BL12XU
NSRRC ID

1. Overview

BL12XU is one of the two contact beamlines between National Synchrotron Radiation Research Center (NSRRC, Taiwan) and Japan Synchrotron Radiation Research Institute (JASRI). BL12XU has an undulator source and two branches of the mainline and a sideline (see Fig.1). The mainline has been fully operational since 2001 and used by many domestic / foreigner scientists from Japan, Taiwan, Germany, USA and so on. Inelastic x-ray scattering (IXS) experiments were mainly performed in BL12XU in 2012 and several other experiments such as high-resolution diffraction or coherent diffractive imaging were also carried out. The side line is dedicated to Hard X-ray photoelectron Spectroscopy (HAXPES) and a new end station has been built to incorporate two electron energy analyzers.

2. Mainline

2-1 Instrumentation

• **20 keV IXS spectrometer:** This spectrometer has been developed to enhance the count-rates of experiments under extreme conditions such as high pressure. The spectrometer was applied to several experiments, such as XRS based EXAFS studies on magnesium silicate glass and XANES-type studies on iron sulfide. We also tried a plasmon study in liquid silicon confined in a high temperature furnace. A multi-channel NaI scintillation counter was tested as a possible replacement of the single–channel NaI detector or a PILATUS 2D detector. The position sensitivity is utilized for correcting a slope error of the bent Laue crystal analyzers. The NaI crystal used has a 2 mm-thickness and almost 100% detection efficiency, much higher than that of the PILATUS (<40%) at this photon energy. Further commissioning is undergoing.

Fig. 2 Magnesium silicate mineral compressed in sintered-diamond anvil cell, mounted in the 20 keV bent Laue spectrometer.

2-2 Experiments

In 2012, we carried out 8 experiments of non-resonant IXS (NIXS), 2 of resonant IXS (RIXS), 12 of resonant x-ray emission spectroscopy (RXES), 3 of coherent diffractive imaging (CDI), 3 of high-resolution diffraction, and 2 of the optics development. An interesting example is described below.

• **Ground state wavefunction determined by NIXS:** The ground state of 4*f* electrons, one of the most important information to understand transport and magnetic behavior of rare earth compounds, are often determined by the polarization dependence in soft x-ray absorption. However, the absorption was usually dominated by dipolar transition and thus this technique does not probe the rotational symmetry higher than 4-fold. Willer *et al*. demonstrated that NIXS at high scattering angles becomes effective in such a case because non-dipolar components dominates the scattering [see Willer et al, Phys. Rev. Lett. **109** (2012) 046401, for details].

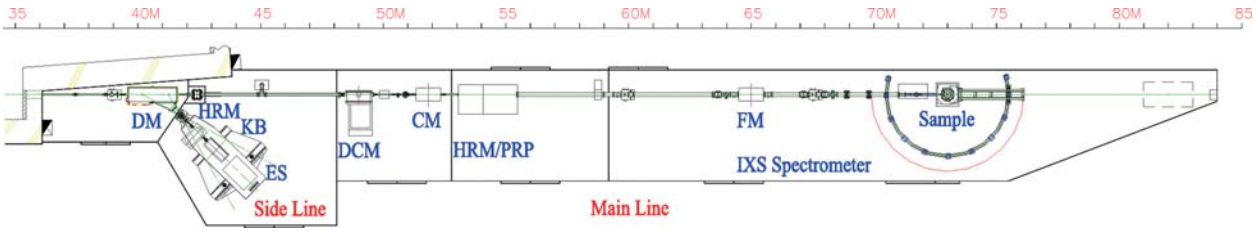

Fig. 1 Schematic diagram (top view) of the BL12XU: DM is a diamond monochromator for the sideline, DCM a double crystal monochromator for the mainline, CM a collimating mirror, HRM a high resolution (channel cut) monochromator, PRP a phase retarding plate, FM a focusing mirror, and IXS an inelastic x-ray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

3. Sideline

The photon energy range for performing HAXPES experiments at the side line is 6 to 12 keV. The photoionization cross section usually has a strong angular dependence and is often characterized by the so-called asymmetry β-parameter, with β equal zero being isotropic while β equal 2 or -1 being the most anisotropic. For many core levels β in this photon energy range is usually larger than unity thus the photoionization cross section becomes maximized in the detection geometry when the photoelectron emission direction is along the (linear) polarization vector (usually in the horizontal plane). This is the most popular detection geometry, the so-called horizontal geometry, of HAXPES end stations worldwide. It also has the advantages that the photoelectron signal rate becomes dramatically enhanced near grazing incidence for thin film samples with a flat surface and that the normal emission geometry of photoelectrons also ensures the largest probing depth for bulk sensitivity. However, for transition metal compounds which often exhibit strong correlation effect due to their open shell 3*d*-orbitals in the valence bands the angular photoionization cross section of valence band 4*s*-orbitals, which play only a minimal effect in correlation, is enhanced at this horizontal geometry because their β's are very near 2.

This problem is further compounded by the fact that in this high photon energy range the photoionization cross section of a valence 4*s*-orbital of transition metal elements exceeds that of the 3*d*-orbitals, thus, the measured valence band spectra contain a large component due to the *s*-orbitals and it complicates the analysis of correlation effect mainly due to the *d*-orbitals. To overcome this problem we have adopted a vertical geometry in which the detected photoelectrons are along the vertical direction to be perpendicular to the (horizontal) polarization, as a result the contribution from the *s*-orbitals becomes almost vanished. We have tested both geometries in our systems to achieve excellent results. But the end station has to be reconstructed to meet individual needs and it is impossible to switch during beamtime. We have built a new end station equipped with two electron energy analyzers in both horizontal and vertical geometries to be easily switched during beamtime to satisfy needs of different types of measurement even on the same samples. The test results are rather satisfactory. See Fig. 4.

* This sideline project is in collaboration with Prof. L.H. Tjeng of the Max-Planck-Institute for Chemical Physics of Solids (MPI-CPfS) in Dresden, Germany.

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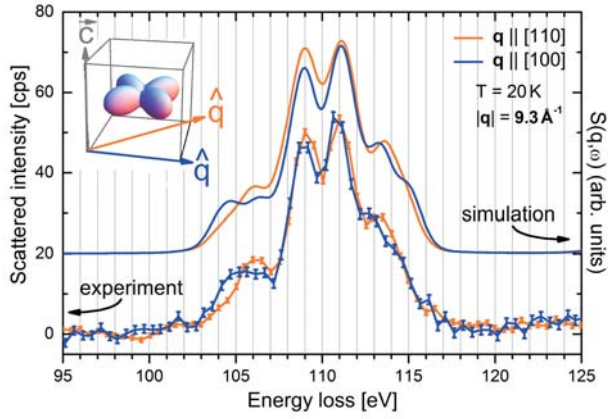

Fig. 3 Theoretical and experimental NIXS spectra at the Ce N-edge in $CeCu_2Si_2$. Clear anisotropy is observed with momentum transfers along the [100] and [110] directions due to non-dipolar (octupole and even higher order) transitions.

Fig. 4 Newly constructed HAXPES end station equipped with two electron energy analyzers for both horizontal and vertical geometries.