Warsaw University of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-00000GL-0042	Name of the course	Polish	Nanomateriały magnetyczne	
			English	**Nanoscale Magnetic Materials**	
Type of the course	Elective lecture for PhD students				
Course coordinator	Prof. dr hab. inż. Marcin Leonowicz				
Implementing unit	WIM PW	Scientific discipline / disciplines*	materials engineering, physical sciences		
Level of education	Education of PhD students	Semester	Winter		
Language of the course	English				
Type of assessment:	Grade on a basis of written test	Number of hours in a semester	30	ECTS credits	2
Minimum number of participants	12	Maximum number of participants	-	Available for students (BSc, MSc)	Yes/~~No~~

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	2				
	in a semester	30				

* does not apply to the Researcher's Workshop

1. Prerequisites

Basic knowledge on physics of solid state and fundamentals of materials science and engineering.

2. Course objectives

Aim:
The course is oriented towards teaching of advanced materials engineering using magnetic nanomaterials, as an example. The course comprises: Introduction to basic magnetic parameters and units. Magnetic interactions in solid body and classification of magnetic materials. Bulk magnetism and magnetism of small particles and nanostructures. Types of hard and soft magnetic nanomaterials, their structure, processing methods and properties. Major applications of magnetic nanomaterials.

Course Objectives:
1) To teach students the basic definitions of physics of solid state related to magnetism.
2) To teach students the basic classes of hard and soft magnetic materials.
3) To present students the basics of nanomagnetism with respect to bulk magnetism.
4) To teach students the methods of the processing of magnetic materials.
5) To provide students with knowledge of applications of magnetic materials and their selections for particular applications.

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

Lecture

1. Basic definitions and units (electricity and magnetism, magnetic flux, induction, susceptibility, permeability, classification of magnetic materials on a basis of magnetic hysteresis.
2. Ferromagnetism (magnetic moment of atom, exchange forces, exchange energy, temperature dependence of magnetisation, magnetic anisotropy, demagnetising field, magnetostatic energy).
3. Domain structure (domain wall width, interaction of domain wall with inclusions, effect of magnetic field on domain structure).
4. Overview of hard and soft magnetic nanomaterials and their applications.
5. Nanocrystalline and nanocomposite magnetic materials (effect of nanostructure on the magnetic properties, effect of enhanced magnetic exchange interactions).
6. Recording materials (magnetic tapes, magnetic discs, thin films, cylindrical domains, recording density).
7. Magnetic nanomaterials for biomedical applications
8. Magnetic refigeration

Laboratory
N/A

4. Learning outcomes			
	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
K01	The student knows and understands the world achievements, including theoretical foundations and practical issues, and selected specific issues, in the field of magnetic materials, their structure, technology and applications.	SD_W2 P8S_WG	written test
K02	The student knows the main development trends of material engineering in the field of research and selection of magnetic materials for specific applications.	SD_W3 P8S_WG	written test
K03			
Skills			
S01	The student knows how to communicate on specialist topics in materials engineering, relevant to magnetic materials, to the extent that allows active participation in the national and international scientific environment, including international consortia of research universities.	SD_U4 P8_UK	
S02			
S03			
Social competences			
SC01	The student is ready to recognize the importance of knowledge and scientific achievements in solving cognitive and practical problems with the use of magnetic materials.	SD_K2 P8S_KK	

*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
Written test

6. Literature
• Materials from the lecture, handouts Additional literature • P. Campbell, *Permanent magnet materials and their applications*, Cambridge, University Press, 1996. • R.C. O'Handley, *Modern magnetic materials, principles and applications*, John Wiley and Sons, New York 2000. • B. D. Cullity, C. D. Graham, *Introduction to Magnetic Materials*, 2nd Edition. J. Wiley-IEEE Press 2008.

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	30
2	Hours of consultations with the academic teacher, exams, tests, etc.	2
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	10
4	Amount of time devoted to the preparation for exams, test, assessments	8
	Total number of hours	**50**
	ECTS credits	**2**

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