Development of gigapixel imaging XAFS

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X-ray spectromicroscopy is one of the powerful characterization techniques that enables not only element specific, but also chemical-state-sensitive map. Recent progress of the synchrotron, X-ray optics, camera resolution, and computational capability realized high resolution spectromicroscopy including 3D nano-imaging. Applying the state-of-art spectromicroscopic techniques to the materials characterization, one has to tackle on finding “a needle in the haystack” [1]. This problem becomes more prominent in investigating the natural-resource-based samples, where the “haystack” itself is highly inhomogeneous and one basically has no idea about which part in the sample exist the reaction front-end or trigger sites. To this end, we tried to maximize the spectromicroscopic information exploited from a piece of sample, by enlarging the field of view in 2D imaging XAFS with moderate resolution.

Experiments were performed at PF-AR NW2A beamline in High Energy Accelerator Research Organization (KEK). Based on the imaging XAFS experiments performed at this beamline so far [2], we combined higher magnification lens (10X) to the latest sCMOS camera (Hamamatsu ORCA-Quest) to realize 10 megapixels per shot with the effective pixel size of 0.46 μm. Sample position were scanned to obtain the imaging XAFS datasets taken at about 200 energy points, to be stitched at the final step of analysis. It took about 12 hours to obtain 72 imaging XAFS datasets resulting in a 600 megapixel chemical state map. Home-made ImageJ plugin was developed to explore the pixel or ROI spectra, normalize, and perform singular value decomposition [3] using the standard spectra.

Chemical state of Fe with submicron resolution were mapped over ~10 mm area of an iron ore sinter sample which experienced the reduction process of ironmaking. Wide-area and high-resolution analysis enabled understanding the heterogeneous chemical state by interpreting the local XANES spectra, combined with the microscopic information such as the grain shape, crack distribution and other characteristic structures. The developed technique provides indispensable information on the trigger sites of reduction degradation of iron ore sinters.

Figure 1. Schematic of the gigapixel imaging XAFS.


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