DESCRIPTION OF TRAINING PROGRAMME

FOT THE DOCTORAL SCHOOL AT THE KAZIMIERZ WIELKI UNIVERSITY

<table>
<tr><td colspan="3">INFORMATION ON COURSE</td></tr>
<tr><td colspan="2">Course</td><td>Monographic lecture/ Title: Novel materials for mechanical engineering</td></tr>
<tr><td colspan="2">Type of classes</td><td>specialist classes</td></tr>
<tr><td colspan="2">Academic year</td><td>2021/2022</td></tr>
<tr><td colspan="2">Field of science</td><td>engineering and technology</td></tr>
<tr><td colspan="2">Discipline of science</td><td>mechanical engineering</td></tr>
<tr><td colspan="2">Class instructor</td><td>prof. dr hab. Yuriy Zorenko</td></tr>
<tr><td colspan="2">Number of hours</td><td>30</td></tr>
<tr><td colspan="2">Forme of classes</td><td>lecture</td></tr>
<tr><td colspan="2">Pass rules</td><td>credit</td></tr>
<tr><td colspan="2">Language of lecture</td><td>English</td></tr>
<tr><td>Framework learning outcomes (8 PRK)</td><td colspan="2">• knows and understands to such an extent that is possible to revise existing paradigms – world heritage, including theoretical foundations, general issues and selected specific issues – specific to a scientific or artistic discipline
• knows and understands the main trends in the development of the scientific or artistic disciplines covered in the curricula
• is able to communicate on specialist topics to the extent that they enable an active participation in the international scientific community
• is able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment</td></tr>
<tr><td colspan="3">DETAILED DESCRIPTION OF CLASSES</td></tr>
<tr><td colspan="2">Particular learning outcomes</td><td>Methods of verifications of learning outcomes</td></tr>
<tr><td colspan="2">K_W has extensive knowledge of mechanics, physics and material science, and their historical development, as well as the importance of civilization and the impact of these fields of science and other fields of science
K_W02 has new studies on new discoveries in mechanics, physics and their materials as well as contemporary development trends;
K_W07 has knowledge of experimental and observational techniques
K_W08 knows the theoretical foundations of the construction and research of research and measurement activities in research and measurement of mechanics;</td><td>W01 possess an extended knowledge in the field of physics and material engineering, concerning on the technologies of material preparation in various crystalline forms in macro-, micro- and nano-scale;
W02 possess a knowledge on latest discoveries in the field of materials science;
W07 possess information on experimental techniques delivered to the materials in various crystalline forms;
W08 knows the theoretical basis of the structure and operation of research equipment for materials in various crystalline forms in macro-, micro- and nano-scale.</td></tr>
<tr><td colspan="3">PROGRAM CONTENT IMPLEMENTED DURNING CLASSES</td></tr>
<tr><td colspan="3">Classification of the materials and technologies: for chemical composition, for crystalline form and for synthesis technology. The use of materials in various crystalline forms in modern electronics and energetics.
Modern crystal technologies.
Czochralski method. Physical basis of the method and apparatus for crystal growth. Forms of melt-crystal interfaces. Crystal diameter control.
Bridgman-Stokbarger method. Physical basis of the method, stadium of crystal growth and apparatus. Choice of crucible and shapes of crystals.
Micro-pulling down method (MPD). Physical basis of the method and the device that is used for this method. Crystal shapes obtained by MPD methods.</td></tr>
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Edge-Defined Film-Fed Growth (EDFG) method. Physical basis of the method and the device that is used for this method. Types of crystals obtained by EDFG method.
Modern film technologies.
Liquid epitaxy method (LPE) of film growth. Homo- and hetero-epitaxial crystallization using LPE method. Boundary conditions for LPE growth of the single crystalline films. Mismatch between the films and substrate lattices. Transition layers. The difference in the structure and properties of the films and crystals of the same material (on the example of films and crystals of YAG:Ce and LuAG:Ce garnets). Two- and three-layer epitaxial structures.
Molecular beam epitaxy (MBE) method. Physical basis of the MBE and general characteristics of this method. Scheme of the MBE setup. Examples of the application of the MBE method.
Metal Organic Vapor Phase Epitaxy (MOVPE) method - epitaxy from the of gas phases with organometallic compounds. Physical basis and general characteristics of this method. Examples of the application of the MOVPE method.
Hot Flament Chemical Vapor Deposition (HF CVD) method and its general characteristics. Examples of the application of the HF CVD method.
Advanced ceramic technologies. The technology of ceramics production by the self-propagating combustion synthesis method.
Advanced nanocrystalline technologies. Nano-crystals embedded in the dielectric matrices (on the example of CsBr:Br phosphor). Formation and destruction of nanocrystals (NC) embedded in the dielectric matrices. The influence of NC creation on the properties of materials.
Engineering and optimization of functional materials.
Materials for scintillators. Physical principles of scintillators work. History of scintillators. Main stages of the scintillator excitation. Parameters of scintillators.
Technological methods of creating scintillators. Scintillator applications. Scintillators in various types of tomography and the physical basis of these methods. Microtomography. Single crystalline films as scintillation screens in microtomography.
Methods for optimizing the properties of scintillators (on examples $CdWO_4$ and $CaWO_4$ tungstates; cesium iodide CsJ:Tl; orthosilicates Lu_2SiO_5:Ce and YAG:Ce and LuAG:Ce garnets).
Materials for dosimetry. Materials from thermally and optically stimulated luminescence (TSL and OSL) and the physical principles of their operation. Operation of TSL and OSL methods. Examples of TSL and OSL materials. Main parameters of TSL and OSL materials. Methods of TSL and OSL material preparation for dosimetry and optimization of their properties.
Materials for lasers. A brief history of lasers. Diagram of lasers and principles of their operation. The use of lasers. Gas and excimer lasers. Materials for gas and excimer lasers.
Technology of obtained laser materials in the form of crystals. Examples of crystals as laser materials. Laser ceramics. Single crystalline films as functional materials for micro-lasers. Types of emission centers in the laser materials and ranges of their emission.
The material for lighting in the solid state form. Types of light sources and principles of their operation. The structure of light sources and the dynamics of their development.
Methods of white light creation. White light parameters. Fluorescent lamps. LED diodes. Physical principles of the LED diode operation. Construction of LED emitting white light (WLED). Stages of WLED technology.
LED converters in various crystalline forms. Examples of converters for WLED. White light "engineering": principles and possibilities. Examples of the LED converter in the form of YAG:Ce garnet.
Cathodoluminescent materials. Traditional powder cathodoluminescent (CL) materials and technologies for their fulfillment. CL materials in the form of single crystalline films and areas of their applications. Advantages of CL materials in the form of monocrystalline layers. Dopants that give the color of light in various spectral ranges.
Methods of creating cathodoluminescent materials. An example of creating a CL screens with the white color of the emission. "Engineering" of the CL emission spectrum: principles and possibilities. Examples CL lighting display based on the YAG:Ce garnets.
Materials for marking. Fluorescence and phosphorescence. Examples of phosphors with persistent luminescence. Application of the persistent phosphorus. Nano-markers. Dependence of nano-marker properties on its dimension. Storage phosphors. Composite technology. Nano-coatings. Examples of using persistent phosphorites for marking in medical and biological researches.
Materials for ultrasound diagnostics (UD). Ultrasonic wave ranges. Main characteristic of UD materials. Reflection of UD waves. Doppler effect. The history of UD medicine applications and the main UD diagnostic applications. UD materials. Piezoelectric effect and electromechanical effects. Examples of UD materials: traditional and modern. Technology for creating UD materials.

Didactic methods and eduactional techniques	Lecture in the form of a multimedia presentation, discussion of selected lecture places, individual work with books and literature, preparation of a presentation by a student on a selected topic.
Evaluation criteria	Assessment of the student presentation on the selected topic (0.3); credit with grade - written assignment: 4 questions from different chapters and a practical task (0.7).
The form and conditions of passing (the form of verification of learning outcomes)	Credit with grade
Literature	**Basic literature** 1. **Nanocomposite, Ceramic, and Thin Film Scintillators**. Published by Pan Stanford Publishing Pte. Ltd.; Printed in the USA. ISBN 978-981-4745-22-2 (Hardcover); ISBN 978-981-4745-23-9 (eBook). 2. **Inorganic Phosphors: Compositions, Preparation and Optical Properties,** Ed. by William M. Yen, Marvin J. Weber, CRC Press, 2004. 3. S. Aruna , A. Mukasyan, **Combustion synthesis and nanomaterials,** Current Opinion in Solid State and Materials Science, 12 (200) 44–50. 4. My lectures in the form of multimedia presentations. **Supplementary literature** 1. Guozhong Cao. Nanostructures&Nanomaterials, USA, Imperial College Press, 2004. 2. Rainer Wasser, Nanoelectronics and Information Technology, 3rd Edition, Wiley WGH, 2012. 3. L.C. Feldman, J. W. Mayer, Fundamental of Surfaces and Thin Film Analysis, North-Holland, 2012.