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Electron Diffraction Techniques: From Preparation to Structural Insights

Abstract:

Crystallographic characterization of three-dimensional (3D) crystal structures is essential for understanding the functional properties of materials. Selecting an appropriate strategy is therefore crucial for gaining new insights into the structural analysis of complex systems. Studying beam-sensitive or uniquely disordered materials presents significant challenges. Although there are already existing methods such as X-ray powder diffraction (XRPD), the data may exhibit reflection overlap or other problems that make structure determination difficult. To address these issues, especially in nanocrystalline materials, complementary characterization methods are increasingly employed.

The presented work highlights the growing role of 3D electron crystallography - specifically single-crystal electron diffraction and high-resolution transmission electron microscopy - as hybrid approaches for structural analysis. Drawing on selected case studies [1, 2, 3], I show how technical challenges can serve as catalysts for methodological innovation [4, 5]. Finally, I outline general procedures for ab initio structure elucidation of unknown or polycrystalline structures.

References

- [1] M. O. Cichocka et al., *Cryst. Growth Des.*, 2018, 18, 2441-2451.
- [2] M. O. Cichocka et al., *J. Am. Chem. Soc.*, 2020, 142, 15386–15395.
- [3] M. O. Cichocka et al., *Inorg. Chem.*, 2022, 61, 29, 11103–11109.
- [4] M. O. Cichocka et al., *J. Appl. Cryst.*, 2018, 51, 1652-1661.
- [5] M. O. Cichocka et al., *ACS Appl. Mater. Interfaces*, 2020, 12, 15867-15874.

About the speaker:

Dr. Magdalena Ola Cichocka has built a research career centered on electron microscopy and electron crystallography, with a focus on structural analysis of complex and beam-sensitive materials. Her work has taken place across leading institutions in Europe and South Korea, where she has developed innovative methodologies and contributed to advancing the field of electron diffraction.

Her journey began in 2011 with an ERASMUS internship at IFW Dresden (Germany), where she studied dynamic transformations in Pt-filled carbon nanotubes using in-situ low-voltage TEM. After completing dual degrees in Biology and Physics at Adam Mickiewicz University (UAM, Poland), she enhanced her TEM expertise at Sungkyunkwan University (SKKU) in South Korea.

During her PhD at Stockholm University (Sweden), she investigated disordered nanocrystalline structures using XRPD, HRTEM, and 3D electron diffraction (3D ED). She developed a methodology for high-throughput continuous rotation electron diffraction collection, which remains a key methodological contribution to the field.

Her postdoctoral work has consistently addressed structural analysis using electron microscopy techniques. At TU Delft (the Netherlands), she developed ultramicrotomy-based sample preparation for 2D materials and metals, enabling HAADF-STEM and EDS analysis. At IFW Dresden, she explored thermoelectric systems via ex-situ and thermal in-situ TEM/STEM/EDS, linking atomic-scale features to macroscopic properties.

Currently at TU Darmstadt (Germany), she investigates multiphase and disordered perovskites using 3D ED and scanning (precession) electron diffraction (S(P)ED), continuing her commitment to advancing structural characterization techniques for complex materials.