The X-ray Absorption Spectroscopy Beamline at the Australian Synchrotron

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Introduction

The x-ray absorption spectroscopy (XAS) beamline at the Australian Synchrotron aims to deliver a bright, highly stable, scanned, monochromatic photon beam covering ~ 4–65 keV with the intention of measuring XAS spectra of all elements from Ca-U. The capability of performing standard XAS experiments as well as specialised measurements involving extreme sample environments, etc., place requirements on the flexibility of the beamline in terms of control over the final beam spot position and focus and the energy resolution of the incident photon beam. Different modes of operation allow the beamline to be optimised for particular experiments.

Methods and Materials

The source for the beamline will be a 20 period (10 cm), high field (1.9 T) wiggler with a critical energy of ~11.6 keV. The period and field have been designed to keep the K factor below 18 (limited by the storage ring and front end design) but yield a high critical energy. The device is currently under production by ADC, Ithaca, USA and is scheduled for installation into the storage ring (straight 12) in late December 2006.

For the beamline optics, Accel Instruments, Bergish Gladbach, Germany, has been awarded a *turnkey* system contract including all beamline components and optics as well as an EPICS-based control system. The first optical component will be a bendable collimating mirror with 3 stripes - Si, Rh and Pt - on a flat Si substrate. Cooling will be achieved with three slots immersed in a Ga eutectic. The liquid-N_2 cooled double crystal monochromator will be equipped with Si(111) and Si(311) crystal pairs, selectable by in-vacuum translation and cooled indirectly. For each crystal pair, the length of the second crystal will allow the beam foot-print to walk along the length of the crystal to maintain a fixed 25 mm offset. The monochromator may be operated in fixed offset, pseudo channel-cut, step-acquire-step and slew-scan modes of operation. Focusing to two experimental stations, separated by 5 m, will be achieved with a bendable dual toroidal refocusing mirror consisting of two toroids of minor radii 34.5 and 46 mm coated with Pt and Rh, respectively, on a flat ULE glass substrate. Vertical and horizontal focusing will be achieved by adjusting the mirror curvature and the incidence angle of the mirror, respectively. A simple harmonic rejection mirror on the experimental table will restrict the harmonic content to < 10^{-5} over the entire energy range.

Several operational modes have been proposed to optimise performance and harmonic content for a given energy range while managing power for the significant heat loads. For low energies, the first Si stripe can absorb ~1 kW of power, whilst for higher energies, C foils will be used to reduce the power component from low energy photons. Power management for the first crystal of the monochromator will be a critical aspect of beamline operation. The beamline will be terminated by a single Be window. Power concerns, the low energy cut-off and the variable incidence angle of the collimating mirror necessitate the use of differential pumping elsewhere. The combination of flexibility and high performance will necessarily add complexity to the operation and optimisation of the beamline.

For commissioning and day-one operations, the first experimental hutch will house a standard transmission XAS set-up including a cryostat. A multi-element Ge detector for fluorescence measurements will follow shortly thereafter. The second hutch will accommodate specialised equipment such as that required for extreme sample environments. The addition of a quick-XAS monochromator is planned at a later stage.

Results

The theoretical performance of the optical design has been simulated with Shadow and results are shown in Table 1. Harmonic content of < 10^{-5} can be readily achieved. Figure 1 depicts the simulated focal spot performance calculated via raytracing.

Energy (keV)	Crystal pair	Resolution (eV)	Flux in focus spot	Flux through a .2x1 mm slit
6	Si(111)	0.7	2.05E+13	1.64E+13
10	Si(111)	1.3	3.32E+13	2.70E+13
20	Si(111)	2.4	1.82E+13	1.50E+13
30	Si(311)	1.25	1.50E+12	4.28E+11

Table 1. Calculated performance of the XAS beamline without the inclusion of loss factors. Actual photon fluxes are expected to be approximately ten times lower.

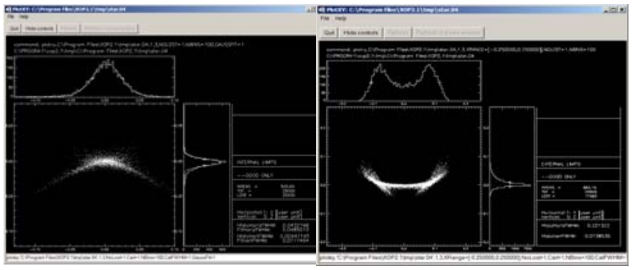

Figure 1. Simulated focal spot at sample position 1 (33 m from the source) showing the effect on the horizontal focus of varying the angle of incidence of the refocussing mirror but correcting the bend radius to achieve the vertical focus. Left: 3.15 mrad and R = 6984 m. Right: 2.95 mrad and R = 7457 m.