X-ray Fluorescence Imaging and Spectroscopy with Sub-μm and Sub-100nm Spatial Resolution for Mineralogy and Geochemistry

J. THIEME[1], G. WILLIAMS[1], Y.-C. CHEN-WIEGART[1,2], B. BOWERMAN[1], J. HUROWITZ[2], T. GLOTCH[2], C. LEGETT[2], M. SCHOONEN[1,2], J. COATES[3]

[1]NSLS II, Brookhaven National Laboratory (correspondence: jthieme@bnl.gov), [2]Department Of Geosciences, Stony Brook University, [3]Energy Biosciences Institute, University of California, Berkeley

The National Synchrotron Light Source II (NSLS-II) at Brookhaven National Laboratory is a synchrotron radiation source of extremely low emittance; it provides an ideal platform for sub-μm focused beam instruments. The Sub-μm Resolution X-ray spectroscopy (SRX) beamline has been developed specifically as an X-ray fluorescence (XRF) analytical probe, utilizing the high brightness of NSLS-II. The scientific emphasis is the study of complex systems with chemical heterogeneity at sub-μm and sub-100nm length scales. XRF mapping and XANES spectroscopy experiments to investigate the elemental composition and the chemical state of a sample are the core capabilities of this beamline. The accessible energy range of 4-25 keV allows for X-ray absorption spectroscopy experiments across the periodic table from titanium up to plutonium. Two sets of mirror optics are used for focusing, a high photon flux set delivering about 10^{13} phot/sec in a sub-μm sized spot and a high spatial resolution set that will deliver a focal spot size of less than 100 nm at a photon flux of approx. 10^{11}-10^{12} phot/sec. The photon flux SRX delivers in a sub-μm spot, ultimately combined with the use of new energy dispersive detectors like the 384-element Maia, opens up new possibilities for compositional and spectroscopic analysis of major and trace elements in natural and synthetic materials. In the near future, tomographic XRF imaging, micro-diffraction measurements concurrent to XRF mapping, in-situ laser heating, and diffraction imaging techniques such as ptychography will be implemented as beamline capabilities available for experiments. Beamtime requests already have to be prioritized because of the heavy demand for experimental time by the international scientific community, an unambiguous sign for the beneficial impact of such nanoprobe and spectroscopy beamlines. A detailed description of the SRX beamline will be given here. Examples from mineralogy and geochemistry applications, such as XRF mapping and XANES spectroscopy of uranium in the field of nuclear forensics, of inhibition of sulfidogenesis by tungsten, and of rock samples representing analogs to Mars Return Samples, will highlight the actual performance of SRX.