Materials science and engineering - workshops

Workshops in research teams. Each candidate will declare their willingness to cooperate with a given research team at the recruitment stage, selecting the appropriate topic. These will be stationary classes carried out in modern research laboratories. Each student has to obligatorily complete one topic from presented below:

Content

1. Preparation and characterization of selected high-entropy alloy

Maciej Zubko, PhD, Assoc. Prof., Krystian Prusik, PhD, Assoc. Prof., Paweł Świec, PhD, Eng.

The aim of the workshop will be to produce and characterize a selected high-entropy alloy. A modern group of engineering materials known in the literature since 2004 are High Entropy Alloys (HEAs). By definition, HEAs are alloys with at least five elements in equilibrium atomic concentrations. For non-atomically equilibrium alloys, the element concentration should be within 5-35 atomic % range. High-entropy alloys exhibit excellent mechanical properties.

The research part of the workshop will include the preparation of selected chemical composition of the alloy, making the molding and obtaining the finished alloy by arc melting methods. The next stage of the workshop will be the analysis of the microstructure of the obtained material using the methods of light microscopy and scanning electron microscopy. The final stage will be determination of the alloy mechanical properties by microhardness measurements.

2. Using microscopic methods to analyze the materials structures

Maciej Zubko, PhD, Assoc. Prof., Krystian Prusik, PhD, Assoc. Prof., Paweł Świec, PhD, Eng.

Electron microscopy has been the research tool of choice of the last century. By using an electron beam, the structure of materials can be imaged on the micro and nanometer scales. In addition, the electron beam interacting with matter provides additional information about the structure of materials, such as local chemical composition. At the workshop, students will be introduced to modern methods of both scanning and transmission electron microscopy. They will learn about sample preparation methods and how to interpret the results obtained.

3. Powder metallurgy and modification of titanium-based materials

Grzegorz Dercz, PhD, MSc, Assoc. Prof., Izabela Matuła, PhD, Assoc. Prof., Magdalena Szklarska, PhD.

A series of specialized workshops will allow the student to produce and modify the surface of a titanium-based material for potential application in medicine. In the first stage the student will be introduced to the method of producing materials - powder metallurgy, and will produce a projected alloy for potential use in medicine. The surface of the material will be modified by depositing a biocompatible coating using an electrochemical method. In the second stage, the student will be introduced to the basic methods of characterizing the structure, microstructure, porosity and basic properties of the prepared materials. The student will investigate the X-ray diffraction, optical microscopy, stereology, scanning electron microscopy and corrosion resistance and analyze the results.

4. In quest of the perfect polymer material - is this plastic mysterial?

Sylwia Golba, PhD, Eng. Assoc. Prof., Justyna Jurek-Suliga, PhD.

During the workshop, the student will select a material for the presented medical application (targeted design of medical materials), perform an analysis of basic physicochemical properties (chemical composition analysis, morphology imaging, strength analysis), prepare a report with a discussion of the obtained results. Small

laboratory equipment (glass, metal), vials, glasses, winches, scissors, chemical reagents including solvents, pH meter + heads, filters, filters.

5. Density Functional Theory in practice - ab initio studies of solids-state physics

Anna Majtyka-Piłat, PhD.

The proposed course places particular emphasis on developing practical skills in performing quantum-mechanical calculations using Density Functional Theory (DFT) for selected monoatomic and diatomic systems, such as silicon, iron, and gallium arsenide. To ensure a proper understanding and execution of the calculations, the course will also cover the necessary theoretical background.

DFT is a powerful computational tool that enables the determination of structural, electronic, optical, mechanical, and magnetic properties of multi-atomic systems.

6. Fabrication and characterization of magnetic shape memory alloys

Edyta Matyja, PhD, Eng.

The aim of the workshop will be to produce and characterize a selected magnetic shape memory alloy (MSMA).

Magnetic shape memory alloys represent a unique group of smart materials that combine the properties of conventional shape memory alloys with ferromagnetism properties. Their ability to change shape under the influence of a magnetic field makes them promising for applications in actuators, sensors, and energy-efficient cooling systems. Among the best-known alloys of this type are Ni–Mn–In and Ni–Mn–Ga systems, which exhibit martensitic transformations near room temperature.

During the workshop, students will prepare a selected alloy composition using the method of mechanical alloying followed by sintering and/or arc melting. The next stage will include the microstructural characterization of the obtained material using electron microscopy methods. The selected mechanical properties and the phase transformation characteristics which is connected with shape memory effects.

At the final stage, students will analyze the obtained results and discuss the relationship between the chemical composition, microstructure, and martensitic transformation and mechanical properties of produced alloys.

7. Advanced biomaterials lab: modifying and characterizing titanium surfaces

Agnieszka Stróż, PhD Eng.

The aim of the workshop will be to prepare, modify, and characterize the surface of biomaterials based on titanium and its alloys. Titanium and its alloys are among the most commonly used materials in biomaterials engineering due to their high biocompatibility, corrosion resistance, and favourable mechanical properties. One of the key areas of research is the modification of their surfaces to improve tissue integration and give them additional biological and physicochemical functionalities. The research part of the workshop will include the preparation of biomaterial sample surfaces for modification (through grinding, polishing, and cleaning processes), followed by their modification using selected physicochemical and electrochemical methods, such as electrochemical anodizing or chemical etching. As a result of these processes, layers with varying roughness will be obtained on the surface of titanium and its alloys. The samples will be analyzed for surface morphology using optical microscopy and scanning electron microscopy (SEM). In addition, an assessment of wettability and surface properties will be performed to determine the potential biomaterial applications of the obtained layers.