Utility of Scanning Transmission X-ray Microscopy to Investigate Chemical Composition in Perovskite Thin Films

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Organic–inorganic lead halide perovskites with remarkable photoelectric properties have achieved power conversion efficiencies of 25.2 %, making them a promising candidate as an emerging solar cell technology [1]–[4]. Formation of high crystalline perovskite film is necessary for stable and high efficient solar cells. Among them, vacuum-based deposition processes are profitable because highly uniform and smooth thin films can be obtained [5], [6]. Especially, characterization of evaporated perovskite thin films using various technique contribute to the accurate analysis in the physical or chemical point of view [7].

Scanning transmission X-ray microscopy (STXM) is an experimental technique based on near edge X-ray absorption fine structure (NEXAFS) spectroscopy [8]. This spectro-microscopy technique allows us to obtain quantitative chemical composition maps in bulk of materials with high spatial resolution (~ 50 nm). We have been exploring the utility of this technique in order to characterize perovskite films synthesized with evaporation techniques. In this poster, we present some strategies developed to study these materials. In particular, we have shown how the soft x-ray energy range from 270 to 750 eV, that includes the C K-edge, N K-edge, Pb N-edge and I M-edge, can be used to quantify elemental and molecular concentration[9]–[11].

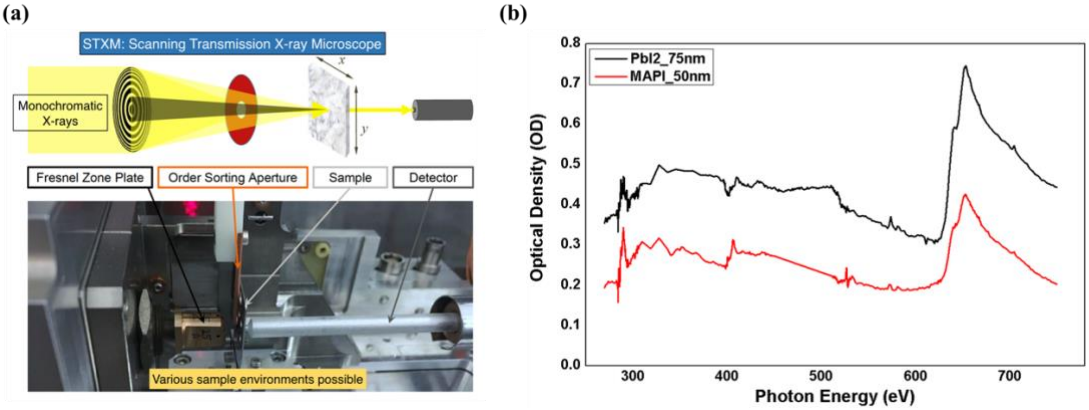

Figure 1. (a) Schematic of scanning transmission X-ray microscope (b) Carbon K-edge, Nitrogen N-edge and Iodide M-edge NEXAFS spectroscopy of PbI_2 and $MAPbI_3$ perovskite film.

Keywords
Organic–inorganic halide perovskite, Co-evaporation, Scanning transmission X-ray microscopy

Reference

[1] D. B. Mitzi, C. A. Feild, Z. Schlesinger, and R. B. Laibowitz, *J. Solide State chem.*, 114, 1. 159–163, 1995.
[2] S. D. Stranks *et al.*, *Science*, 342, 10, 341–345, 2013.
[3] J. H. Noh, S. H. Im, J. H. Heo, T. N. Mandal, and S. Il Seok, *Nano Lett.*, 13, 4, 1764–1769, 2013.
[4] "NREL efficiency chart." [Online]. Available: https://www.nrel.gov/pv/cell-efficiency.html.
[5] M. Liu, M. B. Johnston, and H. J. Snaith, *Nature*, 501, 7467, 395–398, 2013.
[6] L. K. Ono, S. Wang, Y. Kato, S. R. Raga, and Y. Qi, *Energy Environ. Sci.*, 7, 12, 3989–3993, 2014.
[7] M. Sowinska, C. Das, K. Wojciechowski, and Z. Rouissi, *ISSRNS*, 15, 1, 1500962, 2016.
[8] H. Ade, *Academic Press*, 32, 225-262. 1998.
[9] J. Stöhr, R. Jaeger, J. Feldhaus, S. Brennan, D. Norman, and G. Apai, *Appl. Opt.*, 19, 23, 3911, 1980.
[10] C. Reverdin *et al.*, *AIP Conf. Proc.*, 207, 5, 207–212, 2008.
[11] M. W. Lin *et al.*, *Adv. Mater. Interfaces*, 3, 17, 1–12, 2016.