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Correlative imaging with multi-modal scanning probe microscopy

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Scanning probe microscopy offers a unique opportunity to detect structural and chemical heterogeneities over the sample volume with high spatial resolution and sensitivity. This approach finds wide applications in functional materials and devices. The multi-modal imaging mode collects fluorescence, transmitted scattering and Bragg diffraction signals simultaneously (as shown in Fig. 1), thus providing a comprehensive characterization of the specimen.

The abundant information embedded in different channels offers a new opportunity to utilize the correlation across various contrast mechanisms and enhance the obtained image quality. We explored the potential to extend the depth of field of the ptychography method using the multi-slice [1] and focus-stacking [2] methods. Adopting the low spatial-frequency information from the fluorescence channel, we can push the depth resolution down to 500 nm [3]. Using the reconstructed beam profile from ptychography, we developed a machine-learning network to decouple the blurry impact from measurement and significantly enhance the fluorescence image quality [4]. Using the multi-model imaging method, we studies the imperfections in self-assembled nanoparticle super-lattices [5], revealed the surface modification and lattice distortion in co-doped cathode particles [6], and observed the healing effect of battery materials in an annealing process [7].

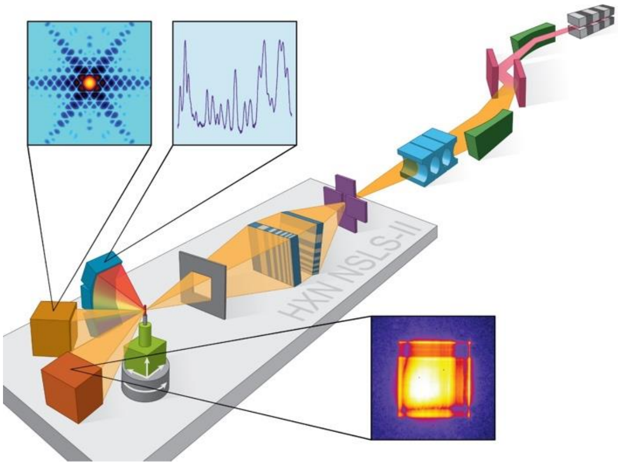

Figure 1. The Hard X-ray Nanoprobe beamline at NSLS-II is operated as a scanning probe microscope collecting fluorescence, transmitted scattering and Bragg diffraction signals simultaneously.

[1] H. Ozturk, H. Yan, Y. He, M. Ge, Z. Dong, M. Lin, E. Nazaretski, I. Robinson, Y. Chu and X. Huang, *Optica*, 5(5), 601-607, (2018).

[2] X. Huang, H. Yan, I. Robinson and Y. Chu, *Opt. Lett.*, 44(3), 503-506, (2019).

[3] X. Huang, H. Yan, Y. He, M. Ge, H. Ozturk, Y. Fang, S. Ha, M. Lin, M. Lu, E. Nazaretski, I. Robinson, and Y. Chu, *Acta. Cryst.*, A75, 336-341, (2019).

[4] L. Wu, S. Bak, Y. Shin, Y. Chu, S. Yoo, I. K. Robinson and X. Huang, submitted.

[5] A. Michelson, B. Minevich, H. Emamy, X. Huang, Y. Chu, H. Yan and O. Gang, *Science*, 376(6589), 203-207, (2022).

[6] Y. Hong, X. Huang, C. Wei, J. Wang, J. Zhang, H. Yan, Y. Chu, P. Pianetta, R. Xiao, X. Yu, Y. Liu, and H. Li, *Chem*, 6(10), 2759-2769, (2020).

[7] J. Li, Y. Hong, H. Yan, Y. Chu, P. Pianetta, H. Li, D. Ratner, X. Huang, X. Yu, Y. Liu, *Energy Storage Materials*, 45, 647-655, (2022).