Lehrstuhl für Physik

Department Physik, Mechanik und Elektrotechnik
Montanuniversität Leoben

A-8700 LEOBEN, Franz Josef Straße 18, Austria
Tel: +43 3842 402-4601, Fax:+43 3842 402-4602
e-mail: physics@unileoben.ac.at

S E M I N A R
on
Semiconductor Physics and Nanotechnology

Mo, 27.05.2024, 11:15 Uhr,

Seminar in
person in the Physics lecture hall *or* via Zoom

"Prospects and Challenges in the Characterization of Complex Nanomaterials with Scanning Transmission Electron Microscopy"

Dr. Daniel Knez
Institute for Electron Microscopy and Nanoanalytics, Graz, Austria

Aberration-corrected electron optics, novel detection techniques, and advanced computational capabilities have transformed scanning transmission electron microscopy (STEM) into one of the most powerful characterization techniques for a wide range of materials. Its versatility stems from the availability of different imaging and diffraction modes, as well as analytical techniques such as electron energy-loss spectroscopy (EELS) and energy-dispersive X-ray spectroscopy (EDXS). These methods allow us to deduce information about structure, elemental composition, and chemical bonding with atomic resolution, leading to numerous breakthroughs in understanding fundamental phenomena in physics, chemistry, and materials science in recent years.
However, in practice, atomic-level structural and chemical characterization, such as the detection of impurities or analysis of point defects, is often hindered by experimental challenges in sample preparation, limitations in signal-to-noise ratios (SNR), and the high current densities introduced by a highly focused electron beam. These factors often lead to steady, yet often unrecognized, specimen transformations, especially when applying atomic resolution imaging and spectroscopic techniques that generally require higher acquisition doses. Consequently, many sensitive material systems—such as battery materials, nanoporous materials, and nanoclusters - require the development of novel methodologies in preparation, characterization, and data analysis.
The seminar talk will provide an overview of analysis strategies, addressing the aforementioned challenges and exemplifying selected research questions with different nanoscale material systems. Specifically, lithiation processes at the atomic level in LiFePO4 [1], mapping of electronic states and distribution of oxygen vacancies in complex oxide thin films [2], and the three-dimensional localization of single atoms in the pores of beryl [3] will be discussed. Emphasis will be placed on the use of low-dose imaging and diffraction techniques, as well as on the advantages of utilizing modern direct detection EELS.

[1] Šimić, Nikola et al., Advanced Energy Materials, under review

[2] Knez, Daniel et al.; “Unveiling Oxygen Vacancy Superstructures in Reduced Anatase Thin Films”. (2020) Nano letters 20 (9), pp. 6444. DOI: 10.1021/acs.nanolett.0c02125.
[3] Knez, Daniel et al.; “Three-dimensional distribution of individual atoms in the channels of beryl”. (2024) Commun Mater 5 (1). DOI: 10.1038/s43246-024-00458-8.

Zoom – Link:
https://zoom.us/j/96375934537?pwd=RTlKTWhSdzRHU211YTY1bGFxTUtpZz09
Meeting-ID: 963 7593 4537
Kenncode: =r=4YQ