Karlsruher Institut für Technologie

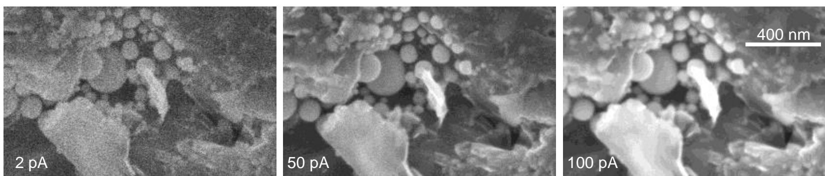
Laboratorium für Elektronenmikroskopie

Master Thesis

Optimization of electron microscopy imaging techniques for beam sensitive samples

Motivation

Imaging of samples with low atomic number and/or low density represents a challenging task in election microscopy. On the one hand due to the reduced electron-matter interaction cross-section and on the other hand due to the radiation sensitivity of such materials. The increasing demand for analyzing 'soft' matter like polymers or biological materials requires the elaboration of suitable imaging techniques in electron microscopy and the reduction of electron beam exposure. The later leads to a deterioration of the signal-to-noise ratio and requires restoration of the image information.



Tin balls embedded in organic material. Secondary electron imaging at different beam currents

Tasks

- Radiation damage analysis in function of primary electron energy, current and dose in transmission electron microscopy (TEM) and scanning electron microscopy (SEM)
- Distinction of knock-on damage and radiolysis by the variation of the electron beam energy
- Optimization of techniques for imaging ‚soft' materials by usage of different detectors (secondary, backscattered and transmitted electrons), variation of detection parameters (detection angle, suction fields) and variation of instrumental parameters (stage bias, chamber cooling)
- Quality improvement of electron microscopy images recorded with reduced electron beam dose, noise filtering and signal restoration. Implementation of adaptive filtering for feature recognition
- Implementation of artificial intelligence (AI) for detection and disposal of electron microscopy artifacts (sample charging, drift, convolution with beam broadening)

Timeline

- 1-2nd month: Introduction to SEM and TEM operation, literature and book review to understand problem and tasks
- 3-9th month: SEM, TEM and STEM imaging of beam sensitive samples with different detectors and for various experimental setups. Restoration of noisy images, implementation of (adaptive) filter for feature detection
- 9-12th month: Preparation and analysis of results, thesis writing, talk in LEM seminar

Goals:

- Optimization of electron microscopy imaging of beam sensitive materials
- Characterization of electron radiation damage
- Signal restoration of noisy images

What you will learn:

- Usage of various electron microscopes and detectors
- Physics of electron-matter interactions
- Electron microscopy image processing and restoration
- Interpretation and presentation of results

What you bring:

- Studies in physics, materials science, or similar disciplines
- Independent working (after initial guidance)
- Motivation to learn new topics in the field of electron microscopy
- Interest in image processing, denoising and filtering

Starting date:

- To be determined

Contact:

- Dr. Erich Müller, erich.mueller@kit.edu
- TT.-Prof. Dr.-Ing. Yolita Eggeler, yolita.eggeler@kit.edu

http://www.lem.kit.edu