BL12XU
NSRRC ID

1. Introduction

BL12XU is one of the two contract beamlines operated by the National Synchrotron Radiation Research Center (NSRRC), Taiwan. It is designed mainly to support inelastic X-ray scattering (IXS) experiments and hard X-ray photoemission spectroscopy (HAXPES). BL12XU has an undulator light source and two branches: the mainline and the sideline (Fig. 1). The mainline, which has been fully operational since 2001, is used by both domestic and international scientists for IXS. The sideline is used for HAXPES. The HAXPES end-station has been open to general users since 2011. This end-station is co-operated with the Max-Planck Institute for Chemical Physics of Solids (MPI-CPfS), Germany.

In June 2020, NSRRC and RIKEN/JASRI agreed on the extension of the contract for the 12XU and B2 operations for an additional six years. The two beamlines are expected to aid research in the high-energy region, where the Taiwan Photon Source is less effective.

2. Instrumentation

The beamline major upgrading of 12XU and B2 is being performed from FY2023 to FY2026. We are expected to complete the preparations for the SPring-8-II project, that is, the ring upgrading to produce brilliant synchrotron radiation.

In FY2024, we modified the IXS spectrometer to mount more analyzers. Twenty spherical bent Bragg analyzers for low-energy fluorescence (5–15 keV) and five triangular Laue analyzers for high-energy fluorescence (15–30 keV) will be mounted upstream and downstream, respectively (Fig. 2). High-energy fluorescence reaches the Laue analyzers through an aperture between the 2nd and 3rd rows of a 4×5 Bragg analyzer matrix.

The new layout of the beamline optics was investigated. Now, the double-crystal monochromator (DCM), the collimating mirror (CM), and the focusing mirror (FM) are positioned at 49, 52, and 65 m from the light source, respectively. The DCM and CM will remain at the same positions, but FM will be relocated by 3 m downstream to accommodate the coherent diffractive scattering experiments (more specifically, ptychography) as the highest coherence is available this position.

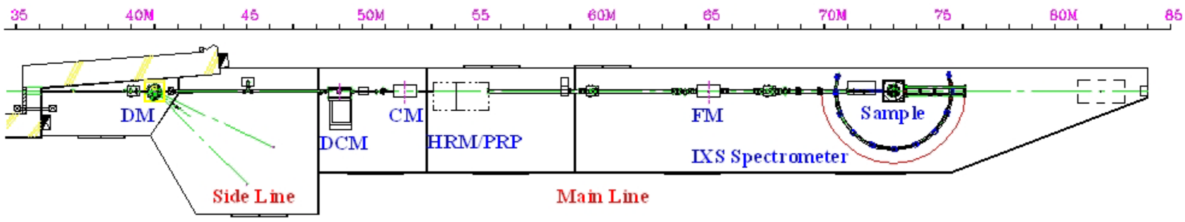

Fig. 1. Schematic diagram (top view) of BL12XU. DM is a diamond monochromator for the sideline, DCM a double-crystal monochromator for the mainline, CM a collimating mirror, HRM a high-resolution (channel cut) monochromator, PRP a phase retarding plate, FM a focusing mirror, and IXS an inelastic X-ray scattering spectrometer.

The CdTe 0.5 M-pixel detector purchased in FY2023 was successfully integrated into the IXS spectrometer. The high linearity between the photon numbers and the detector counters was observed, up to 10 million counts per second.

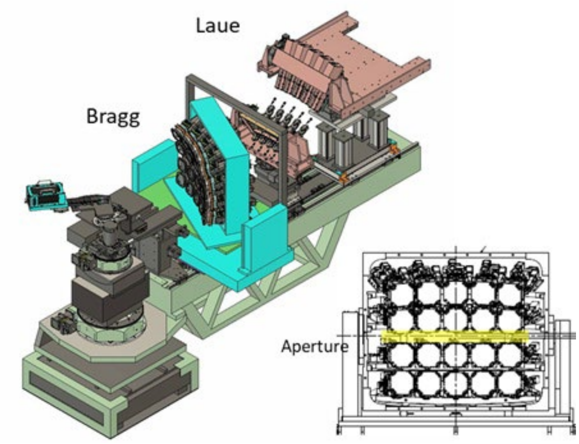

Fig. 2. Schematic view of inelastic X-ray scattering spectrometer to be available after the upgrade, consisting of 20 Bragg analyzers and five Laue analyzers.

3. Experiments

In FY2024, 24 IXS/XES and 15 HAXPES experiments were performed by general users. In total, 28 papers were published from 12XU. They include four papers on high-energy-resolution fluorescence detection (HERFD)-XAS studies of 3d/4f strongly correlated electron systems [1–4], six on HERFD-XAS studies of catalysts [5–10], three on X-ray Raman scattering [11–13], 15 on HAXPES studies of strongly correlated electrons [14–28], and three on a HAXPES study of semiconducting or other functional materials [26-28]. Representative papers are briefly introduced below.

Electronic structure evolution upon lithiation: A Li K-edge study of silicon oxide anode through X-ray Raman spectroscopy

Huang et al. investigated the local structural changes surrounding lithium in lithium silicate, Li_xSiO_y, and silicide, Li_xSi, within Li/SiO_x batteries during the reversible structural transformations by X-ray Raman scattering [13]. The features observed in the Li K-edge XRS spectra provide insights into the development and alteration of Li_xSiO_y, which emerges in the initial phases and may be accompanied by a reduction in the ionicity of Li–O bonding during lithiation (Fig. 3). These features also agree well with the accompanying FDMNES code simulation. The absence of a significant edge shift indicates a similarity in the electronic structure of Li_xSi throughout lithiation, and no evidence of Li_2O formation has been observed.

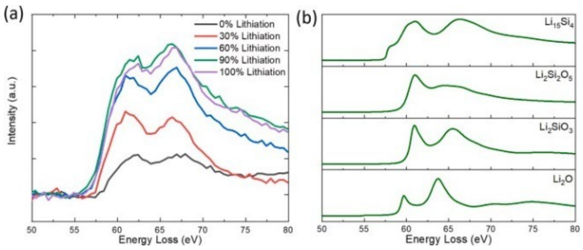

Fig. 3. (a) Li K-edge X-ray Raman spectra of SiOx electrodes at 0, 30, 60, 90, and 100% lithiation states in the third cycle. (b) Simulated Li K-edge XRS spectra of $Li_{15}Si_4$, Li_2SiO_3, $Li_2Si_2O_5$, and Li_2O.

Spectroscopic Evidence of Kondo-Induced Quasiquartet in $CeRh_2As_2$

Christovam et al. investigated models describing the low-temperature properties of $CeRh_2As_2$, which is a new multiphase superconductor with strong suggestions of an additional itinerant multipolar ordered phase, using a combination of several types of X-ray spectroscopy, HAXPES, XAS, and nonresonant inelastic X-ray scattering (NIXS) [16]. The HAXPES data obtained in 12XU indicated significant orbital hybridization in this heavy-fermion compound. Combined with the data obtained by the other spectroscopic techniques, the conjecture of a quasi-quartet ground state, which is crucial for superconductivity to coexist with other types of order, was validated.

HIRAOKA Nozomu, YOSHIMURA Masato, ISHII Hirofumi, and SHAO Yu-Cheng
NSRRC

References:

[1] Yamaoka, H. et al. (2024). *Phys. Rev. B* **109**, 155147.
[2] Yamaoka, H. et al. (2024). *Phys. Rev. B* **110**, 205129.
[3] Yoshikane, N. (2024). Doctoral Thesis (Osaka Metropolitan University).
[4] Lee, K. et al. (2024). *Phys. Rev. B* **110**, 24422.
[5] Bhalothia, D. et al. (2024). *Adv. Sci.* **11,** 2404076.
[6] Beniwal, A. et al. (2024). *Chem. Eng. J.* **493**, 152834.
[7] Zeng, W.-J. et al. (2024). *Mater. Today Sustain.* **27,** 100820.
[8] Tomoki, M. et al. (2024). Doctoral Thesis (Tokyo Metropolitan University).
[9] Wang, J. et al. (2024). *Angew. Chem. Int. Edit.* **63,** e202403333.
[10] Li, R. et al. (2024). *J. Colloid Interf. Sci.* **674**, 326.
[11] Matsuda, K. et al. (2024). *J. Phys. - Condens. Mat.* **36**, 75501.
[12] Tezuka, Y. et al. (2024). *Phys. Rev. B* **109**, 35132.
[13] Huang, H.-J. et al. (2024). *J. Power Sources Adv.* **29**, 100155.
[14] Stavinoha, M. et al. (2024). *Phys. Rev. B* **109**, 35112.
[15] Takegami, D. et al. (2024). *Phys. Rev. B* **109**, 35132.
[16] Christovam, D. S. et al. (2024). *Phys. Rev. Lett.* **132**, 46401.
[17] Takegami, D. et al. (2024). *Phys. Rev. B* **109**, 155108.
[18] Nakamura, R. et al. (2024). *Phys. Rev. B* **109**, 165148.
[19] Nguyen, T. L. et al. (2024). *Phys. Rev. B* **109**, 35102
[20] Takegami, D. et al. (2024). *Phys. Rev. B* **109**, 235138.
[21] Huang, H.-J. et al. (2024). *J. Power Sources Adv.* **29**, 100155.
[22] Bandyopadhyay, A. et al. (2024). *Phys. Rev. B* **109**, 184403.
[23] Bandyopadhyay, A. et al. (2024) *Phys. Rev. Mater.* **8**, 74405.
[24] Nakamura, R. et al. (2024). *Phys. Rev. B* **110**, L081109.
[25] Fujinuma, K. et al. (2024). *Phys. Rev. B* **110**, 125136.
[26] Nguyen, T. L. et al. (2024). *J. Phys. Soc. Jpn.* **93**, 121006.
[27] Kao, Y.-C. et al. (2024). *APL Mater.* **12**, 51118.
[28] Chang, C.-Y. et al. (2024). *Mater. Today Nano* **25**, 100466.