraction pattern of an amorphous material, but rather a broad peak. How can this indicate the lack of long-range order?<br>**Examples of Project/Discussion Tasks**<br>1. Suggest a potential application of an amorphous material in electronics and justify the method used to obtain it.<br>2. Compare the advantages and disadvantages of amorphous metals compared to conventional structural steels.<br>3. Prepare a short paper: "Modern Glasses for Optoelectronics Examples and Development Prospects." |
| Work placement | Not applicable |

Document generated electronically. Does not require a seal or signature.