AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Engineering of functional materials

Academic year: 2017/2018 Code: CIM-2-204-FM-s ECTS credits: 4

Faculty of: Materials Science and Ceramics

Field of study: Materials Science Specialty: Functional Materials

Study level: Second-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 2

Course homepage: —

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Module summary

The aim of this course is to define the scope of this material group, taking into account the correct naming, concepts and definitions and presenting selected issues related to fabrication.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence			
M_K001	The student is able to provide information and opinions on the modern functional materials and their applications in universally understandable way	IM2A_U06, IM2A_U05	Participation in a discussion, Scientific paper, Presentation, Test, Activity during classes
Skills			
M_U001	The student knows how to propose a modern functional material for the specific application and the place where commercial materials can not meet the applicable requirements.	IM2A_U13, IM2A_U11, IM2A_U15	Participation in a discussion, Scientific paper, Presentation, Test, Activity during classes
Knowledge			
M_W001	The student knows the polymer, metallic, ceramic and composite functional materials	IM2A_W07	Participation in a discussion, Scientific paper, Presentation, Test, Activity during classes

M_W002	The student knows the methods of selection of functional material for a specific application..	IM2A_W09	Participation in a discussion, Test, Activity during classes

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Others	E-learning
Social competence												
M_K001	The student is able to provide information and opinions on the modern functional materials and their applications in universally understandable way	-	-	-	-	-	+	-	-	-	-	-
Skills												
M_U001	The student knows how to propose a modern functional material for the specific application and the place where commercial materials can not meet the applicable requirements.	+	-	-	-	-	+	-	-	-	-	-
Knowledge												
M_W001	The student knows the polymer, metallic, ceramic and composite functional materials	+	-	-	-	-	+	-	-	-	-	-
M_W002	The student knows the methods of selection of functional material for a specific application..	-	-	-	-	-	+	-	-	-	-	-

Module content

Lectures

Tematyka wykładów

1. Introduction to functional materials engineering – definitions, material classifications.
2. Nature-derived patterns in materials engineering – biomimetism in functional materials engineering, smart and multifunctional materials.
3. Conductive and electrically active polymers (EAP) in functional materials engineering – types of polymers, mechanisms of electrical conductivity, the methods

of modifying the structure and properties of polymers- based functional materials.
4. Smart materials in functional materials engineering – types of smart materials (active, passive), manufacture, sensors, actuators, smart textiles, e-textiles
5. New manufacture techniques for functional material applications – electrospun fibrous nanomaterials.
6. New manufacturing techniques for functional material applications – 3D printing, Stereolithography, Selective Laser Modeling (SLA), PolyJet methods LDM Liquid Deposition Modeling (LDM), Fused Filament Fabrication (FFF).
7. Self-repairing materials – self- healing mechanisms in synthetic materials, methods for creating self- healing mechanisms of defects in functional materials.
8. Self-organizing materials- the phenomena of self-organization, the types of interactions between system components, materials types and engineering, examples of application
9. Wood as an example of functional materials – raw material types, raw material selection and engineering for wood – derived materials, properties.
10. Wood-derived functional materials – wood and cellulose-derived processing methods , processing variables, properties, applications.
11. Magnetic functional materials- metal alloys and composites- based functional materials, magnetic and magnetorheological fluids, ferromagnetic materials, processing, properties, examples of application.
12. Functional materials in renewable energy sources – economic, technological, environmental and sociological aspects in the development of renewable energy sources, current state of knowledge and outlook for the future, technological problems, economic factors.
13. Phase-change materials (PCM) in thermal energy conversion systems.
14. Functional materials for extreme environments.

Seminar classes

Tematyka seminariów

Trends in the development of functional materials
-Introduction to engineering design. Types of the projects. Analysis of the design process. Design tools. Material functionality/materials type relationships, analysis of the shape, final product and manufacture methods.
- Basic material characteristics (mechanical, electrical, thermal, etc.). Classifications of the known functional and structural materials, evaluation criteria, e.g. specific properties, fracture energy, strain, electrical conductivity etc. Definition of the characteristic properties of particular groups of materials, i.e. polymers, metals, ceramics, composites.
- Discussion on the possibility of classifying different properties of materials using characteristic figures for materials selection, eg. Young’s modulus – Mechanical strength, Young’s modulus – density.
- Comparison of various material groups and their properties by means of the charts for materials selection in engineering design, e.g. Young’s modulus/strength, Young’s modulus/density. Practical aspects of charts for material selection in engineering design, optimal material selection, maximization of functionality of devices/products.
- Introduction into “Functionality Index”, analysis of its meaning, examples of FI for simple shapes. Procedures for selection of materials for a specific application. Criteria maximizing functionality of a material. Examples of materials selection.
-Calculation examples of Functionality Index for the elements having cylindrical shape i.e., rods, tubes, columns together with materials selection. Determination of optimal solutions using characteristic records of different materials. Computation examples of Functionality Index and material selections for the various applications,

e.g. beams, mirrors of large telescopes, springs.
– Materials selection involving shape factor of the engineering design. Shape factors. Mathematical formulas involving basic shape factors of a material . Shape factor and functionality index. Shape factor for internally cross-shaped of a device. Diagrams of materials selection involving the shape factor.
- Cumputational problems related to the determination of functionality index involving shape factor. Computational tasks related to the determination of functionality index involving optimal shape of a designed material. Determining the optimum cross-sectional shape of a device. Diagrams supporting selection of appropriate methods for materials manufacturing.
-Student presentations on selected topics referring to functional materials.

Method of calculating the final grade

final mark=30% of the seminar mark (avarage marks from tests, mark from presentation) + 70% of the exam mark

Prerequisites and additional requirements

Prerequisites and additional requirements not specified

Recommended literature and teaching resources

1. Zhenhai Xia, Biomimetic Principles and Design of Advanced Engineering Materials, ISBN: 978-1-118-53307-9, 2016
2. Leszek L.Dobrzański- Materiały inżynierskie i projektowanie materiałowe, wyd.Naukowo- Techniczne, 2006, Wa-wa
3. Michael F.Ashby- Dobór materiałów w projektowaniu inżynierskim, Wyd.Naukowo- Techniczne,1992, Wa-wa
4. Deborah D.L.Chung, Composite Materials: Science and Applications, Functional Materials for Modern Technologies, Springer,2002
5. Ji-Huan He, et al. Electrospun Nanofibres and Their Applications. Shawbury, Shrewsbury, Shropshire, SY4 4NR, UK, 2008
6. R.Pampuch, S.Błażewicz, G.Górny, Materiały Ceramiczne dla elektroniki, Wyd.AGH, Kraków 1993
7. Debora D.L. Chung, Functional materials (Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications), World Scientific Publishing Co. Pte. LTd. 2010.
8. Thomas J.J. Muller , Uwe H.F. Bunz. Functional Organic Materials. Wiley-vch, Weinheim 2007.
9.Charles Wilkie, Georges Geuskens, Victor Manuel de Matos Lobo. Handbook of research on functional materials, CRC Press Taylor & Francis Group, 2014
10. Lectures
11. Articles: http://www.sciencedirect.com.science-direct-elsevier.wbg2.bg.agh.edu.pl/

Scientific publications of module course instructors related to the topic of the module

Additional scientific publications not specified

Additional information

None

Student workload (ECTS credits balance)

Student activity form	Student workload
Contact hours	10 h
Examination or Final test	2 h
Realization of independently performed tasks	9 h
Preparation for classes	17 h
Preparation of a report, presentation, written work, etc.	12 h
Participation in lectures	30 h
Participation in seminar classes	30 h
Participation in auditorium classes	10 h
Summary student workload	120 h
Module ECTS credits	4 ECTS