BL practice at BL25SU

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Program of BL practice

We, at the BL25SU, plan MCD spectra measurements and angle-resolved photoemission spectroscopy (ARPES) experiment, on 1st. and 2nd. of Oct, respectively. So, menus of the practice are difference between the first and the second days.

Outline of BL25SU

BL25SU is designed for research on electronic structures, magnetic states and surface structures of solids with high energy-resolution circularly-polarized soft X-rays. Left- and right-handed circularly polarized radiation is obtained along the same optical axis by twin helical undulators. The helicity of the circularly polarized radiation can be periodically switched at 0.1, 1 or 10 Hz by using kicker magnets distributed around the two undulators [1]. The beamline monochromator is a constant deviation type with varied line-spacing plane gratings covering an energy region of 0.12 ~ 2 keV. The resolving power of the monochromator is more than 10,000 in the whole energy region [2].

Four kinds of spectroscopic techniques are available for public use: **high energy-resolution photoemission spectroscopy**, **magnetic circular dichroism of core absorption**, **two-dimensional angular distributions of photoelectrons**, **photoelectron emission microscope**. Measurements are performed in ultra high vacuum conditions down to 10^{-8} Pa.

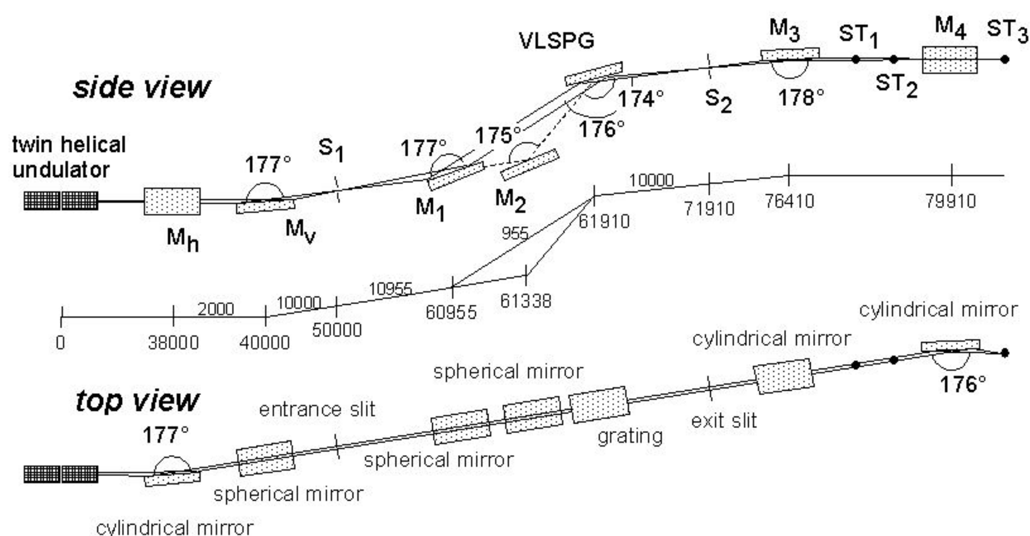

Fig.1 Layouts of beamline optics at BL25SU. MCD apparatus is installed as a station-4 (ST_4) downstream of the ST_3.

Time schedule of 1st, Oct.

9:30- Introduction of beamline design and major scientific activities.

10:30- Samples preparation and introduction of the samples to a load lock chamber.

11:00- Introduction of the helicity switching and MCD data acquisition techniques.

12:00- Measurement of beam properties under helicity switching in the 1 Hz mode.

13:00- ------- Lunch -----------

14:00- MCD measurements (Spectra and hysteresis loops). I propose having a time for exchanges of scientific interests and discussion on some technical subjects during the measurements.

16:30- Up to participant's interests and requests.

-17:30 Close

X-ray magnetic circular dichroism

Magnetic circular dichroism (MCD) of soft x-ray absorption is a powerful tool to study magnetic and electronic states of ferromagnetic and ferrimagnetic materials [3-5]. At BL25SU, helicity switching of circularly polarized radiation performed by the twin helical undulators are used for MCD measurements. Two absorption spectra corresponding to an MCD are measured by one energy scan switching the helicity at each energy point. The helicity-switching method is effective for precise measurements. The switching frequency is currently 1 Hz [6].

Samples are magnetized by a water-cooled type electromagnet equipped with double yorks. The electromagnet generates variable magnetic field up to 1.9 T at the sample position [7]. Sample temperature can be controlled from 10 K to 300 K and from 300 K to 550 K. Absorption intensity is measured by means of the total electron yield (TEY). A combination of the helicity switching technique and the apparatus provides element specific magnetic hysteresis (ESMH) measurements. For more detailed information of XMCD at BL25SU, please find a review paper of ref. [8], which can be downloaded free of charge.

Samples for the practice

In the XMCD practice, we will use FeCo alloy thin films grown on Cu metal buffer layer. Using these samples having different thickness of the FeCo layers, we will estimate probing depth of TEY detection by recording Cu absorption in addition to standard XMCD measurement at the Co $L_{2,3}$-edges. The spin and orbital magnetic moments will be deduced using magneto-optical sum rules [9, 10].

Time schedule of 2nd, Oct.

9:30- Introduction of beamline design and major scientific activities.

10:30- Samples preparation and introduction of the samples to a load lock chamber.

11:00- Introduction of ARPES data acquisition techniques.

12:00- Sample surface preparation by cleaving.

13:00- ------- Lunch -----------

14:00- ARPES measurements.

It will take a couple of hours to finely tune the sample orientation against the ARPES analyzer. If we have some extra time, we will also try to observe photoelectron diffraction patterns using a two dimensional analyzer.

-17:30 Close

Angle-resolved photoemission spectroscopy

Angle-resolved photoemission spectroscopy (ARPES) is a powerful tool for observing electronic band structures of solids. ARPES measurements are usually performed using vacuum ultraviolet (VUV) light with energies from a few tens to ~100 eV. In these cases, photoelectrons mainly come from surface layers because of their low penetration depths [11]. Thus, VUV-ARPES is quite useful when, for example, studying the top layers of two dimensional crystals such as graphite or other layered compounds. However, when the materials of interest have three dimensional structures and their bulk electronic states are needed to be explored, we have to gain the bulk sensitivity of ARPES. At BL25SU, such bulk-sensitive ARPES is available by virtue of using the high resolution soft x-rays mentioned above [12].

ARPES spectra are measured with a hemispherical electron analyzer (VG Scienta AB, SES200). When a sample emits photoelectrons from a soft-x-ray spot of ~100 µm on the surface, this analyzer can simultaneously detect angle-dispersed photoelectrons emitted in a plane including the electron lens axis of the analyzer. In our system, this plane is set vertical. Thus, vertically angle-dispersed photoemission spectra can be measured in parallel with an acceptance angle of about ±5°. In most cases, the acceptance angle is enough to cover the full first Brillouin zone when using soft x-rays. Samples can be cooled down to about 9 K using a closed-cycle He cryostat. The details of the system are described in Ref. [13].

Samples for the practice

In this practice, we will measure a Si wafer as a typical material which has a three dimensional crystal structure. A clean surface of the sample will be obtained by cleaving it *in situ*. The cross-sectional surface of the cleaved 0.5-mm-thick Si wafer is large enough for the beam spot of ~100

μm [14]. The sample position will be tuned using an optical microscope mounted on the measurement chamber [14]. We will measure band dispersions along the Γ-X direction in k-space using a photon energy of about 0.9 keV. Both the sample angle and excitation energy will have to be carefully tuned to observe clear dispersions.

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