ATOMIC SCALE ELECTRON ENERGY-LOSS SPECTROSCOPIC PROFILING TECHNIQUE: THE FUTURE OF C_C-CORRECTED ENERGY-FILTERED TRANSMISSION ELECTRON MICROSCOPY

X. Y. Zhong[1,*], L. Jin[2], A. Tavabi[2], J. Rusz[3], H. B. Jiang[1], Z. C. Wang[1], M. Luysberg[2] and R. E. Dunin-Borkowski[2]

[1]National Center for Electron Microscopy in Beijing, School of Materials Science and Engineering, Tsinghua University, Beijing 100084, P.R. China
[2]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute, Forschungszentrum Jülich, 52425 Jülich, Germany
[3]Deptmt. of Physics, Uppsala University, S-75121 Sweden, and IOP, Academy of Sciences, Czech Republic

Abstract

Energy-filtered transmission electron microscopy (EFTEM) and scanning transmission electron microscopy (STEM)-Electron Energy-loss spectroscopy (EELS) are two traditional methods to access the chemical information with high spatial resolution in the transmission electron microscope (TEM) [1]. Compared to STEM-EELS technique, the major obscales in the applications of EFTEM is the low dose efficiency, poor energy resolution due to the relatively large slit width of energy window, poor signal to noise ratio and limited spatial resolution due to delocalizationn [2]. Here we make these major advances via the ground-breaking use of a combination of electron energy-loss spectrum Profiling (ELSP) [3-5] and chromatic aberration correction [6]. In the example of $CaTiO_3/SrTiO_3$ superlattice thin films, we can acheive the EELS spectra from the individual atomic planes of Ca, Sr and Ti at $CaTiO_3/SrTiO_3$ interfaces at the atomic resolution under the parrallel beam illumination. Compared to the conventional EFTEM, our method can provide much higher dose efficiency and high spatial resolution, which is quite similar to stripe STEM-EELS mode. This method combined with electron energy-loss magnetic chiral dichroism [7,8] can be potentially be applied for access the magnetic information at the atomic scale.

Acknowledgement: The authors thank to Dr. Lei Jin, Dr. Chris Boothroyd, Dr. Lothar Houben, Dr. Martial Duchamp, Dr. Juri Barthel, Doris Meertens, Maximilian Kruth, Dr. Markus Lentzen and Prof. Chunlin Jia at Research Centre Jülich, Prof. Yutaka Moritomo at University of Tsukuba, Hanbo Jiang, Zechao Wang, Prof. Jing Zhu and Prof. Rong Yu at Tsinghua University.

[1] R.F. Egerton. Electron Energy-Loss Spectroscopy in the Electron Microscope, Springer, New York, 2011.
[2] B.D. Forbes, L. Houben, J. Mayer, R. E. Dunin-Borkowski, and L. J. Allen. Ultramicroscopy 147, 98 (2014).
[3] L. Reimer, I. Fromm, P. Hirsch, U. Plate, R. Rennekamp. Ultramicroscopy 46, 335 (1992).
[4] K. Kimoto, T. Sekiguchi, T. Aoyama. J. Electron Microsc. 46, 369 (1997).
[5] T. Walther. Ultramicroscopy 96, 401 (2003).
[6] K.W. Urban, J. Mayer, J.R. Jinschek, M.J. Neish, N.R. Lugg, L. J. Allen. Phys. Rev. Lett. 110, 185507 (2013).
[7] P. Schattschneider, S. Rubino, C. Hébert, J. Rusz, J. Kunes, P. Novák, E. Carlino, M. Fabrizioli, G. Panaccione, G. Rossi. Nature 441, 486 (2006).
[8] Z.Q. Wang, X.Y. Zhong, R. Yu, Z.Y. Cheng, J. Zhu, Nature Commun. 4 (2013) 1395.