Materials science and engineering - basic lectures

A summer school student is required to attend all lectures in his or her primary discipline

Content

1. Electron microscopy as a tool for studying the structure of materials

Krystian Prusik, PhD, Assoc. Prof.

Direct observation of the structure of materials allows us to understand its influence on their properties. It is possible thanks to the use of transmission and scanning electron microscopy. The use of an electron beam instead of visible light allows to increase the resolving power and the range of obtained magnifications even up to 20 million or more times. Such a magnification span allows for observation of matter at any scale: macro, micro or nano. Electrons are also one type of ionizing radiation that is able to remove bound electrons from electron shells, transferring some of its energy to individual atoms in the sample. One of the advantages of using ionizing radiation is that it produces a wide range of additional signals that provide us with information about the chemical composition and many other details about the materials under study. All this has resulted in electron microscopy being hailed as a complete material research tool of the last millennium.

2. Analysis of the disordered structure of materials on the basis on the X-ray electron diffraction

Maciej Zubko, PhD, Assoc. Prof.

Classical crystallography is based on the description of the crystal structure by determining the position of atoms in a unit cell and is the essential tool for materials characterization. Developed for over a hundred years, it crystallography has established methods allowing to determine the crystal structure of the studied substances on the basis of X-ray or electron diffraction. It turns out, however, that for some types of materials such a description is insufficient because they exhibit a disordered crystal structure. In such cases, classical crystallography provides only information of the materials' average crystal structure. Therefore, the information obtained on this basis may not be sufficient to fully know and understand the properties of the studied materials.

The lecture will present selected methods of analyzing the structure of disordered materials on the basis of X-ray and electron diffuse scattering.

3. Biomaterials based on titanium alloys - production and modification

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

The development of today's medicine and its opportunities pose a new challenge for scientists, which is the development of innovative biomaterials that meet a number of requirements determined by their destination. Optimization of the mechanical properties and biocompatibility of metallic materials can be achieved by selecting the phase and chemical composition, heat and plastic treatment, and also by modifying their surfaces. All types of biomaterials and their applications will be discussed during the lecture. A particular focus will be placed on titanium-based biomaterials as an alternative to the commonly used metallic biomaterials. The course will also present the most popular surface modification methods of biomaterials, which allow maintaining the appropriate proportions between the mechanical properties and the material's biocompatibility. The last part of the lecture will discuss issues related to the production of biomaterials. One of the methods of obtaining biomaterials is powder metallurgy, which has been developing very dynamically in recent decades.

This method makes it possible to receive materials from powders without melting the main component. This method allows for products from hard-melting metals (tungsten, tantalum), sintered carbides, metals with a significant difference in melting point, which makes this method very widely applicable.

4. Wrap your head around polymers

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

During the lectures, the basic groups of polymer materials will be presented along with their applications, including medical ones. Case studies related to the use of polymeric materials in forensic analysis will be presented. The techniques of insight into the structure of the material and their influence on the macroscopic properties of the material will be discussed.

5. X-ray methods of material testing

Małgorzata Karolus, PhD, MSc, Assoc. Prof.

This lecture is dedicated to X-ray–based material testing methods, with particular emphasis on diffraction techniques used in the structural analysis of crystalline and polycrystalline materials. The lectures combine essential theoretical background with a practical approach to the interpretation of experimental results.

The course introduces the principles of X-ray interaction with matter and outlines the fundamentals of X-ray diffraction as a tool for structural characterization. Basic methods of qualitative and quantitative structural analysis are presented, including phase identification and phase composition analysis. Practical aspects of X-ray measurements, data interpretation, and selected applications in materials engineering are also discussed.