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Opportunities for Coherent X-ray Scattering in Interfacial Geochemistry†

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The advent of fourth generation hard X-ray synchrotron sources, optimized to produce coherent X-rays, provides fundamentally new opportunities in geochemistry, especially to understand how structural complexity influences geochemical reactivity. There are two broad areas in which coherence will contribute new insights. The first opportunity is in coherent imaging (such as Bragg Coherent Diffraction Imaging, BCDI, and other imaging modalities). Coherent X-ray scattering (characterized by "speckles") can be inverted to directly *image* the actual structure within a sample (i.e., the shape and strain within a crystalline grain) rather than the average characteristics that are measured with non-coherent X-ray scattering (e.g., ensemble-averaged crystallite size and lattice spacing). The second opportunity derives from the sensitivity of coherent scattering to *dynamics*. X-ray photon correlation spectroscopy (XPCS) monitors the temporal evolution of speckle intensities to probe the dynamic evolution of spatial correlations within a sample. XPCS is the X-ray equivalent to dynamic light scattering (DLS) but with additional sensitivity to atomic-scale dynamics due to the short wavelength of the X-ray photon (~1 Å). In the case of equilibrium dynamics, XPCS probes not only diffusion constants (like DLS), it also can probe the dispersion relations that define the diffusion mechanisms. Finally, XPCS provides unique sensitivity for probing non-equilibrium phenomena, such as crystal growth and domain coarsening during crystallization. Opportunities and potential challenges will be discussed.

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