Sub-Micron Resolution X-ray Spectroscopy Beamline (SRX)

Scientific Scope

Scientific communities such as environmental sciences, life sciences, and material sciences have identified the need to develop analytical resources to advance the understanding of complex natural and engineered systems that are heterogeneous on the micron to nanometer scale. These needs for high intensity x-ray nanoprobes resulted in the commitment of the NSLS-II Project to build the Sub-Micron Resolution X-Ray Spectroscopy Beamline (SRX) showing a unique combination of high spectral resolution over a very broad energy range and very high beam intensity in a sub-micrometer spot. NSLS-II will provide one of the best sources in the world for such an instrument. The research topics to be addressed require characterization of elemental abundances and speciation in samples that are heterogeneous at the sub-micrometer scale.

Beamline Description

The SRX beamline shares a low-β straight section with two canted in-vacuum undulators with the X-ray Fluorescence Nanoprobe (XFN). Each beamline is optimized to reach very high spatial resolution for a specific energy range. SRX is optimized to access higher energy and is included in the initial scope of NSLS-II. It will access an energy range from E = 4.65 keV to E = 25 keV. Two sets of Kirkpatrick-Baez (KB) mirror optics will focus the beam creating either a sub-micrometer sized focal spot at high flux or a sub-100 nm spot at moderate flux. A swap between the two setups will be possible in a couple of minutes. XFN is optimized for lower energies, accessing spectroscopic edges from E = 2 keV to E = 15 keV. This beamline will require additional funding to be completed. Zone plates (ZP) will be used as focusing optics, creating a focal spot below 30 nm.

The wide energy range covered by SRX will allow the scientific community to address a wide range of research topics, as absorption edges of a large number of elements can be reached (see Figure 1). This will enable scientists to use elemental mapping as well as spectroscopy for their studies. Finally, both beamlines are required to cover and even larger energy range without compromising the aim of combining X-ray spectroscopy and sub-micron spatial resolution in an optimal way.

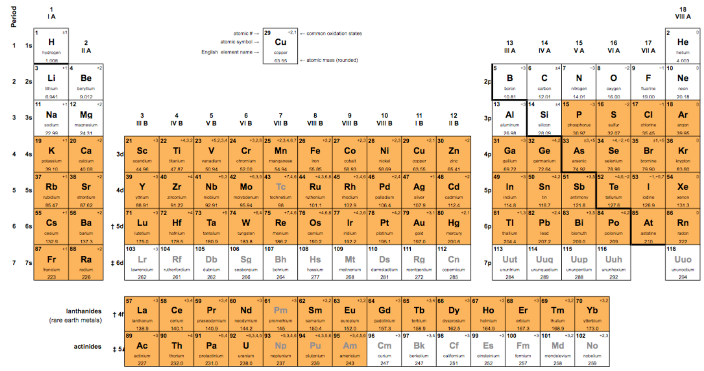

Figure 1 Periodic table showing elements high-lighted that have an absorption edge in the energy range covered by SRX and are therefore accessible for spectromicroscopy.

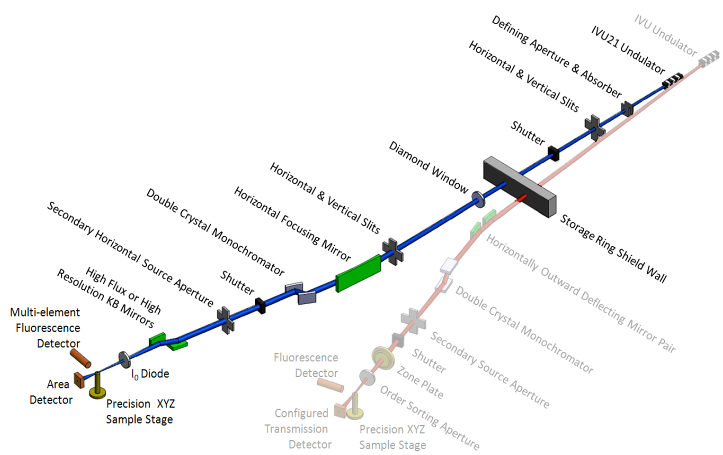

Figure 2 Schematic representation showing the optic layout of the SRX beamline (greyed out the XFN beamline).

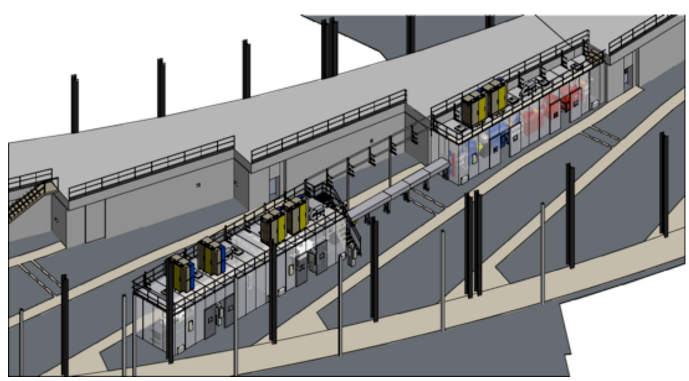

Figure 3 3D CAD model of the SRX beamline showing the first optical enclosure (right) and the two endstation hutches for SRX and XFN (left and middle).

Techniques Available

- X-ray absorption imaging
- X-ray fluorescence imaging
- X-ray tomography
- X-ray fluorescence trace element mapping
- XANES absorption spectroscopy
- XANES fluorescence spectroscopy
- X-ray spectromicroscopy
- X-ray microdiffraction

SRX Beamline Performance

Source	In-vacuum undulator, λ = 21 mm, L = 1.5 m
Energy range	4.65 keV ≤ E ≤ 25 keV
Monochromator	Horizontally deflecting DCM, Si (111), Si (311)
Energy resolution	ΔE ≈ 1.5-2.5 eV @ 12 keV ΔE ≈ 0.9 eV @ 7 keV
High-flux setup	0.5 x 0.5 μm^2 (H x V) at > 10^{13} phot/sec
High-resolution setup	60 x 60 nm^2 (H x V) and 10^{11} - 10^{12} phot/sec at @ 7 keV tunable to 30 x 30 nm^2 (H x V) at 10^{11} phot/sec @ 18 keV

Sample Environment

Beginning with thin sections from geosciences over micro- and nanoparticles in suspensions to microbial or biological specimens, the sample stage will be able to accommodate a great variety of samples from different scientific areas. Environmental cells will be available for complex samples.

NSLS-II National Synchrotron Light Source II

SRX Team

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Current Status:	final design
Installation:	starts Oct 2013
Commissioning:	begins Mar 2014
User Operation:	begins June 2015