Doctoral School
Warsaw University of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-0000FGK-0366	Name of the course	Polish	**Zaawansowane materiały ceramiczne i ich rola w rozwoju naszej cywilizacji**
			English	**Advanced ceramic materials and their role in development of our civilization**
Type of the course	specialized			
Course coordinator	Prof. Mikołaj Szafran, PhD, DSc, Eng	Course teacher	Prof. Mikołaj Szafran, PhD, DSc, Eng	
Implementing unit		Scientific discipline / disciplines*	Inżynieria Cheminczna Nauki Chemiczne Inżynieria Materiałowa	

Level of education	doctoral studies	Semester	winter		
Language of the course	English				
Type of assessment	pass	Number of hours in a semester	26	ECTS credits	2
Minimum number of participants	12	Maximum number of participants	30	Available for students (BSc, MSc)	No

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	2				
	in a semester	26				

* does not apply to the Researcher's Workshop

1. Prerequisites

Knowledge of broadly understood chemistry, chemical engineering and materials engineering

2. Course objectives

The aim of the lectures and seminars is to provide doctoral students as the development of advanced ceramic materials has changed and continues to change our civilization, with particular emphasis on the development of this area after World War II and what changes occurred as a result of the race for mastery of the cosmos and as a result of the ongoing arms race. During the course, the role of broadly understood chemistry and physics in the design of this type of materials including organic chemistry, polymer chemistry and colloid chemistry will be presented. Especially a lot of space will be devoted to ceramic nanomaterials, starting from the synthesis of nanopowders, through their deagglomeration and sintering. The material of the lecture content will be closely related to the research conducted by the lecturer at the Faculty of Chemistry of the Warsaw University of Technology and at other faculties of Warsaw University of Technology.

3. Course content (separate for each type of classes)

Lecture

1. What is ceramics, definitions, properties, comparison with metals and plastics, ceramic technology during ages
2. Introduction to technology of ceramics:

- ceramic and nanoceramic powders,
- methods of shaping and forming in ceramic technology:
- die pressing, extrusion, slip casting;
- methods of molding of advanced ceramics, e.g. tape casting, gelcasting, injection molding,
- direct coagulation casting

3. Main problems in application of nanoceramic powders:

- deagglomeration of nanoceramic powders;
- sintering of nanoceramic powders

4. Colloidal processing of advanced ceramic materials and composites 5. Molding of advanced ceramic materials: one of the most important stage in technology of ceramics 6. New methods of sintering of advanced ceramic materials (hot pressing, hot isostatic pressing, microwave sintering, spark plasma sintering, U-FAST, (UP-Graded Field Assisted Sintering Technology) 7. Terracotta Army, the greatest archaeological find of the 20th Century 8. New glasses and their role in development of temporary civilization 9. Shear thickening fluid and their application in our live 10. Ferroelectric ceramic-polymer composites for microwave application 11. Ceramics in medicine: dental ceramics, bone repair ceramics, joint Implants 12. Ceramics and the electronics age 13. Ceramics in space 15. Refractory materials and their role in technology of steel and other metals, ceramics, glass, etc. 16. Composites, materials of the future 17. 3-D printing of advanced ceramics materials
Laboratory

4. Learning outcomes			
Type of learning outcomes	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
W01	The graduate knows the general chemical and physicochemical fundamentals of technological processes used in the ceramics and related industries	SD_W1	written test
W02	The graduate knows the current directions of development of ceramic technology and materials engineering related to advanced ceramics	SD_W2	written test
W03	The graduate understands the basic unit operations and technological processes involved in obtaining various types of ceramic materials and composites	SD_W3	written test
Skills			
U01	The graduate can make a critical analysis and evaluation of the results of scientific research, expert activity and other creative works and their contribution to the development of knowledge, to assess the usefulness and possibility of using the results of theoretical work in practice	SD_U2	written test
U02	The graduate can communicate on specialist topics relevant to the represented scientific discipline, to the extent enabling active participation in the national and international scientific environment, including as part of international consortia of research universities	SD_U4	active participation during classes written test
U03	The graduate can initiate a debate and participate in the scientific discourse as well as provide	SD_U5	active participation during classes

	appropriate arguments in scientific discussions and public debates on various topics		
Social competences			
K01	The graduate continues to improve professional and personal competencies, by following and analyzing the latest developments related to the advanced ceramic materials	SD_K1	written test
K03	The graduate is ready to recognize the importance of knowledge and scientific achievements in solving cognitive and practical problems	SD_K2	written test

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
Results of a test + active participation during classes

6. Literature
Primary references:
[1] David W. Richerson, The Magic of Ceramics, Second edition, Copyright©2012 by The American Ceramic Society, Published by A. John Wiley&Sons, Inc.,
[2] C. Barry Carter, M. Grant Norton, Ceramic Materials, Science and Engineering, Second edition, 2013, Springer Science+Business Media, LLC.
[3] Suk-Joong L. Kang, Sintering. Densification, Grain Growth, and Microstructure, Elsevier 2005
Secondary references:
[1] Sintering. Mechanisms of Convention Nanodensification and Field Assisted Processes, eds. R. Castro, K. van Benthem, Springer 2013.
[2] A.R. West, Solid State Chemistry and its Applications, Wiley 2014

7. PhD student's workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	26
2	Hours of consultations with the academic teacher, exams, tests, etc.	10
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	
4	Amount of time devoted to the preparation for exams, tests, assessments	10
	Total number of hours	**45**
	ECTS credits	**2**

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)

8. Additional information	
Number of ECTS credits for classes requiring direct participation of academic teachers	2
Number of ECTS credits earned by a student in a practical course	

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