Nuclear Resonant Scattering (BL09XU)

1. Introduction

BL09XU is a standard X-ray beamline at SPring-8 with a in-vacuum linear undulator (λ_u=32*mm*) and an inclined Si double crystal monochromator [1]. The experiments on the nuclear resonant scattering and the structure analysis of surface and interface are conducted at BL09XU.

2. Bunch Structure

The time structure of the incident X-ray is very important for time resolved experiments such as nuclear resonant scattering. Since the maximum current per bunch is limited considering the emittance and lifetime of the ring current, the higher the total ring current, the lower the selectable pattern of the bunch filling. In October 1998, 70 mA operation began in place of 20 mA operation. The 12 bunch + 48 bunch train operation and the 3 bunch train × 21 operation were performed for nuclear forward scattering and nuclear inelastic scattering, respectively. The pattern of bunch filling will change with the 100 mA operation scheduled in 1999.

3. Optics

The Optical system for nuclear resonant scattering is usually composed of a high heat load monochromator (beamline monochromator) and a high resolution monochromator. The optical system for the structure analysis of surface and interface is usually composed of only a high heat load monochromator. A flat mirror for eliminating the higher harmonics will be installed after the high heat load monochromator.

3.1 Beamline Monochromator

A rotated inclined double crystal monochromator of Si with a pin-post cooling is used as the beamline monochromator. The typical width (FWHM) of the first crystal rocking curve for 14.4 keV with a 1 ×1 mm^2 aperture at 29 m from the undulator source is 10 arcsec. Figure 1 shows the vertically integrated horizontal beam profile at the experimental hutch. Several dips are due to the crystal distortion from the groove of the cooling water [2].

3.2 High Resolution Monochromator

A high resolution monochromator is a powerful tool for a study of nuclear resonant scattering. It is used to eliminate non-resonant parts from incident X-rays in case of the nuclear resonant elastic scattering. It is also used to change the energy of the incident X-rays in case of the nuclear resonant inelastic scattering. Three kinds of high resolution monochromators for 14.4 keV X-rays with different energy resolutions are available at BL09XU. Their specifications and the measured values are listed in the Table 1.

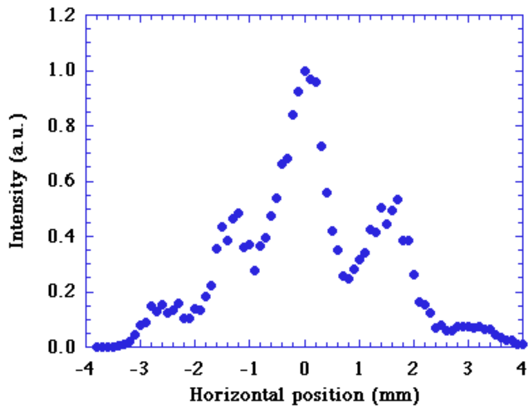

Fig. 1. Horizontal beam profile at the experimental hutch.

Table 1. High resolution monochromators for 14.4 keV available at BL09XU

reflection	ΔE	Photons/sec/70 mA
Si 511-Si 975 (2 nested channel cuts)	3.5 meV	1.5×10^9
Si 511-Si 975 (2 nested channel cuts)	2.5 meV	6×10^8
Si 975-Si 975 (2 flat crystals)	1.6 meV	2×10^8

4. Goniometers

There are two tables and one multi-axis goniometer in the experimental hutch, as shown in the Fig. 2. The high precision goniometers are arranged on the tables.

4.1 High Precision Goniometers

Two kinds of versatile goniometers are prepared as shown in Table 2. One is a ω-2θ goniometer whose axes are rotated in full circles by the stepping motors with the finest step 0.36 arcsec for ω and 0.72 arcsec for 2θ when the motor drivers are in full step mode. The other is a tangential bar-type goniometer with the finest step of 0.005 arcsec by the stepping motor. Two of the six tangential bar-type goniometers are equipped with encoders with 0.0056 arcsec resolution, and two of them are equipped with encoders with 0.072 arcsec resolution. One of the features of the goniometer system at BL09XU is their flexibility. The surface of the tables are polished and the goniometers can be smoothly moved on the tables by air pads under the goniometers.

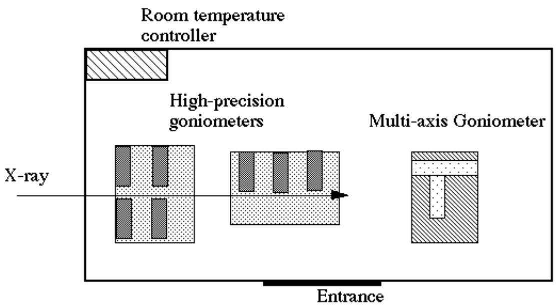

Fig. 2. Schematic view of the experimental hutch.

Table 2. High precision goniometers

	Tangential bar-type	Two-axis (ω-2θ)
Drive	stepping motor	stepping motor
Finest step	0.005 sec	0.0001 degree
Stroke	± 3 degrees	360 degrees
Encoder	0.0056 sec, 0.072 sec	

4.2 Multi-axis Goniometer

A multi-axis goniometer (Kohzu TDT-17) has been installed downstream of the high precision goniometers in the experimental hutch [3]. It is mainly used for the surface and interface structure analysis of the samples in the air. The main component is a 4-axis goniometer placed on the stage with an α axis that rotates within the ± 3 degrees, as shown in the Fig. 3. All the axes are rotated by the stepping motors and the finest steps per pulse are listed in the Table 3. They are controlled by the software SPEC. Two motor controlled slits are arranged for the spatial restriction of the incident and diffracted beam. A one or two directional Soller slit (Huber 3030-1) with a 0.4 degree acceptance or an analyzer crystal can be selected in front of the detector to lower the background noises. An ionization chamber is used for the incident flux monitor. NaI(Tl) scintillation detector and Ge SSD are used for the signal counting.

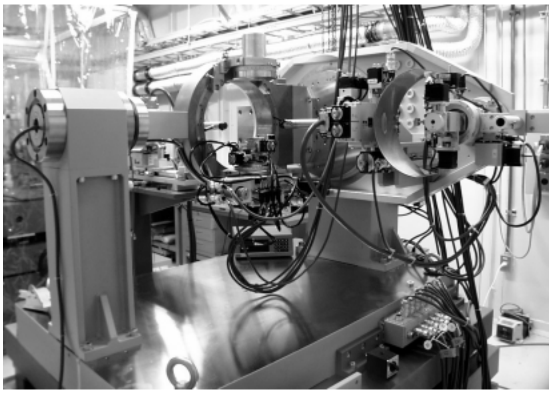

Fig. 3. Multi-axis goniometer for surface and interface structure analysis.

Table 3. Finest step of multi-axis goniometer when motor drivers are in full step mode

Axis	ω	χ	ϕ	2θ	α
Finest step (sec)	0.09	1.7289	1.8	0.72	0.144

References

[1] Y. Yoda and T. Harami, SPring-8 Annual Report 1996, 40 (1996).
[2] M. Yabashi, SPring-8 Annual Report 1997, 70 (1997).
[3] T. Takahashi *et al.*, SPring-8 Annual Report 1997, 299 (1997).