HIGH RESOLUTION HELICAL UNDULATOR SOFT X-RAY BEAMLINE

The beamline **BL25SU** for "Soft X-ray Spectroscopy of Solid", was the first soft X-ray beamline commissioned at SPring-8. It was designed for high-precision studies of electronic states and surface structures of solids.

The goal on the first stage operation was to perform high-resolution photoemission spectroscopy in the photon energy (hν) range between 0.5 and 1 keV, within which lie the *L* and *M* edges of 3*d* and 4*f* elements. Satisfactory performance was achieved in the spring of 1999.

A schematic layout of the beamline is shown in Fig. 1. A detailed description of the beamline has been reported in a recent article [1].

The light source is a "twin helical undulator" [2] . Two helical undulators were installed in tandem in a 4.5 m straight section of the storage ring. The gap of each undulator, consisting of 12 periods of 12 cm length, can be closed independently to a minimum gap of 30 mm. Fundamental radiation can be thus emitted throughout the photon energy range between 0.22 and 3 keV.

The optical system consists of pre-focusing mirrors (M_h and M_v), a grating monochromator (S_1– M_1 or M_2–VLSPG–S_2) and the post-focusing mirrors (M_3 and M_4). The constant deviation type monochromator employs a spherical mirror (M_1 or M_2) and the varied line-spacing plane gratings (VLSPG) as monochromatizing optics. Energy resolution (E/ΔE) of about 10^4 or more was expected by ray tracing, even when possible slope errors (1 μrad for the spherical mirror M_1 or M_2 and 0.5 μrad for the plane grating) were considered [1].

The energy resolution on this beamline was experimentally tested by examining the core-level photoabsorption spectroscopy of several gases obtained by recording photo-ionized ion currents. The Ne 1*s* spectrum is shown in Fig. 2. The entrance and exit slits were set to 30 μm and 15 μm, respectively. The 1*s* - 3*p* transition at 867.12 eV has a FWHM of 265±3 meV. This value is slightly better than the former best value of 268±5 meV obtained at ELETTRA [3]. The instrumental resolution is estimated from the least-squares fit by assuming that an observed spectral peak shape is the result of the Lorentzian natural line function (FWHM: Γ_L) convoluted by the Gaussian monochromator resolution (FWHM: Γ_G). The fitted curve in Fig. 2 is obtained with the optimized parameters of Γ_L = 246 meV and Γ_G = 62 meV. Both of the two values are smaller than those reported thus far, illustrating the superior performance of this monochromator when

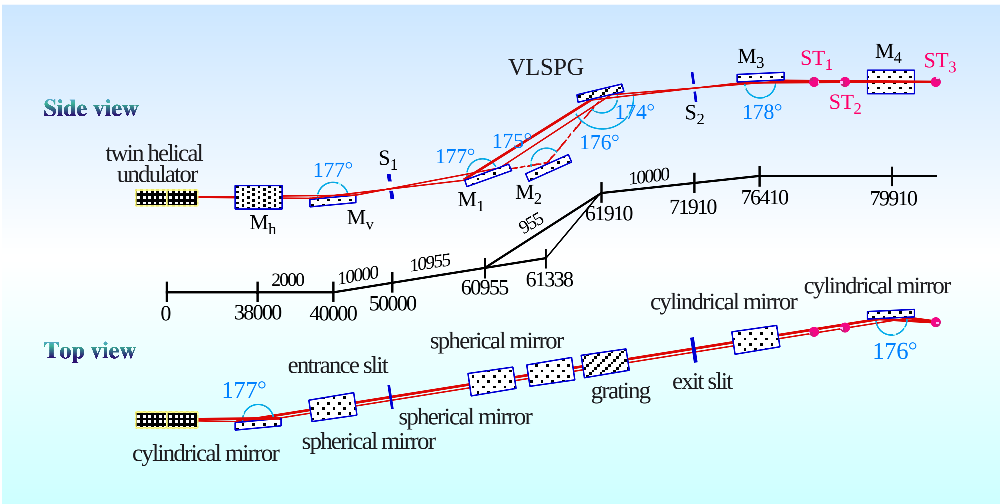

Fig. 1. Optical layout of beamline BL25SU.

compared to its competitors. The highest resolution to date was attained by second-order diffraction from a grating with 1200 lines/mm groove density [3], while our data was obtained by first-order diffraction from a grating with 600 lines/mm groove. This increased diffraction efficiency allows for a higher flux at experimental stations.

To further analyze the monochromator resolution, we measured a photoemission spectrum near the Fermi-edge of an evaporated Au film at hν = 867.6 eV using a GAMMADATA-SCIENTA SES-200 analyzer. Total system resolution (Γ_t) of 80±5 meV was obtained following fitting analysis (Fig. 3). The energy resolution of the electron energy analyzer using the same entrance slit and pass energy was found to be 58 meV upon measurement with He I (hν= 21.2 eV) radiation. This spectral analysis indicates an estimated monochromator resolution (Γ_d) of 52 ±10 meV. We can conclude, therefore, that resolving power (E/Δ E) about 15,000 is achieved at ~867 eV in our monochromator.

We have also obtained high-resolution spectra in the lower hν range such as the *K* absorption of N_2 (~400 eV) and O_2(~540 eV). These spectra were found to be of equal or higher resolution than any formerly published results.

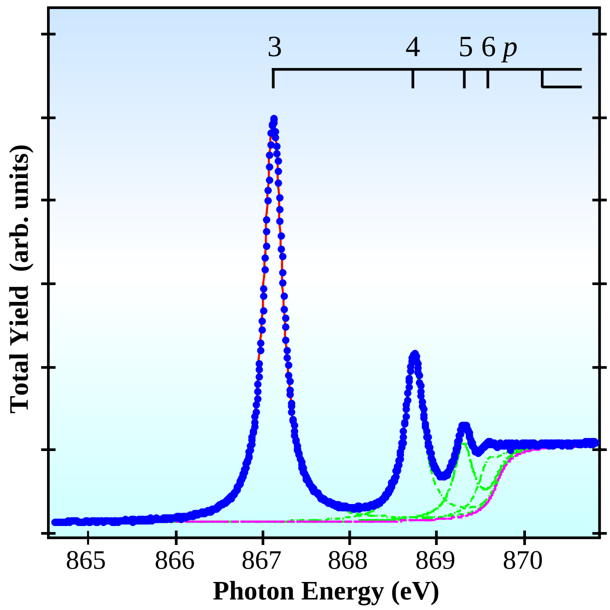

Fig. 2. 1s photoabsorption spectrum of Ne gas.

High stability of all optical components, an essential condition for high-resolution functioning of the monochromator, was maintained due to the low heat load from the helical undulators.

The typical value of the photon flux was about 1×10^{11} photons/sec at 870 eV with the resolution of 10^4 in the first harmonic for the upstream undulator radiation.

Due to the consistency and quality of these preliminary performance assessments, various experiments of high-resolution bulk sensitive photoemission as well as core absorption magnetic circular dichroism are being performed intensively on this beamline.

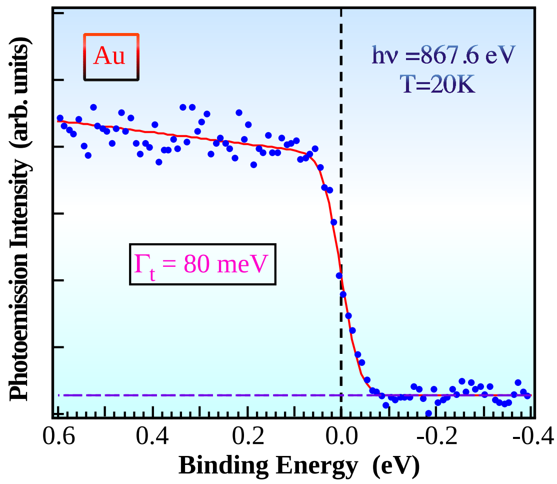

Fig. 3. Photoemission spectrum near the Fermi energy of Au.

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References

[1] Y. Saitoh *et al.* , J. Synchrotron Rad. **5** (1998) 542.
[2] T. Hara *et al.*, J. Synchrotron Rad. **5** (1998) 426.
[3] M. Coreno *et al.*, Phys. Rev. A **59** (1999) 2494.