SPIN-Lab Centre for Microscopic Research on Matter - 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:

Contents

1.   Three-dimensional modelling and manufacturing of polymer porous scaffolds for cell proliferation

Jolanta Rajca, MSc Eng.

The aim of the project is to fabricate three-dimensional, porous polymer scaffolds with controlled geometry and properties that support bone cell proliferation. The participant will become familiar with the ultrasonic spraying technique, which enables

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the creation of structures with complex morphology, and will then perform detailed characterization using X-ray microtomography (micro-CT).

Parameters such as porosity, pore distribution and connectivity, fibre thickness, and surface roughness will be analysed. The next stage of the project will involve computational modelling of fluid flow through the fabricated scaffolds to assess their potential for tissue engineering applications.

The participant will also take part in in-situ experiments, observing in real time the infiltration process and structural changes within the scaffolds.

The project combines elements of materials engineering, microscopy, and three-dimensional modelling, offering hands-on experience in the study of advanced biomaterials.

2.   Characterization of photoactive materials by correlative microscopic techniques

Aleksandra Nyga, PhD Eng.; Anna Hercog, MSc Eng.

The workshop focuses on the characterization of photoactive materials using advanced microscopic and spectroscopic techniques. The students will investigate thin films of selected photoactive compounds - metalloporphyrin derivatives, fullerenes, and/or organic compounds - that are used in optoelectronic applications such as OLEDs or singlet oxygen generation systems.

During the course, students will prepare thin films of these compounds by the drop-casting method and analyse their surface morphology and microstructure using Scanning and Transmission Electron Microscopy (SEM). They will further explore the possibility of combining SEM imaging with Raman spectroscopy (RISE technique) to obtain correlated structural and spectroscopic information.

The aim of the workshop is to visualize the morphology of the drop-cast layers, detect Raman signals characteristic of the investigated compounds, and assess the feasibility of distinguishing mixtures of two or three photoactive species within one sample.

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3. Hyperspectral imaging for rapid diagnosis of Aspergillus flavus infections on wheat grains at an early stage of infection

Adam Krain, MSc

Measurements carried out in the SPIN-Lab Centre for Microscopic Research on Matter will assess the safety of cereal cultivation and storage for the presence of aflatoxins. The research will be conducted using a confocal microscopy and hyperspectral probe.

The aim of the proposed project is to identify molecular patterns that will enable the early detection of aflatoxins, which are metabolites of certain species of the Aspergillus genus, primarily

A. flavus. Aflatoxins, like other compounds from the mycotoxin group, pose a serious threat to consumers due to their highly toxic effects (i.e. hepatotoxic, immunosuppressive, or mutagenic). Aflatoxins fluorescence in the blue and green light range enables the development of simple and reliable methods for their detection in contaminated material based on spectral methods.

4. The influence of plastic deformation on the microstructure and surface chemical composition of structural steel: a correlation analysis using SEM-EDS and WDS

Wioletta Kuśmierska-Matyszczak, PhD, Eng.

Research conducted at the SPIN-Lab Centre for Microscopic Research on Matter concerns changes in the microstructure and chemical composition of structural steel surfaces. The analysis will be performed using scanning electron microscopy (SEM) techniques coupled with EDS (energy dispersive) and WDS (wavelength dispersive) detectors, which enable simultaneous assessment of surface topography and chemical composition. The analysis will focus on identifying local changes in the concentration of alloying elements and impurities at the micro- and nanoscale.

The proposed project aims to investigate how various processing factors affect microstructural and chemical changes occurring on the surface of structural steel. The analysis will include the identification of changes in phase distribution, grain morphology, as well as local element losses on the sample surface. The research will

involve a correlation analysis between the type of treatment and the observed microstructural changes and chemical composition.

5.   Synthesis and microstructural characterization of fluorescent zinc chalcogenide quantum dots

Jakub Jała, MSc Eng.

This workshop course focuses on the development and optimization of embedding protocols for biological samples intended for Focused Ion Beam (FIB) analysis. Students will explore how variations in resin composition influence sample stability, milling behaviour, and imaging quality under ion and electron beams. Through guided experiments, participants will prepare biological specimens using different resin formulations and curing conditions. Emphasis will be placed on evaluating resin hardness and compatibility with biological tissues. Students will learn to assess sample performance using FIB-SEM imaging and correlate preparation parameters with resulting image fidelity. The course encourages experimental design thinking, data-driven optimization, and reproducible documentation of methods. By the end of the lab, students will have developed and validated an optimized embedding protocol tailored to FIB applications in biological research.

6.   Development of an optimized embedding protocol based on resin composition tuning for high-fidelity xenon plasma focused Ion beam sectioning of biological samples

Daniel Wójcik, MSc, Łukasz Feldo-Grudziński BSc

This workshop course focuses on the development and optimization of embedding protocols for biological samples intended for Focused Ion Beam (FIB) analysis. Students will explore how variations in resin composition influence sample stability, milling behaviour, and imaging quality under ion and electron beams. Through guided experiments, participants will prepare biological specimens using different resin formulations and curing conditions. Emphasis will be placed on evaluating resin hardness and compatibility with biological tissues. Students will learn to assess sample performance using FIB-SEM imaging and correlate preparation parameters with resulting image fidelity. The course encourages experimental design thinking, data-driven optimization, and reproducible documentation of methods. By the end of

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the lab, students will have developed and validated an optimized embedding protocol tailored to FIB applications in biological research.

7.   Characterization of carbon materials by TEM

Aleksandra Nyga, PhD Eng., Anna Hercog, Msc Eng.

The workshop focuses on the characterization of carbon nanotubes using advanced microscopy techniques, with particular emphasis on Transmission Electron Microscopy (TEM). Students will investigate single-walled and/or multi-walled carbon nanotubes, which are used, among others, in opto- and nanoelectronic devices, sensors, and functional composites.

During the course, students will prepare carbon nanotube samples by drop-casting suspensions onto appropriate TEM substrates and will subsequently analyze their morphology, degree of aggregation, and microstructure (diameter, number of walls, structural defects) using TEM. Additionally, scanning electron microscopy (SEM) may be employed to assess the distribution of nanotubes on the substrate surface and – where instrumentation is available – Raman spectroscopy to identify the characteristic D, G, and 2D bands and to evaluate the structural quality of the investigated materials.

The aim of the workshop is to visualize the micro- and nanostructure of carbon nanotubes in TEM images, to identify morphological features and defects that affect the functional properties of the material, and to assess the possibility of distinguishing samples differing in type, degree of ordering, or mode of functionalization of the nanotubes based on the analysis of TEM images (and, optionally, spectroscopic data).

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