AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name:	Bioceramics
Academic year:	2017/2018
Code:	CIM-2-203-FM-s
ECTS credits:	2
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:	—
Responsible teacher:	prof. dr hab. inż. Ślósarczyk Anna (aslosar@agh.edu.pl)
Academic teachers:	prof. dr hab. inż. Ślósarczyk Anna (aslosar@agh.edu.pl) dr inż. Zima Aneta (azima@agh.edu.pl) dr inż. Czechowska Joanna (jczech@agh.edu.pl)

Module summary

—

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 aware of the therapeutic effects and the possible side effects of implant materials used in bone substitution	IM2A_K08, IM2A_K02, IM2A_K06	Activity during classes
M_K002	The student knows the roles of bone substitutes, the principles for their selection and design.Student understands the importance of biomaterials engineering for medicine and economy.	IM2A_K07, IM2A_K06	Activity during classes
Skills			
M_U001	Student is able to design materials to fill bone defects, that differ in composition, microstructure and mechanical strength.	IM2A_U04, IM2A_U02, IM2A_U08, IM2A_U11	Presentation

M_U002	Student can propose methods to assess physicochemical and biological properties of ceramic implant materials and bioceramic composites.	IM2A_U02, IM2A_U08, IM2A_U16	Presentation
Knowledge			
M_W001	Student knows the classification of ceramic biomaterials and scope of their application in medicine.	IM2A_W03, IM2A_W15	Examination
M_W002	Student knows and understands the concepts associated with the production of bioceramics (raw materials, molding methods, methods of sintering, final treatment and sterilization).	IM2A_W02, IM2A_W14	Examination
M_W003	Student knows and understands manufacturing technologies of various forms of bioceramic implant materials (powders, granules, dense and porous implants, coatings)	IM2A_W03, IM2A_W14	Examination
M_W004	Student knows the principles for the assessment of physicochemical and biological ceramic implants in vitro and in vivo.	IM2A_W04	Examination

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 aware of the therapeutic effects and the possible side effects of implant materials used in bone substitution	-	-	-	-	-	+	-	-	-	-	-
M_K002	The student knows the roles of bone substitutes, the principles for their selection and design.Student understands the importance of biomaterials engineering for medicine and economy.	-	-	-	-	-	+	-	-	-	-	-
Skills												
M_U001	Student is able to design materials to fill bone defects, that differ in composition, microstructure and mechanical strength.	-	-	-	-	-	+	-	-	-	-	-

M_U002	Student can propose methods to assess physicochemical and biological properties of ceramic implant materials and bioceramic composites.	-	-	-	-	-	+	-	-	-	-	-
Knowledge												
M_W001	Student knows the classification of ceramic biomaterials and scope of their application in medicine.	+	-	-	-	-	+	-	-	-	-	-
M_W002	Student knows and understands the concepts associated with the production of bioceramics (raw materials, molding methods, methods of sintering, final treatment and sterilization).	+	-	-	-	-	+	-	-	-	-	-
M_W003	Student knows and understands manufacturing technologies of various forms of bioceramic implant materials (powders, granules, dense and porous implants, coatings)	+	-	-	-	-	+	-	-	-	-	-
M_W004	Student knows the principles for the assessment of physicochemical and biological ceramic implants in vitro and in vivo.	+	-	-	-	-	+	-	-	-	-	-

Module content

Lectures

<u>History of bioceramics.</u>
The history of preparation and application of ceramic implant materials in medicine. First, second and third generation of ceramic biomaterials. The significance of bioceramics for orthopedics, maxillofacial surgery and dentistry.

<u>The structure of bone. Ceramic and composite bone substitutes.</u>
Bone as a natural composite. Requirements for bone substitutes. Advantages and disadvantages of ceramic bone substitutes. Techniques to combine implants with bone. The impostance of bone/implant interface.

<u>Types of bioceramics- classification criteria.</u>
Characteristics and applications of various forms of ceramic implants (powders, granules, dense and porous materials, materials with the surface porosity, functionally graded materials).

<u>Manufacturing, physicochemical and biological evaluation of sintered and chemically bonded bioceramics.</u>
Methods of manufacturing (raw materials, forming, sintering, final treatment, sterilization). Evaluation of microstructure, porosity, mechanical strength, cohesion, chemical stability, biodegradability, biocompatibility and bioactivity.

<u>Inert, bioactive and resorbable bioceramics.</u>

Bioactive glasses, glass-ceramics and ceramics. The significance of bioactivity, biodegradability and tendency to resorption. Mechanisms of bioactivity. Criteria of bone implant materials selection.

Dense and porous alumina ceramics.
Alumina powders, methods for the preparation of dense and porous alumina implants. The range of applications of alumina bioceramics in medicine.

Oxide bioceramics on the basis of ZrO2 and TiO2
The role of T-M phase transition in developing the physicochemical and biological properties of bioceramics on the basis of ZrO2 and ZrO2-Al2O3 composites (ZTA, ATZ). TiO2-based materials for medical applications – form and properties.

Calcium phosphate based bioceramics.
Bioceramics based on: hydroxyapatite (HA), whitlockite (β-TCP) and biphasic HA-β-TCP bioceramics (BCP) manufacturing, properties, applications in medicine. New trends in research on CaPs bioceramics.

Bioactive composites
The reason for application of composites in medicine. The inorganic-organic and inorganic-inorganic composites. Hybrid materials.

Bone cements
Types of bone cements. Advantages and disadvantages of PMMA and calcium phosphate cements. Requirements for bone cements. Methods of designing rheological parameters and setting times of cement pastes. New generation of bone cements.

Bioceramics for dentistry.
Application of ceramics in dentistry, prosthetics, implantoprosthetics, orthodontics, endodontics, periodontics and maxillofacial surgery. Types of dental cements. Properties and range of applications of: dental porcelain, dental oxide ceramics and glass-ceramic materials. Bioceramics in guided tissue regeneration.

Ceramic coatings on metallic implants.
The aim and methods of coating. Characteristics and criteria of coatings evaluation (thickness, phase composition, microstructure, adhesion to the substrate, durability).

Ceramic homogeneous and heterogeneous drug carriers.
Types of drug carriers. Mechanisms of drug release. The importance and selection of ceramic materials for local drug administration .

Biomimetics.
Patterns from nature in technology and biomaterials engineering. Natural structures – laminates and FGM. Natural composites. The significance of bioceramics for tissue engineering.

Seminar classes

Porous ceramic implant materials - the range and function of porosity in medical applications.

The significance of hybrid materials for implantology.

The importance of gypsum as an implant material.

Bioceramics for dental application.

Bioceramics in the treatment of bone diseases and injuries. The importance of biomimetics in manufacturing of implant materials.

Principles for selecting materials for implantology.

In vitro and in vivo evaluation of bioceramics.

Methods of forming and heat treatment of bone implants. The function of rapid prototyping techniques.

Hydroxyapatite based bioceramics for orthopedic, dentistry and maxillofacial surgery.

Development, properties and range of applications of whitlockite based bioceramics.

The significance of composites for medicine.

Oxide bioceramics.

Glass-ceramics for implantology.

Factors determining behavior of ceramic implant materials in vivo.

Method of calculating the final grade

0,5• examination grade+0,5• seminaries grade

Prerequisites and additional requirements

Basic knowledge of chemistry, biology and materials engineering.

Recommended literature and teaching resources

1.„Biomateriały t. IV” praca zbiorowa pod red. S. Błażewicza i L. Stocha, wyd. Exit Warszawa 2003
2.Z. Jaegermann, A.Ślósarczyk „Gęsta i porowata bioceramika korundowa w zastosowaniach medycznych” UWND AGH-Kraków 2007
3.R.B.Heimann " Clasic and advanced ceramics" VILEY- VCH Verlag GmbH & Co. 2010
4.B.D.Ratner,A.S.Hofmann,F.J.Schoen,J.E.Lemons" Biomaterials Science. An Introduction to Materials in Medicine" Elsevier- Academic Press, 2013
5.F. Nadachowski, S.Jonas, W.Ptak „Wstęp do projektowania technologii ceramicznych” UWND AGH-Kraków 1999
6. "Inżynieria Biomateriałów Engineering of Biomaterials”
7.“Biomaterials”
8.“Journal of Materials Science. Materials in Medicine”

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

1.Borkowski L., Pawłowska M., Radzki R.P., Bieńko M., Polkowska I., Belcarz A., Karpiński M., Słowik T., Matuszewski Ł., ŚLÓSARCZYK A., Ginalska G. ,Effect of a carbonated HAP/β-glucan composite bone substitute on healing of drilled bone voids in the proximal tibial metaphysis of rabbits., Materials Science and Engineering C (2015) 1;53:60-67. (IF=2,736)
2.Mróz W., Budner B., Syroka R., Niedzielski K., Golański G., ŚLÓSARCZYK A., Schwarze D., Douglas T. E.L., In vivo implantation of porous titanium alloy implants coated with magnesium-doped octacalcium phosphate and hydroxyapatite thin films using pulsed laser deposition, Journal of Biomedical Materials Research. Part B, Applied Biomaterials (2015) 103 [1]: 151–158. (2,328)
3.Kolmas J., Jabłoński M., ŚLÓSARCZYK A., Kolodziejski W., Solid-State NMR Study of Mn2+ for Ca2+ Substitution in Thermally Processed Hydroxyapatites, Journal of the American Ceramic Society (2015) 98: 1265–1274. (IF=2,428)
4.Kolmas J., Kaflak A., Zima A., ŚLÓSARCZYK A., Alpha-tricalcium phosphate synthesized by two different routes: Structural and spectroscopic characterization, Ceramics International (2015) 41(4) 5727-5733.(IF=2,110)
5.Czechowska J., Zima A., Paszkiewicz Z., Lis J., ŚLÓSARCZYK A., Physicochemical properties and biomimetic behaviour of α−TCP−chitosan based materials, Ceramics International (2014) 40[4]: 5523–5532.(IF=2,110)
6.Paluszkiewicz C., Czechowska J., ŚLÓSARCZYK A., Paszkiewicz Z., Evaluation of a setting reaction pathway in the novel composite TiHA-CSD bone cement by FT-Raman and FT-IR spectroscopy, Journal of

Molecular Structure (2013) 1034; 289–295. (IF=1,585)
7.Zima A.,Paszkiewicz Z., Siek D., Czechowska J., ŚLÓSARCZYK A., Study on the new bone cement based on calcium sulfate and Mg, CO3 doped hydroxyapatite, Ceramics International (2012) 38[6] 4935–4942.
8.ŚLÓSARCZYK A., Bioceramika hydroksyapatytowa, Prace Komisji Nauk Ceramicznych, Polski Biuletyn Ceramiczny nr 13, Polskie Towarzystwo Ceramiczne, Kraków 1997

Additional information

None

Student workload (ECTS credits balance)

Student activity form	Student workload
Participation in auditorium classes	15 h
Participation in conversation seminars	15 h
Preparation of a report, presentation, written work, etc.	15 h
Preparation for classes	15 h
Realization of independently performed tasks	0 h
Summary student workload	60 h
Module ECTS credits	2 ECTS