THE DOCTORAL SCHOOL OF IPPT PAN

COURSE OFFERED IN THE DOCTORAL SCHOOL OF IPPT PAN

Name of the course	Polish	**Wielofunkcyjne materiały aktywne: stopy z pamięcią kształtu, polimery, kompozyty i innowacyjny stop Ti bez Ni o nazwie Gum Metal - badane różnymi technikami**			
	English	**Multifunctional active materials: Shape Memory Alloys, Polymers, Composites and innovative Ti Ni-free alloy named Gum Metal - studied by various techniques**			
Type of the course	**Introductory lecture**				
Course coordinator	**Prof. dr hab. inż. Elżbieta Pieczyska**	Course teacher	**Prof. dr hab. inż. Elżbieta Pieczyska**		
Implementing unit	**DMD**	Scientific discipline / disciplines	**Mechanical Engineering / Materials Science**		
Level of education	**doctoral studies**	Semester	**Summer or winter**		
Language of the course	**English or Polish**				
Type of assessment	**examination**	Number of hours in a semester	**20**	ECTS credits	**3**

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	**2**	**0**	**0**	**0**	**0**
	in a semester	**20**	**0**	**0**	**0**	**0**

1. Prerequisites

Fundamental knowledge of the smart and multifunctional materials, i.e. shape memory alloys (SMA), high elastic Ti alloys, shape memory polymers (SMP) will be presented. In addition, fundamentals of the 3D printing, experimental mechanics and thermomechanical couplings.

2. Course objectives

The goal of the course is to introduce students to various types of intelligent multifunctional materials that are able to adapt their properties to the change of an external stimuli and this adaptation can be used as a stimulating factor. The materials can combine the properties of a sensor and actuator, providing miniaturization, important in medical, space or mechatronic applications. The group of these materials comprises shape memory alloys (SMA), shape memory polymers (SMP), composites (SMC) and innovative Ti alloys with high strength and elasticity, named Gum metals. The fundamental research on experimental mechanics, 3D printing and thermomechanical couplings will be also presented.

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

Lecture

1. Introduction to experimental mechanics
2. What do we mean by thermomechanical couplings?
3. Why is infrared camera so useful in new materials study?
4. Introduction to shape memory materials: SMA, SMP, SMC and 3D printing
5. Application of SMA, SMP and SMC in engineering, textile and medical industry
6. Experimental studies on SMA, SMP, SMC and 3D printing
7. Thermo-mechanical properties of TiNi SMA, subjected to various kinds of loadings
8. Introduction to thermodynamics of martensitic forward/reverse transformation in SMA
9. Introduction to unique mechanical and structure properties of Ti β alloy Gum Metal
10. Gum Metal unique properties investigated by IR and digital image correlation DIC

4. Learning outcomes			
Number of the learning outcome	Learning outcomes description	Reference to the learning outcomes according to the 8th level of PRK	Learning outcomes verification methods*
Knowledge			
1	The graduate acquires basic knowledge of the experimental mechanics, infrared techniques and thermomechanical couplings	P8S_WG	Homeworks/Examination
2	The graduate acquires basic knowledge about various kinds of shape memory materials and methods of their analysis.	P8S_WG	Homeworks/Examination
3	The graduate knows how to transfer the acquired knowledge to his/her research field and proper dissemination of results	P8S_WK	assessment of activity during classes
Skills			
1	The graduate is able to analyze problems of shape memory material thermomechanical response under loading.	P8S_UW	Homeworks/Examination
2	The graduate is able to choose proper test conditions and analyze the material behavior for the given range of deformation and thermomechanical conditions.	P8S_UW	Homeworks/Examination
3	The graduate is able to critically analyze the correctness and scope of applicability of the performed thermo-mechanical analysis	P8S_UW	Homeworks/Examination assessment of activity during classes
4	The graduate is able to transfer the acquired knowledge to the industrial environment and disseminate the results of this research.	P8S_UW	assessment of activity during classes
Communication			
1	The graduate is able to communicate his/her results in a clear and rigorous way in the international scientific community	P8S_UW	
Social competences			
1	The graduate is ready to think and act in a creative and entrepreneurial way.	P8S_KO	assessment of activity during classes
2	The graduate is ready to critically evaluate the achievements of the represented scientific discipline, including his or her own contribution to the development of this discipline.	P8S_KK	assessment of activity during classes

*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
assessment of activity during classes, results of the examination

6. Literature

Literatura podstawowa:

[1]

[2]

Literatura uzupełniająca:

[1] Pieczyska E.A., Gadaj S.P., Nowacki W.K., Tobushi H. , *Phase-transformation fronts evolution for strain- and stress- controlled tension tests in TiNi Shape Memory Alloy*, EXPERIMENTAL MECHANICS, ISSN: 0014-4851, Vol.46, pp.531-542, **2006**

[2] Pieczyska E.A., Tobushi H. , Kulasiński K., *Development of transformation bands in TiNi SMA for various stress and strain rates studied by a fast and sensitive infrared camera*, SMART MATERIALS AND STRUCTURES, ISSN: 0964-1726, Vol.22, No.3, pp.035007-1-8, **2013**

[3] Pieczyska E.A., Maj M., Kowalczyk-Gajewska K., Staszczak M., Urbański L., Tobushi H. , Hayashi S. , Cristea M. , *Mechanical and Infrared Thermography Analysis of Shape Memory Polyurethane*, Journal of Materials Engineering and Performance, ISSN: 1059-9495, Vol.23, No.7, pp.2553-2560, **2014**

[4] Pieczyska E.A., Staszczak M., Kowalczyk-Gajewska K., Maj M., Golasiński K.M., Golba S. , Tobushi H. , Hayashi S. , *Experimental and numerical investigation of yielding phenomena in a shape memory polymer subjected to cyclic tension at various strain rates*, POLYMER TESTING, ISSN: 0142-9418, Vol.60, pp.333-342, **2017**

[5] Pieczyska E.A., Maj M., Golasiński K.M., Staszczak M., Furuta T. , Kuramoto S. , *Thermomechanical Studies of Yielding and Strain Localization Phenomena of Gum Metal under Tension*, Materials, ISSN: 1996-1944, DOI: 10.3390/ma11040567, Vol.11, No.567, pp.1-13, **2018**

[6] Pieczyska E.A., Maj M., Staszczak M., Świec P. , Furuta T. , Kuramoto S. , *Investigation of strain rate sensitivity of gum metal under tension using digital image correlation*, ARCHIVES OF CIVIL AND MECHANICAL ENGINEERING, ISSN: 1644-9665, Vol.20, No.2, pp.53-1-14, **2020**

7. PhD student's workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the lecturer in the classroom	**20**
2	Hours of consultations with the lecturer, exams, tests, etc.	**15**
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	**35**
4	Amount of time devoted to the preparation for exams, test, assessments	**30**
	Total number of hours	**100**
	ECTS credits	**3**

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