BL35XU
High-Resolution Inelastic Scattering

1. Introduction

BL35XU is dedicated to investigations of the dynamics in materials using inelastic X-ray scattering. Recently, the beam time has been allocated to non-resonant high-resolution inelastic X-ray scattering (IXS) measurements, where a Si backscattering monochromator is utilized in accordance with the high-order reflection. The energy resolution is around 1.5 meV (hν=21.747 keV using the Si(11 11 11) reflection) and 3 meV (hν=17.794 keV using the Si(9 9 9) reflection).

Versatile measurements are conducted for both crystalline and disordered materials. The cylindrical mirror provides a beam size of less than 80 μm × 80 μm (FWHM). This supports measurements of small samples with a size of < 1 mm^3. Due to the additional focusing system using the KB mirror, a smaller beam size of less than 20 μm × 20 μm (FWHM) is available, which allows measurements in extreme conditions such as a high temperature with a high pressure (in a diamond anvil cell).

This beamline is used by researchers from diverse fields because it can directly observe atomic dynamics and phonons in solids. For example, the beamline has been used to observe the atomic dynamics in liquid and glass, electron–phonon correlations in correlated materials, elastic constants with high pressure, which are often correlated to seismology, and phonon lifetimes of thermoelectric materials.

2. X-ray beam position monitor

In BL35XU, the beam position was determined by the slits, and the X-ray path was maintained in accordance with the slit window. This method generally works, but recent requests have asked for more precise position determination, especially in the KB-mirror setup and thin-film measurements. Hence, a more accurate method is required.

To estimate the beam position correctly, an X-ray beam position monitor (XBPM) was installed in the X-ray path in FY2019. XPBM is composed of a 10.5-μm-thick 4H-SiC film, which is mostly transparent (>98%) for 18–22 keV X-rays. The detection area, which measures 9 mm × 3 mm, is divided into four regions with 10-μm gaps. Due to the motorized translation stages, precise movement of XBPM can be realized. The obtained signal from XBPM is amplified by a four-channel picoammeter. These specifications are the same as those in the XBPM system recently installed at BL43LXU [1].

Figure 1 shows the beam position close to the sample position (500 mm from the sample) with an energy scan (from −40 meV to 80 meV, Fig 1(d)). During the measurements, slit conditions were the same as before. The total intensity did not change during the energy scan (Figs. 1(a) and (b)). This result has been confirmed by other (apd) monitors. However, the beam shifted around 60 μm in the horizontal direction during the energy scan, but it was mostly stable in the vertical direction. In the measurements, because XBPM was located 500 mm away from the sample position, the above shifts mostly correspond to those at the sample position. The 60-μm shift in the 120-meV scan corresponds to the angle drift of the backscattering crystal of 1.5 μrad/K. In the future, this XBPM can be moved to an arbitrary location in the X-ray path due to the high X-ray transmission and compactness of the system.

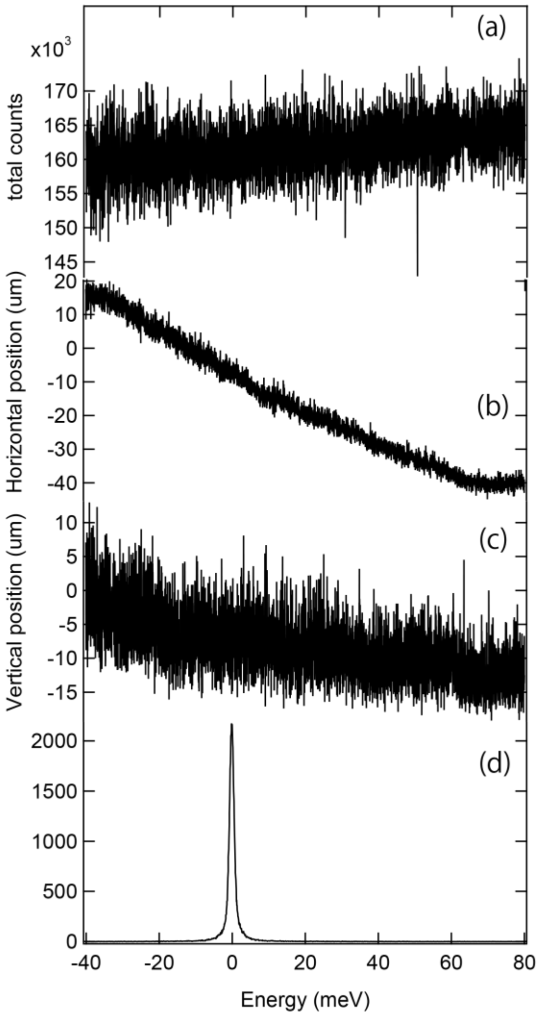

Fig. 1. X-ray position dependence with an energy scan. (a) Total flux obtained from XBPM. (b) and (c) Horizontal and vertical position shifts in the energy scan. (d) Corresponding IXS energy scan (−40 meV to 80 meV).

3. X-ray beam position camera

Installing an X-ray camera at the sample position is meaningful for two reasons. First, similar to XBPM, the camera can estimate the beam position change. Compared to XBPM, a camera is usually better suited to detect rapid position fluctuations. Second, a camera can estimate the beam size at the sample position precisely. These features are useful, especially for KB setups. For the newly installed camera, LuAG:Ce is used for the scintillator, realizing high spatial resolution measurements of 200 nm [2]. Combining this scintillator with a 20× magnification lens and a CMOS camera with the 1920×1200 pixels (pixel size: 5.86 μm × 5.86 μm) yields an active detection area of 560 μm (H) ×350 μm (V).

Figure 2 shows the results of the X-ray camera in the normal setup. The observed beam size was 71 μm (H) × 43 μm (V), which is similar to the values obtained by the slit scan. In the previous camera system, where P43 was utilized, the observed beam size was much larger than that in the slit scan, and was less reliable to determine beam size. It should be noted that the beam fluctuates vertically (around 10 μm) over several Hz. Neither the slit scan nor the previous camera detected such fluctuations. Hence, the effect of this fluctuation on the experiments must be considered.

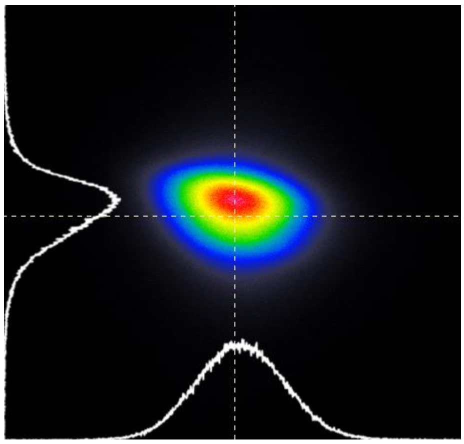

Fig. 2. X-ray image at the sample position.

Hiroshi Uchiyama

Precision Spectroscopy Division, Center for

Synchrotron Radiation Research, JASRI

References:

[1] A. Q. R. Baron, D. Ishikawa, H. Fukui, and Y. Nakajima, AIP Conf. Proc. 2054, 20002 (2019).
[2] T. Kameshima, et al., Optics Letters, 44, 1403 (2019).