Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Advanced multifunctional amorphous and crystalline metallic materials - manufacturing and investigations	
Course name in Polish:	Zaawansowane wielofunkcyjne amorficzne i krystaliczne materiały metaliczne - wytwarzanie i badania	
Number of hours:	15	
Type of course:	Elective course	
Form of course:	mixed forms (combination of lecture, seminar and laboratory)	
Code of course:		
Course leader:	Mariusz Hasiak, Assoc. Prof., Ph.D., D.Sc.	
Faculty of the course leader:	W10 Faculty of Mechanical Engineering	
Email address of the course leader:	mariusz.hasiak@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, electrical engineering and space technologies	☒
	Information and communication technology	☐
	Biomedical engineering	☒
	Chemical engineering	☒
	Civil engineering, geodesy and transport	☒
	Materials engineering	☒
	Mechanical engineering	☒
	Environmental engineering, mining, and energy	☒
	Mathematics	☐
	Chemical sciences	☒
	Physical sciences	☒
	Management and quality studies	☐

2. Objectives

During the course, the student will be introduced to advanced techniques of metallic materials manufacturing. During the course, metallic alloys with amorphous and crystalline structures will be produced by the rapid cooling technique. Further, students will be introduced to advanced research techniques at the nanometer and atomic scales. Measurements of surface topography, phase transitions and mechanical properties for the fabricated materials are planned in the next steps. Numerical data analysis will be one of the key topics discussed in the course with students

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes
1	Introduction to solid state physics and modern manufacturing techniques of metallic materials	2	lecture
2	Production of amorphous and nanocrystalline metallic alloys by arc melting and rapid cooling technique	2	laboratory
3	Introduction to advanced techniques for studying the microstructure of single- and multi-phase materials (X-ray, SEM/EDS, TEM, CEMS/Mössbauer spectroscopy)	2	seminar
4	Investigations of topography of materials in nanoscale by Atomic Force Microscopy (AFM/LFM) with numerical data analysis	2	laboratory
5	Phase transitions studies in metallic alloys (DSC/DTA/TG investigations)	2	lecture
6	Investigation of mechanical properties of materials by nanoindentation testing	2	laboratory
7	Relation between microstructure and mechanical properties in advanced multifunctional amorphous and crystalline materials	2	seminar
8	Analysis of the research results obtained in the course	1	project
9			Select form
10			Select form
11			Select form
12			Select form
13			Select form
14			Select form
15			Select form

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

a) Basic knowledge of manufacturing and metallic materials science;
b) Basic knowledge of metrology;
c) Basic knowledge of physics, chemistry and mechanics
d) Knowledge of the principles of analysis of research results

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	**Learning outcome**	
	KNOWLEDGE. Doctoral student knows and understands:	
SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☒
SzD_W4	research methodology;	☒

SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☒
SzD_W6	the fundamental dilemmas of modern civilization;	☒
SzD_W7	the legal and ethical conditions of scientific activity;	☒
SzD_W8	the economic and other relevant conditions of scientific activity;	☒
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☒
	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☒
SzD_U4	disseminate research results, including in popular forms;	☒
SzD_U5	initiate debates and participate in a scientific discourse;	☒
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☒
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☒
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☒
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☒
	SOCIAL COMPETENCES. Doctoral student is ready to:	
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☒
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☒

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Participation in the discussion, presentation, raport

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

Multimedia presentation, discussion, presentation of measurements, own work, taking your own measurements

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

1. Michael Miller, Peter Liaw, Bulk Metallic Glasses: An Overview, Springer, 2008
2. C. Suryanarayana, A. Inoue, CRC Press, 2018,
3. William D. Callister Jr., David G. Rethwisch, Fundamentals of Materials Science and Engineering. An Integrated Approach, Wiley, 2015,
4. Charles Kittel, Introduction to Solid State Physics, Wiley, 2005,
5. Jiří Němeček, Nanoindentation in Materials Science, 2016
6. C. Suryanarayana, Experimental techniques in materials and mechanics, CRC Press, 2011

9. Other remarks

Additional remarks, comments, (e.g., language of the course)