MONASH University

Monash Centre for Electron Microscopy

Seminar

Development and application of optimum bright-field (OBF) STEM technique for low-dose, atomic-resolution analysis

WEDNESDAY 13 DECEMBER 2023

11:00 AM

SCIENCE LECTURE THEATRE S13
11 Rainforest Walk
Monash Clayton Campus

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Abstract

Owing to the development of aberration correctors in (scanning) transmission electron microscopy (S/TEM), local atomic structure analysis of materials has become a daily practice. However, because of the strong interactions between the sample and electrons, irradiation damage is frequently problematic, especially for so-called beam-sensitive materials such as porous, battery, and polymer materials. The atomic structure of these materials is easily broken by illuminated electrons, and direct observation is limited at higher magnifications. In the early 2010s, a high-speed segmented-type STEM detector was developed and advanced STEM techniques were subsequently implemented [1,2]. The segmented detector has multiple divided detection areas, and the corresponding STEM images are recorded simultaneously, where richer sample information is obtained compared with the conventional annular detector. We then developed a highly dose-efficient STEM imaging technique using a segmented detector as the optimum bright-field (OBF) STEM [3]. In OBF STEM, multiple STEM images simultaneously acquired in the segmented detector channels are assembled via weighting coefficients, which are calculated using phase contrast transfer functions (PCTFs) [4] and STEM noise evaluation theory [5]. The reconstructed OBF image has a dose efficiency that is approximately two orders of magnitude higher than that of conventional phase-contrast STEM techniques, and live OBF STEM imaging is also applicable via real-time reconstruction. We applied this method to zeolite, a popular but beam-sensitive porous material [6]. Zeolite has a framework structure consisting of SiO_4 tetrahedra, and low-dose OBF STEM successfully observed the atomic structures directly for the Si and O sites. In addition, we observed a lattice defect and absorbed cations inside the zeolitic frameworks, demonstrating the capabilities of OBF STEM as a low-dose atomic-resolution imaging technique.

References:

[1] N. Shibata *et al*., Journal of Electron Microscopy **59** (2010) 473-479.
[2] N. Shibata *et al*., Nature Physics **8** (2012) 611-615.
[3] K. Ooe *et al*., Ultramicroscopy **220** (2021) 113133.
[4] T. Seki *et al.,* Ultramicroscopy **194** (2018) 193-198.
[5] T. Seki *et al.,* Ultramicroscopy **193** (2018) 118-125.
[6] K. Ooe *et al.,* Science Advances **9** (2023) eadf6865.

Biography

Kousuke Ooe received his PhD at the University of Tokyo in 2022 under the supervision of Profs. Naoya Shibata and Yuichi Ikuhara. He then obtained a Japan Society for the Promotion of Science (JSPS) postdoctoral fellowship and moved to the Japan Fine Ceramics Center. From 2023 onward, he moved to Monash University through a cross-border JSPS postdoctoral fellowship. His research interests include the development and application of scanning transmission electron microscopy (STEM) techniques, particularly for the low-dose analysis of beam-sensitive materials.

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Visitors are most welcome. Monash University Clayton campus map can be found at: http://www.monash.edu.au/pubs/maps/3-Claytoncolour.pdf. Please note the parking arrangements. There is a designated Visitors Car Park (N1) clearly ground-marked by white paint. Payment for parking is make using the CelloPark app.