MONASH University

Monash Centre for Electron Microscopy

Seminar

Recent progresses in atomic-resolution STEM

Tuesday August 11, 2020	**Dr Ryo Ishikawa** Ryo Ishikawa is a Project Associate Professor of the Institute of Engineering Innovation at the University of Tokyo, Japan.
3.00pm	
ZOOM - https://monash.zoom.us/meeting/register/tJYocO6urj0uHtBRQ1Z2rrAPOFOZBTV1JV8-	

Abstract

Following the development of modern aberration correction in electron microscopy, it has been routinely available sub-Ångstrom spatial resolution in inorganic materials. The currently-achievable spatial resolution is less than half an Ångstrom[1], which seems to be sufficiently high enough to analyze local atomic structures. However, such high spatial resolution is only valid in the lateral two dimensions and the last remaining depth resolution along the axial direction is still no better than 5 – 10 nm in scanning transmission electron microscopy (STEM). Since the physical limit of the depth resolution is dominated by the illumination angle (α) in STEM[2,3], and we have therefore newly developed a Delta-type corrector that can correct up to 6th-fold astigmatism and installed the corrector into our ARM300CF at the University of Tokyo. The flat region in Ronchigram is remarkably improved up to 70 mrad at 300 kV. By utilizing such large α, we have systematically investigated the depth-resolution by using single Ce dopants embedded in cubic boron nitride (*c*-BN)[4], where we obtained 2.1 nm depth resolution with the illumination angle of 63 mrad at 300 kV[5]. We will also discuss the three-dimensional distribution of single Ce dopants in *c*-BN at atomic-scale.

In our group, we are also working on the development of differential phase contrast (DPC) imaging in STEM, which has access to the local electric and magnetic fields in atomic scale[6,7]. One of difficulty of this technique is due to the dynamical diffraction even in a thin specimen, which easily destroys the phase information in a bright-field region. To avoid such the diffraction effect, we choose monolayer graphene and we will discuss the possibility of chemical bonding imaging around single Si impurities in monolayer graphene[8].

References

1. S. Morishita, et al, Microscopy **67** 46 (2018).
2. R. Ishikawa, et al, Ultramicroscopy **151** 122 (2015).
3. R. Ishikawa, et al, Appl. Phys. Lett. **109** 163102 (2016).
4. R. Ishikawa, et al, Phys. Rev. Lett. **110** 065504 (2013).
5. R. Ishikawa, et al, Phys. Rev. Appl. **13** 034064 (2020).
6. N. Shibata, et al, Nat. Phys. **8** 611 (2012).
7. N. Shibata, et al, Nat. Commun. **8** 15631 (2017).
8. R. Ishikawa et al, Nat. Commun. **9** 3878 (2018).

The Presenter

Ryo Ishikawa is a Project Associate Professor of the Institute of Engineering Innovation at the University of Tokyo, Japan. He completed his PhD in Materials Science at the University of Tokyo in 2011. Following his postdoctoral position at the University of Tokyo, he moved to Oak Ridge National Laboratory in USA from 2012 to 2014, and he then joined the University of Tokyo as an Assistant Professor. In 2020, a new social cooperation program of 'Next Generation Electron Microscopy' was established by collaborating JEOL company with the University of Tokyo, and he has been assigned to the current position. His research interests are in the development of atomic-resolution scanning transmission electron microscopy (STEM) including single electron sensitive quantitative STEM imaging, dynamic STEM for single atom tracking, three-dimensional optical depth sectioning with large-angle illumination, and atomic and electronic structure analysis in materials science such as lithium ion battery materials, functional nitride and oxide materials. He received the Albert Crewe Award from the Microscopy Society of America in 2016 and Encouragement Prize from The Japanese Society of Microscopy in 2018.

Convener

Professor Joanne Etheridge
Director, Monash Centre for Electron Microscopy

MICROSCOPY AUSTRALIA

Email: mcem@monash.edu **Tel:** +61 3 9905 5563