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BL12XU
NSRRC ID

1. Introduction

BL12XU, the dedicated Taiwan Inelastic X-ray Scattering (IXS) beamline, started user operation during the 2003 fiscal year. Majority (over 77%) of the beamtime was used for scientific experiments by external users from USA, France, Korea and China, and by in-house users of NSRRC, the rest of the beamtime was used for commissioning activities aiming at adding research capabilities, improving the performance and reliability of the beamline and the spectrometer. There have been 80 user runs for 14 experiments ranging from the dynamical response of electrons in superconductors, optical properties of insulators, to electronic structure of strongly correlated systems. Some experiments included the use of extreme sample environments of high pressure and low temperature to explore the unique advantage of the IXS technique. We give an overview of the major activities here.

2. Beamline and Spectrometer

BL12XU is designed for inelastic x-ray scattering experiments on electronic excitations with variable energy resolutions [1]. So far, two sets of the high-resolution monochromator (HRM) channel-cut crystals have been implemented, using Si(333) and Si(400) reflections, respectively, producing an incident beam with energy width of 50 and 153 meV at ~10 keV. The beamline can be operated also without the HRM in the low resolution mode, using the x-ray beam directly from the high heat-load double crystal monochromator (DCM) with an energy resolution of $\Delta E/E \sim 1.4\times10^{-4}$ eV. The HRM crystals can be withdrew from the beam path without changing the beam position at the sample, offering the convenience of switching between the high- and low-resolution modes rapidly for some experiments. Coupled with the various crystal analysers developed by NSRRC [2], we can now perform non-resonant IXS experiments with a total energy resolution of about 70, 175, 300, and 1300 meV at the near backscattering energy of the Si(555) reflection. For resonant experiments, the spectrometer has been modified to use 2-m radius crystal analysers, which improve the energy resolution substantially by reducing the source size contribution and the strain-induced broadening compared to the 1-m cases. The best resolution obtained so far was 240 meV using a Si(553) analyser for the Cu K-edge.

A major addition to the spectrometer has been a multiple analyser system capable of mounting in total 15 analysers in a 3×5 array with individual high-precision positioning mechanism (Fig.1). This system in principle can improve the counting efficiency by 15 times if all 15 analysers of equal quality are installed and aligned to focus to the same detector, and can be particularly useful for experiments with small angular dependence, such as the X-ray Raman scattering from core-level electrons. The ultimate goal is to perform experiments that are otherwise not possible on the beamline. Initial commissioning results with 3 analyser crystals in the central vertical column are encouraging.

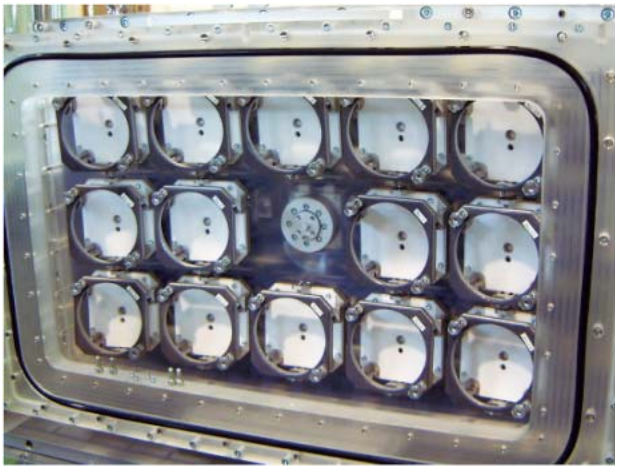

Fig.1 A 3x5 array multiple analyser system installed on the IXS spectrometer of BL12XU.

3. Operation and Control

As IXS experiments usually require long counting time, stability both in energy and intensity is an important aspect of operation. The cryogenically cooled high heat-load DCM was the main source of instability. Over the year, we have been continuously improving the stability by optimizing the operation parameters of the LN2 cooling system and introducing sufficient vibration damping to the internal cooling tubing. The crystal parallelism is now maintained entirely by the use of a SPEC macro running on the background tweaking up the intensity on a time constant of about 3 seconds, without using a MOSTAB module. Long-term (over a few hours) energy stability is better than 10 meV, with the intensity follows basically the drop of the storage ring current within the fill. With the introduction of the top-up operation of the SPring-8 storage ring, the stability is expected to improve further. Beamline and spectrometer control can be performed entirely within another SPEC program, from which one can move and scan all motorized beamline and spectrometer components, including the undulator gap for incident energy scans.

4．User Experiments

Two types of user experiments have been carried out on the beamline: non-resonant IXS (NRIXS) and resonant IXS (RIXS), which require changing the spectrometer setup, and so are usually grouped together to minimize the setup time. The first type of experiments focuses on the dynamical response of electrons of superconductors (MgB_2 and BSCCO), optical properties of insulating materials (CaF_2 and α-SiO_2), and X-ray Raman scattering of light elements under high pressure and low-temperature (various ice phases and solid He). The second type of experiments explores the resonant enhancement of the inelastic scattering cross section to study complex electronic excitations (such as charge transfer excitations) in strongly correlated systems. So far, studies have been performed on typical Mott insulators such as NiO, CoO and other more complicated cuprate systems (e.g., La_2CuO_4, Sr_2CuO_3 and $Sr_2CuO_2Cl_2$). All these experiments have produced important data, and are currently being analysed. Both types of experiments are being pursued equally, although the total beamtime allocated to NRIXS is about 50% more than RIXS due to the lower count rate for the former.

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References

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Y.Q. Cai, P. Chow*, H. Ishii, C.C. Chen and I. Jarrige, NSRRC, Taiwan; *Present address: HP-CAT, APS, USA.