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Imaging Interfacial Structure and Reactivity with X-ray Reflectivity and Microscopy[1]

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A fundamental understanding of interfacial reactions is best achieved with ability to observe the systems of interest directly, ideally with molecular-scale resolution and/or sensitivities. X-ray-based approaches offer broad opportunities for probing complex interfaces in environments (e.g., liquids) that are normally inaccessible. I will describe two complimentary approaches for imaging interfaces. The first, X-ray reflection interface microscopy (XRIM), uses the weak interface-reflected X-ray beam to image laterally heterogeneous interfacial structures and processes using a full-field imaging approach. This approach incorporates all of the sensitivities of X-ray reflectivity (XR, including sensitivity to interfacial topography, structure and composition) as potential contrast mechanisms. Recent applications of XRIM will be described, including the abilities to observe: elementary surface topography (i.e., 6.5 Å-high steps) with ∼100 nm spatial resolution; interfacial reactivity; and liquid-solid interfaces, in-situ. A second, complementary, approach images the vertical distributions of element-specific substructures at an interface through the use of resonant dispersion at X-ray energies close to element's absorption edge (resonant anomalous X-ray reflectivity, RAXR). Recent applications of RAXR will be described including the ability to image element-specific distributions (i.e., ions near a charged liquid-solid interface) and its sensitivity for probing oxidation state specific structures at interfaces. The use of these techniques to observe charge transport at interfaces with respect to energy-related processes will be discussed.

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