Upgrade of Engineering Science Research III, BL46XU

Recently, the number of SPring-8 users in the field of the industrial application has been remarkably increasing. In order to respond to the growing demand in this field, we upgraded BL46XU as an "Engineering Science Research III" beamline.

In this upgrade of BL46XU, we renewed the multiaxis X-ray diffractometer, and installed a hard X-ray photoemission spectroscopy (HAX-PES) device. Additionally, the small X-ray diffractometer specialized for thin-film analysis (a commercial diffractometer ATX-G, manufactured by RIGAKU), which had been installed in BL13XU, was moved to BL46XU, because it was in high demand from industrial application users. The target field of these instruments is expected to be the development research on functional thin films. Furthermore, the high potential of this beamline with an undulator light source makes it possible to respond to various needs of the industrial application field.

The upgrade of the optical components started in the summer of 2008. This upgrade was mainly for expanding the available energy range of X-rays and for improving the flux density of the X-ray beam. After this modification, the available energy range of X-rays is E=6 ~ 35 keV and an X-ray beam can be focused at the sample position with a horizontal beam size of about 150 μm using the newly installed mirror-bender devices. Furthermore, a channel-cut monochrometer for HAX-PES was installed in the optics hatch.

The upgrade of the instruments in the experimental hatch was carried out from December of 2008 to February of 2009. As the standard layout, a multiaxis X-ray diffractometer is placed upstream of the experimental hutch, and a HAX-PES device is placed downstream. ATX-G is set in the experimental hatch temporarily after moving the HAX-PES device with adjustable guide rails in case that some users want to use this diffractometer.

The multiaxis X-ray diffractometer, which was manufactured by HUBER, has a basic construction of a four-circle goniometer whose fundamental scattering plane is vertical (four basic axes, χ, ϕ, ω, 2θ), equipped with four additional axes for horizontal scattering plane, ω_z and $2\theta_z$ (see in Fig. 1). A C-type χ cradle is adopted to get a wide scattering angle range (-20° to 160°) by avoiding dead angles. This design enables precise control of the incident angle of X-rays to the sample surface in the measurements of grazing incidence X-ray scattering (GIXS) for thin films. Two types of motorized sample

Fig. 1. Multi-axis X-ray diffractometer.

Fig. 2. X-ray diffractometer specialized for the thin film analysis (ATX-G).

stage, a XYZ stage and a swivel stage, are installed on the φ axis for adjusting sample position precisely. Furthermore, the position of users' optional accessories (e.g., furnace and tensile tester) can be set efficiently using these sample stages in combination with an X-ray camera. To improve the quality of the GIXS data for thin-film samples, we provide a He-gas sample chamber with a kapton dome to reduce background noise due to air scattering around the sample. To respond to various experimental configurations, we provided various optical components and detectors. As optional optical components, a solar slit and crystal analyzers (Si (111), Ge (111), LiF (002)) can be used. For the detectors, we provided a NaI scintillation counter detector and a silicon drift detector as one-dimensional detectors, and a pixel detector (PILATUS) or an imaging plate as a two-dimensional detector. PILATUS is an effective detector for time-resolved X-ray diffraction measurement. Furthermore, an attenuator automatic changer has been installed for X-ray reflectivity spectral measurement of the dynamic range of approximately ~10^{10}.

ATX-G is a conventional X-ray diffractometer specialized for GIXS measurement for thin-film structural analysis (Fig. 2). This diffractometer is easy to use for many company users because many companies have used it in their laboratories, and its specifications specialized for GIXS enable rapid scan motion. Therefore, this diffractometer is efficient for experiments that need to measure many samples in a fixed experimental configuration.

HAX-PES is powerful tool for chemical analysis on the surface and interface of thin films. This technique realizes a large probing depth of photoemission spectroscopy (PES) up to ~ a few tens of nanometers, detecting photoelectrons with high kinetic energy excited by hard-X-rays. Therefore, it is possible not only to observe the intrinsic characteristic of the samples reducing the effect of the contamination on the surface, but also to detect the depth profile of chemical information from the sample in a nondestructive manner. The number of HAX-PES users in the industrial application field has been increasing markedly in BL47XU. HAX-PES installed in BL46XU can enlarge opportunities for the use of this technique. The HAX-PES system is equipped with a VG-SCIENTA photoelectron energy analyzer, R-4000 (Fig. 3). The sample holder has a tilting device to change the detection angle of photoelectrons to the sample surface (take off angle: TOA). One can investigate the depth profile of chemical composition near the sample surface by measuring the TOA dependence of photoemission spectra using the tilting device.

We expected the high performance of this undulator beamline to improve the industrial application of SPring-8 qualitatively and quantitatively. We will operate BL46XU by flexibly researching various demands of industrial users.

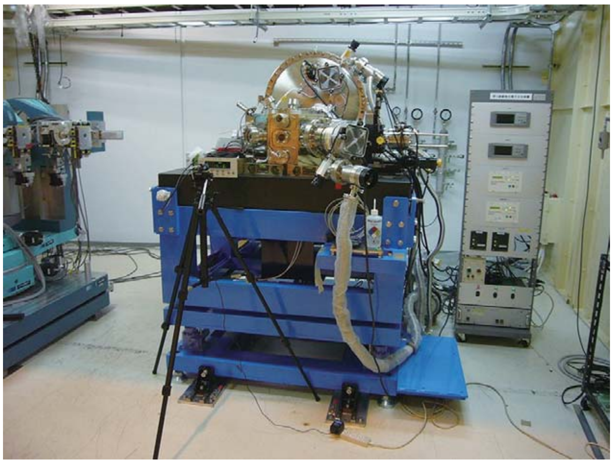

Fig. 3. The device for hard X-ray photoemission spectroscopy.

Masugu Sato

SPring-8/JASRI

E-mail: msato@spring8.or.jp