Using Crystal Optics as Guard Apertures in Hard X-ray Coherent Diffraction Imaging

Xianghui Xiao, Hanfei Yan, Martin de Jonge, Yong Chu, Qun Shen

Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439, USA

Coherent x-ray diffraction imaging (CDI) is a rapidly evolving field of research and is becoming a useful tool for high-resolution imaging of nonperiodic specimens. In principle, the highest resolution achievable in such experiments would only be limited by the x-ray wavelength. However, in practice, the resolution is limited by radiation damage and by data quality such as the signal-to-noise ratio (SNR) of the data at high scattering angles. Preventing the contamination in the data due to the parasitic scattering from upstream elements is one of main challenges to increase the SNR of the data. In a conventional CDI experimental setup, guarding apertures are used to block the parasitic scattering. Those guarding apertures must be carefully aligned to avoid secondary scattering from the apertures themselves. This is especially true in CDI experiments where hard x-rays are used since the alignment of guarding apertures becomes more difficult.

Recently, we have developed a novel crystal guard aperture concept, in which a pair of multiple-bounce crystal optics is employed [Xiao et al, Opt. Lett. 31, 3194(2006)]. Different from the conventional guarding apertures, the crystal guard aperture does not produce secondary scattering and therefore allows a high-quality coherent incident beam. In this presentation we will present the detailed geometries of the crystal guarding apertures used in our CDI experiments. The effectiveness of the crystal guard aperture method has been verified by theoretical analysis and simulations based on Fresnel propagations of a dynamically diffracted Bragg wave. Recent coherent diffraction experiment results and phase-retrieval results have also confirmed the validity of this new guarding scheme.

The Advanced Photon Source is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.