BL12XU
NSRRC ID

1. Introduction

2004 is the second year since BL12XU, the dedicated Taiwan Inelastic X-ray Scattering (IXS) beamline was officially opened for user operation. Throughout last year, the outstanding performance of the SPring-8 source has enabled the beamline and the IXS spectrometer a smooth operation in serving users from USA, France, Korea, Japan, as well as users from Taiwan and in-house users of NSRRC. We have also begun user operation for the second end station for coherent scattering and x-ray optics experiments. There have been 89 user runs for 22 experiments throughout 2004. Majority of these are IXS experiments on the dynamical response of electrons in superconductors, the electronic structure of strongly correlated systems, and phase transitions in complex materials induced by pressure and temperatures. Some experiments included the use of extreme sample environments of high pressure and low temperature to explore the unique advantage of the IXS technique. The rest are scattering and x-ray optics experiments exploring the coherent aspect of the SPring-8 undulator beam. Some results have lead to important publications in reputable international journals. Further Instrument development for IXS has enhanced substantially the research capabilities of the beamline. We summarize the major activities here.

2. Beamline and IXS Spectrometer

BL12XU is designed primarily 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 $\Delta E/E$ ~1.4×10^{-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] and the multiple analyser system reported last year, the IXS spectrometer offers a range of configurations for both non-resonant and resonant IXS experiments as summarized in Table 1 and 2. For the multiple analyser system, in particular, we have now 9 matching crystal analysers, which improved the counting efficiency by 6 times in commissioning experiments.

Table 1 High-resolution non-resonant inelastic x-ray scattering (NRIXS) configurations currently available at BL12XU.

Beamline			IXS Spectrometer	
HRM Configuration	Flux ($\times 10^{11}$ photons/sec)	Bandwidth (meV)	Spherical Analyzers (× available No.)	Total Resolution (meV)
Si(333) 4B	1.5	50@9.886 keV	Si(555) 2m diced (×9)	65@9.886 keV
Si(400) 4B	6.0	120@7.911 keV	Si(444) 2m diced (×9)	135@7.911 keV
		150@9.886 keV	Si(555) 2m diced (×9)	175@9.886 keV
			Si(555) 2m bent (×3)	300@9.886 keV
None (DCM)	120	1250@9.486 keV	Ge(555) 1m bent (×1)	1300@9.486 keV

Table 2　High-resolution resonant inelastic x-ray scattering (RIXS) configurations currently available at BL12XU.

Beamline		IXS Spectrometer		
Resolution Mode	Bandwidth ($\Delta E/E$)	Spherical Analyzer	Energy Range (keV)	Total Resolution (eV)
LR: Si(111) DCM 5-30 keV	1.4×10^{-4}	Ge(333/444/555) 1m bent	5.7~6.6/7.6~8.8/9.6~10.9 (*K*-edges: Cr, Co, Zn)	~1
		Si(440) 1m bent	6.5~7.4 (*K*-edges: Mn)	~1
		Si(531) 1m bent	6.7~7.8 (*K*-edges: Fe)	~1
		Si(553) 1m bent	8.8~10.1 (*K*-edges: Cu)	~1
HR: Si(400) HRM 7.5~11.9 keV	1.5×10^{-5}	Ge(444/555) 2m bent	7.6~8.8/9.6~10.9 (*K*-edges: Co, Zn)	~0.5
		Si(533) 2m bent	7.5~8.6 (*K*-edges: Co)	~0.35
		Si(551) 2m bent	8.2~9.4 (*K*-edges: Ni)	~0.35
		Si(553) 2m bent	8.8~10.1 (*K*-edges: Cu)	~0.35

3. User Experiments

Two user experiments performed on the beamline have lead to important results and have been published in reputable international journals. The first experiment studied the ordering of hydrogen bonds in high-pressure low-temperature ices, and obtained for the first time key spectral signature on the change of H_2O framework among the different ice phases that is essential for understanding the icy planetary interiors as well as the physical and chemical properties of organic and biological systems under pressure [3]. The second experiment realized for the first time in 30 years the x-ray cavity using x-rays of 14.4388 keV. This cavity resonance results from the coherent interaction between the x-ray wave fields generated within a crystal gap smaller than the x-ray coherence length. This finding opens up new opportunities for high-resolution and phase-contrast x-ray studies [4].

Acknowledgement

Excellent technical support by the SPring-8 staff, particularly Dr. Y. Furukawa and Dr. T. Ohata, is acknowledged. We would also like to express our deep appreciation of the continuous and strong support by the JASRI management.

References

[1] Y.Q. Cai, P. Chow, C.C. Chen, H. Ishii, K.L. Tsang, C.C. Kao, K.S. Liang and C.T. Chen : AIP Conf. Proc. **705** (2004) 340.

[2] D.J. Wang, S.Y. Perng, Y.Q. Cai, P. Chow and C.K. Kuan : AIP Conf. Proc. **705** (2004) 869.

[3] Y.Q. Cai, H.-K. Mao, P.C. Chow, J.S. Tse, Y. Ma, S. Patchkovskii, J.F. Shu, V. Struzhkin, R.J. Hemley, H. Ishii, C.C. Chen, I. Jarrige, C.T. Chen, S.R. Shieh, E.P. Huang and C.C. Kao : Phys. Rev. Lett. **94** (2005) 025502

[4] S.-L. Chang, Y.P. Stetsko, M.-T. Tang, Y.-R. Lee, W.-H. Sun, M. Yabashi and T. Ishikawa : Phys. Rev. Lett. **94** (2005) 174801.

Y.Q. Cai, C.C. Chen, H. Ishii, I. Jarrige, and N. Hiraoka
NSRRC, Taiwan;