BL12XU
Asia and Pacific Council for Science and Technology (APCST ID)

1. Introduction

As part of the Taiwanese x-ray facility at SPring-8 BL12XU is designed primarily for inelastic x-ray scattering (IXS) experiments on electronic excitations in correlated electron systems with energy resolution from 10 - 1000 meV. A secondary purpose is for high Q-resolution scattering and x-ray physics and optics. The scientific program, the design of the beamline and the IXS spectrometer were reported in the previous annual reports. [1,2] The on-site installation of the Phase I beamline components, the interlock and control systems were carried out from the beginning of this fiscal year and were completed by November 2001. On December 5 2001, following the successful commissioning of the undulator and the front-end (FE), BL12XU saw the first light from the storage ring (Fig. 1). Subsequent radiation survey of the hutches was passed. The beamline was officially approved for operation on December 17.

Figure 1 First image on a downstream fluorescent screen of the monochromatic beam from the double crystal monochromator (DCM).

BL12XU has since been under commissioning. The performance of all optical components have been examined and improved where necessary. An 8-circle Huber diffractometer for high Q-resolution experiments, and the IXS spectrometer were installed to the beamline by April 2002. By the time of writing this report, we have carried out some initial measurements using the IXS spectrometer, which indicates the readiness of the entire beamline for non-resonant IXS experiments at a total energy resolution of 250 meV with 10-keV photons. In the present report, some of these commissioning works will be presented.

2. Beamline Performance

The first and the most important optical component of the beamline is the high heat-load, double-crystal monochromator (DCM), as its performance determines directly the performance of the entire beamline. The design is of SPring-8 standard [3] with modifications to the crystal mounting stages for cryogenic cooling with LN_2. The cryogenic cooling system, also of SPring-8 standard design, operates with supercooled liquid nitrogen in closed circulation loop, passing through the 2 crystals in series. The maximum heat load taken safely so far was about 550 W delivered to the first crystal from the undulator at a minimum gap of 8.1mm and a FE slit opening of $1.0 \times 1.0 mm^2$. Under optimal operation conditions (flow rate at 5.2 l/m, and temperature set point at 76 K), [4] the vibration and/or heat-load induced broadening of the output beam from the DCM was examined by measuring the rocking curve width of the DCM silicon crystals at (333) reflection for 54 keV. The best (smallest) rocking curve width that could be obtained by adjusting the operation parameters of the cryogenic cooling system was ~ 1

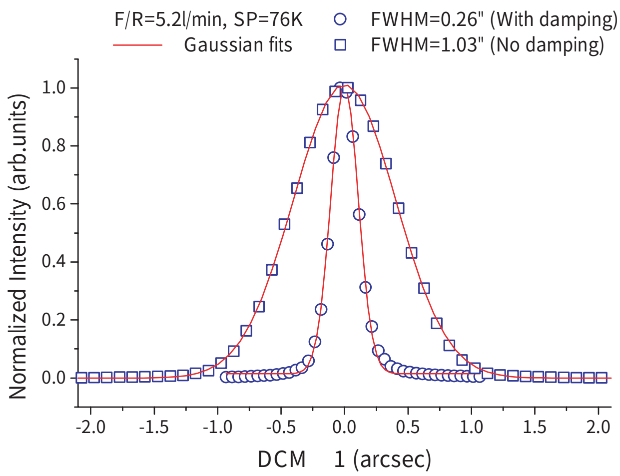

Figure 2 Si (333) rocking curves of the DCM at 54 keV showing the reduction of the width with vibration damping of the flexible cooling tubes inside the DCM.

arcsec (Fig. 2). By wrapping the flexible cooling tubes inside the DCM with Pb tapes, it was found that the broadening was effectively reduced. A mere 0.26 arcsec was recorded with this vibration damping, which is just 0.12 arcsec broader than the intrinsic value.

This improvement is essential for the performance of the collimating mirror (CM). With the vibration damping, beam collimation after the CM was substantially improved and was determined to be less than 0.68 arcsec (3.3 μrad) using the method described in Ref. [5]. With this level of collimation, the energy resolution and the throughput of the high-resolution monochromator (HRM) further downstream were found satisfactory.

The Phase I implementation of the HRM is an in-line combination of 2 silicon channel-cut crystals (C.C.) working at the (333) reflection. At around 10 keV, using the (555) reflection of a Si perfect crystal near backscattering (Fig. 3), the energy resolution of the HRM was found to be 105 and 52 meV, respectively, after the 1st and the 2nd C.C.

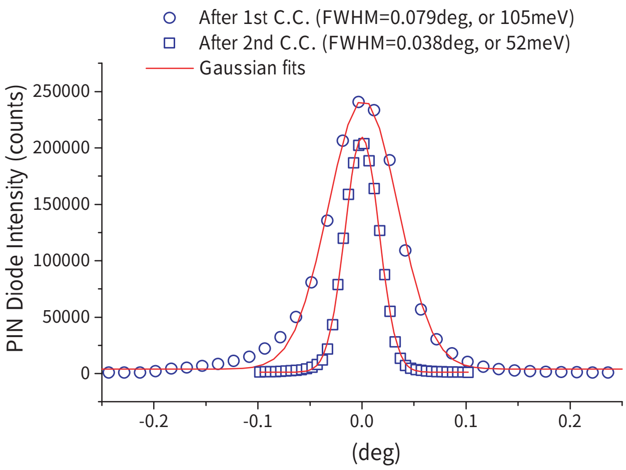

Figure 3 Angular (energy) profiles of the HRM at 9885.8eV as measured by the (555) reflection of a Si perfect single crystal near backscattering.

After the focussing mirror (FM), the beam was focussed to the sample position of the IXS spectrometer with a focussed size of 120(H)×75(V) μm². Total flux from the DCM (without the HRM) was determined using a calibrated Si PIN diode, and was 5×10^{12} phs/sec at 10 keV. [6] This latter measurement included an air path of roughly 1.5 meter.

The intensity and energy stability of the output beam from the DCM is another important aspect for a high-resolution inelastic x-ray scattering beamline. We have implemented a dynamic tunning system to maintain the parallelism of the two crystals, which was found to deviate by up to 1 arc second over an hour-long scan, particularly during the first few hours after the refill. The system utilizes the piezo drive on the 1st crystal $\Delta\theta 1$ stage to maintain the parallelism based on feedback from an ion chamber downstream of the DCM. The control program is entirely implemented under the SPEC control software, which runs on the background and does not seem to interfere with data acquisition during IXS experiments. After the implementation of this dynamic tunning system, intensity stability of the DCM was increased to better than 0.5%. Work is still under way to improve the system further. Further details of the work will be reported elsewhere.

3. IXS Spectrometer

The IXS spectrometer, custom designed and built to accommodate a wide range of experimental requirements, was installed to the experimental hutch in April 2002 (Fig.4). All performance indicators (sphere of confusion of all circles combined: ±7 μm; static stability: 10 μrad; angular stability of the analyzer against arm motion: 10 μrad) reach their design values. Using a bent Si (555) analyser at near backscattering, we obtained the first loss spectrum on an Al foil (Fig.5), which compares well with published data. This marks the completion of the Phase I of the entire inelastic x-ray scattering beamline and the IXS spectrometer, and shows that the beamline is now ready for non-resonant IXS experiments with 10-keV photons at a total energy resolution of 250 meV.

Figure 4 The IXS spectrometer installed in the experimental hutch of BL12XU, custom designed and manufactured by the Advanced Design Consulting, Inc.

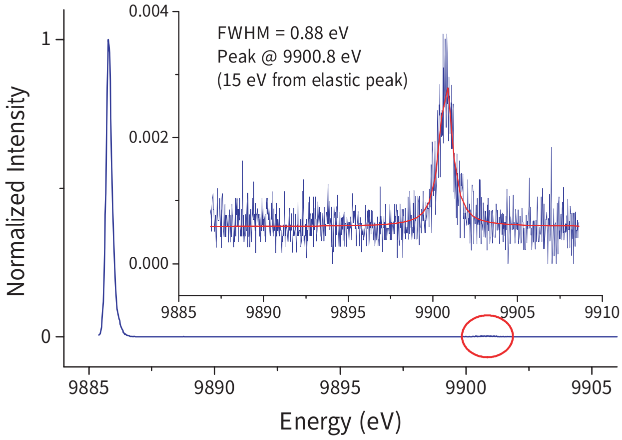

Figure 5 First IXS spectrum showing the plasmon loss feature from a 150-μm thick Al foil. Momentum transfer was 0.437 A^{-1}. Total energy resolution was about 250 meV. Count rate on the peak of the plasmon feature was roughly 10c/sec.

Acknowledgement

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