Observation of Molecular-Scale Interfacial Structures with X-ray Reflection Interface Microscopy*

P. FENTER[1], C. PARK[1], Z. ZHANG[1], Y. WANG[2]

[1] Argonne National Laboratory, Argonne IL, USA, Fenter@anl.gov, cypark@anl.gov, zhanzhang@anl.gov
[2] Xradia Inc. Concord, CA, USA, swang@xradia.com

High resolution X-ray reflectivity (XR) has provided new insights into various structures and processes at the mineral-water interface, including interfacial water structure, cation adsorption and mineral dissolution (Fenter, 2002; Fenter and Sturchio, 2004). XR is effectively limited, however, to large single crystals due to the need to work at grazing angles, and best probes those processes that occur uniformly at mineral-water interfaces since (XR laterally averages the behavior within the interfacial plane).

These limitations can be addressed with a new interfacial microscope that we have recently developed, an X-ray Reflection Interface Microscope (XRIM). This instrument uses micro-focused synchrotron X-ray beams that illuminate small regions of the surface, and uses the specularly reflected X-ray beam to project a magnified image of the surface on a CCD camera using a Fresnel Zone Plate (FZP) lens. A key feature of this microscope is its use of the weak specularly reflected X-ray beam thereby providing interface specificity and sensitivity to molecular-scale defects derived from X-ray phase contrast. This results in images in which topographic features are seen as intensity variations in the image. The feasibilty of this microscope to probe molecular-scale features is demonstrated with images of elementary step distributions on a freshly cleaved orthoclase (001) surface.

I will discuss the new opportunities for understanding interfacial reactivity that can be addressed with this novel and non-invasive microscope. The ability to image elementary interfacial defect structures in real-time opens up a new way to probe interfacial dynamics (e.g., during crystal growth and dissolution) in aqueous solutions at extreme pH. The ability to measure reflectivity over microscopic regions of a surface also opens up, in principle, the possibility of performing interfacial structural analyses of small grained materials.

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References

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