Pink-beam XPCS for *in situ* observation of surface dynamics during crystal growth

Brian Stephenson*[1], Guangxu Ju[1], Irene Calvo Almazan[1], Matthew Highland[1], Carol Thompson[2], Jeffrey Eastman[1], Paul Fuoss[1], Stephan Hruszkewycz[1], Andrew Ulvestad[1], and Hoydoo You[1]

[1]*Argonne National Laboratory, USA*

[2]*Northern Illinois University, USA*

**stephenson@anl.gov*

Coherent x-ray methods are providing revolutionary new capabilities for observing nanoscale dynamics and imaging atomic structure in materials. Recently, these methods have been applied to studies of surfaces. For example, x-ray photon correlation spectroscopy (XPCS) has revealed the dynamics of atomic steps on electrode/electrolyte interfaces [1], and static surface steps have been observed by coherent diffractive imaging applied to crystal truncation rod scattering [2]. The Advanced Photon Source (APS) and other synchrotron facilities worldwide are being upgraded or built to provide greatly increased coherent x-ray flux by using a multi-bend achromat storage ring lattice [3]. In anticipation of these developments, we are exploring the limits of coherent x-ray methods using the current APS source.

Here we describe XPCS measurements at relatively high x-ray energies (e.g. > 25 keV) using the full bandwidth of the third harmonic of the undulator ("pink beam"), to enable *in situ* coherent x-ray studies of materials processing [4]. Using pink beam to achieve high coherent flux at high energy (e.g. 9 x 10^{10} photons per second at 25.75 keV in a 0.85% bandwidth) allows us to begin exploring high-energy coherent x-ray methods in experiments for which such a wide bandwidth can be used. We show that pink-beam XPCS using scattering near the specular direction can successfully reveal surface dynamics. We will describe design and characterization of enabling instrumentation such as coherence defining apertures, compound refractive lens focusing optics, harmonic rejection mirrors, and pixel array detectors with good sensitivity to high x-ray energies. We will also summarize results from additional coherent x-ray methods being developed in our group.

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$*$ Current affiliation of Paul Fuoss: LCLS, SLAC National Accelerator Laboratory, Menlo Park, CA, USA

References

[1] R. M. Karl, Jr, A. Barbour, V. Komanicky, C. Zhu, A. Sandy, M. S. Pierce, and H. You, Phys. Chem. Chem. Phys. 17, 16682 (2015).

[2] C. Zhu, R. Harder, A. Diaz, V. Komanicky, A. Barbour, R. Xu, X. Huang, Y. Liu, M. S. Pierce, A. Menzel, and H. You, Appl. Phys. Lett. 106, 101604 (2015).

[3] R. Hettel, J. Synchrotron Rad. 21, 843 (2014).

[4] G. Ju, M. J. Highland, A. Yanguas-Gil, C. Thompson, J. A. Eastman, H. Zhou, S. M. Brennan, G. B. Stephenson, and P. H. Fuoss, Rev. Sci. Instrum. 88, 035113 (2017).