### Module name:
Bioceramics

### Academic year:
2016/2017

### 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:
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### Responsible teacher:
prof. dr hab. inż. Śłósarczyk Anna (aslosar@agh.edu.pl)

### Academic teachers:
dr inż. Czechowska Joanna (jczech@agh.edu.pl)
dr inż. Śłósarczyk Anna (aslosar@agh.edu.pl)
dr inż. Zima Aneta (azima@agh.edu.pl)

## Module summary

### Description of learning outcomes for module

<table>
<thead>
<tr>
<th>MLO code</th>
<th>Student after module completion has the knowledge/ knows how to/is able to</th>
<th>Connections with FLO</th>
<th>Method of learning outcomes verification (form of completion)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social competence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M_K001</td>
<td>The student is aware of the therapeutic effects and the possible side effects of implant materials used in bone substitution</td>
<td>IM2A_K02, IM2A_K08, IM2A_K06</td>
<td>Activity during classes</td>
</tr>
<tr>
<td>M_K002</td>
<td>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.</td>
<td>IM2A_K07, IM2A_K06</td>
<td>Activity during classes</td>
</tr>
</tbody>
</table>

| **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 |
Module card - Bioceramics

| 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

<table>
<thead>
<tr>
<th>MLO code</th>
<th>Student after module completion has the knowledge/ knows how to/is able to</th>
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</tr>
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<tbody>
<tr>
<td></td>
<td>Lectures</td>
<td>Auditorium classes</td>
</tr>
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<td>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.</td>
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</tr>
<tr>
<td>Skills</td>
<td></td>
<td></td>
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<tr>
<td>M_U001</td>
<td>Student is able to design materials to fill bone defects, that differ in composition, microstructure and mechanical strength.</td>
<td>-</td>
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</table>
### Module content

#### Lectures

**History of bioceramics.**
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.

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

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

**Manufacturing, physicochemical and biological evaluation of sintered and chemically bonded bioceramics.**

**Inert, bioactive and resorbable bioceramics.**

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| 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. | + | - | - | - | - | + | - | - | - | - |

**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**

**Bioceramics for dentistry.**

**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.**

**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**

2. Z. Jaegermann, A.Ślęsarczyk „Gęsta i porowata bioceramika korundowa w zastosowaniach medycznych” UWND AGH-Kraków 2007
3. R.B. Heimann "Classic and advanced ceramics" VILEY- VCH Verlag GmbH & Co. 2010
5. F. Nadachowski, S. Jonas, W. Ptak „Wstęp do projektowania technologii ceramicznych” UWND AGH-Kraków 1999
6. "Inżynieria Biomateriałów Engineering of Biomaterials"
7. "Biomaterials"

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

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)

<table>
<thead>
<tr>
<th>Student activity form</th>
<th>Student workload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participation in auditorium classes</td>
<td>15 h</td>
</tr>
<tr>
<td>Participation in conversation seminars</td>
<td>15 h</td>
</tr>
<tr>
<td>Preparation of a report, presentation, written work, etc.</td>
<td>15 h</td>
</tr>
<tr>
<td>Preparation for classes</td>
<td>15 h</td>
</tr>
<tr>
<td>Realization of independently performed tasks</td>
<td>0 h</td>
</tr>
<tr>
<td>Summary student workload</td>
<td>60 h</td>
</tr>
<tr>
<td>Module ECTS credits</td>
<td>2 ECTS</td>
</tr>
</tbody>
</table>