3 The ISSP Beamlines

The Synchrotron Radiation Laboratory at the Institute for Solid State Physics (the University of Tokyo) supervises three beamlines at the Photon Factory - BL-18A, 19A, and 19B. At these beamlines users perform angle- and spin-resolved photoemission spectroscopy, X-ray absorption spectroscopy, and X-ray emission spectroscopy. In 2007, we made progress in developing the instrumentation at the end-stations of BL-18A and BL-19A.

3-1 Extending the Photoemission Measurement System at BL-18A, SCAD-600

Beamline 18A covers the photon energy range $h\upsilon$= 15~170 eV, and is dedicated to photoemission experiments to investigate the electronic structures of surfaces of metal and semiconductor crystals as well as those adsorbed by atoms and molecules. In order to respond to various demands from users, in 2007 we extensively developed the measurement system. At the end-station, two-types of angle-resolved photoemission spectrometers are now available in the same UHV chamber. One is a hemispherical analyzer (VG Scienta SES-100), mounted on a rotational flange so that users can make extensive k_x,k_y,k_z-band mapping and k_x,k_y,k_z Fermi surface mapping with high energy and angular resolutions ($\Delta\theta<0.2°$ and ΔE=2.2 meV). The position of the analyzer is controlled using a linear transfer mechanism, to be compatible with the other spectrometer (VG ADES500) which is movable in the same UHV chamber. With this second analyzer one can also make polarization-dependent and constant incident angle photoemission measurements to determine the symmetry of the initial wave function. The combination of the VG Scienta SES-100 and VG ADES-500 is named SCAD-600, and provides a scad (a lot) of measurement possibilities for angle-resolved photoemission spectroscopy.

3-2 Development of a High-Efficiency Spin-Polarized Photoemission Spectrometer at BL-19A

The undulator beamline 19A covers the photon energy range $h\upsilon$=20-250 eV, and is dedicated to spin- and angle-resolved photoemission experiments to investigate the spin and electronic structures of surfaces and films with magnetism or large spin-orbit interactions. Usually, beamline end-stations for such studies use Mott-type spin polarimters for spin-resolved photoemission experiments. However here we use a new high-

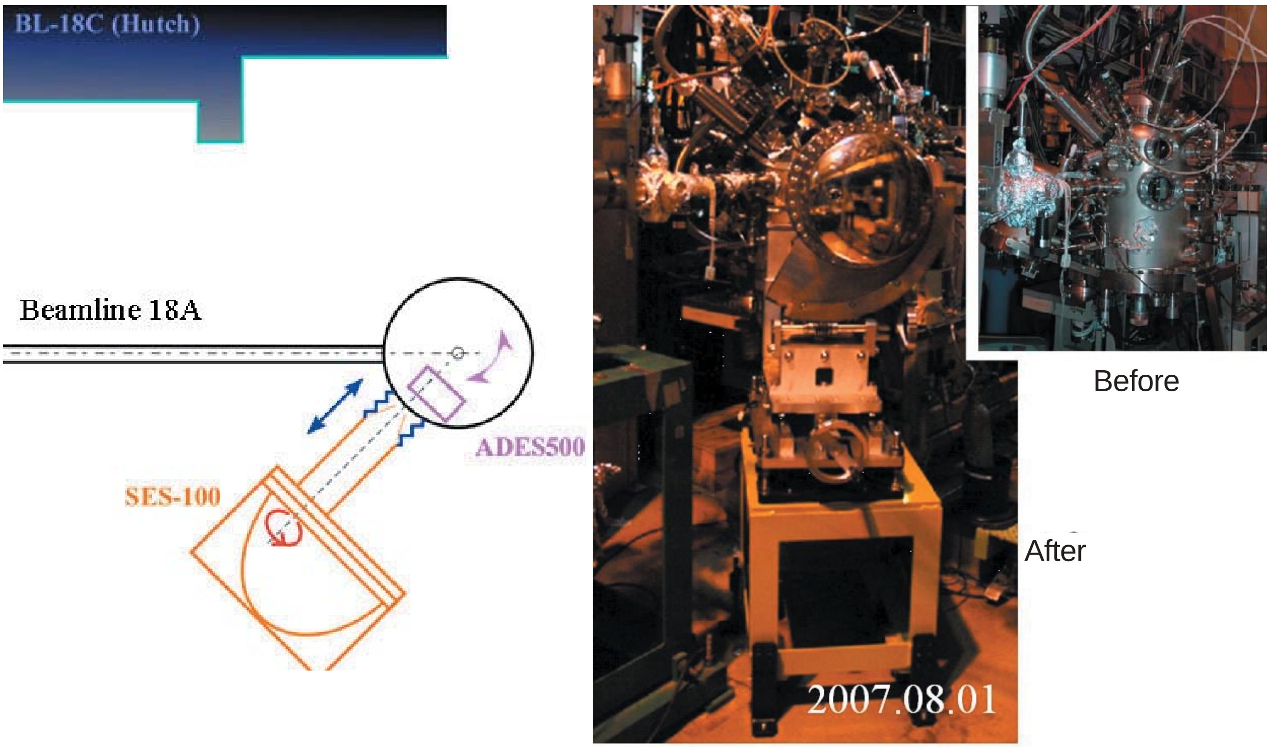

Figure 1
Conceptual drawing, along with photographs before and after the installation of the high-resolution electron analyzer, rotational flange, and linear transfer mechanism (SCAD-600) at BL-18A.

yield spin detector making use of the electron exchange interaction through very low energy electron diffraction (VLEED) of electrons at a ferromagnetic target such as Fe. Such a VLEED-type detector has, in principle, significantly higher spin-resolving power than the Mott detector. However, its usage has been unpractical due to rapid degradation of the target surface during experiments. In 2007, our group members Dr. Taichi Okuda and Mr. Yasuo Takeichi succeeded in preparing a ferromagnetic Fe crystal surface covered with a single-oxide layer. They found that the target stably had significantly high spin-resolving power with a very long life time compared to conventional Fe targets. Furthermore, the efficiency was approximately 100 times higher than that of the Mott detectors. By connecting their detector to a high energy resolution electron analyzer (PHOIBOS 150, SPECS GmbH), they examined the systematic performance as a spin-polarized photoemission spectrometer. In commissioning, they demonstrated the highest performance (high stability, high energy resolution and high spin yield) in the world. The spin-resolved photoemission spectra were obtained with $\Delta E<30$ meV, and the measurement was almost 100 times faster than that with the conventional Mott detector. The potential of this high efficiency, high energy-resolution spin-polarized photoemission spectrometer will definitely reveal new properties of spin and spin-current states in condensed matters.

REFERENCES

[1] T. Okuda, Y. Takeichi, Y. Maeda, A. Harasawa, I. Matsuda, T. Kinoshita and A. Kakizaki, *Rev. Sci. Instrum.,* **79** (2008) 123117.

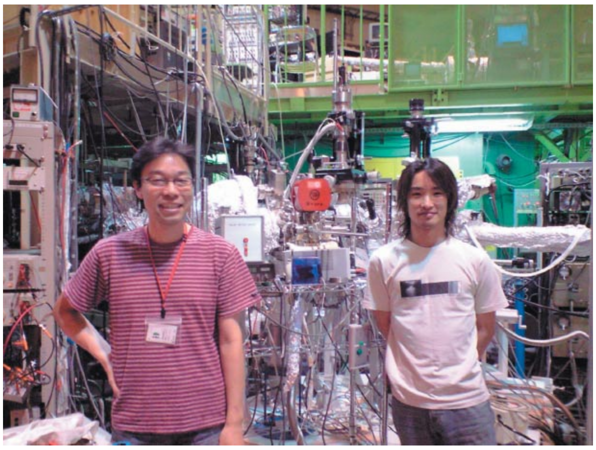

Figure 2
Inventors of the high-efficiency spin-polarized photoemission spectrometer, Dr. Okuda and Mr. Takeichi, at BL-19A.

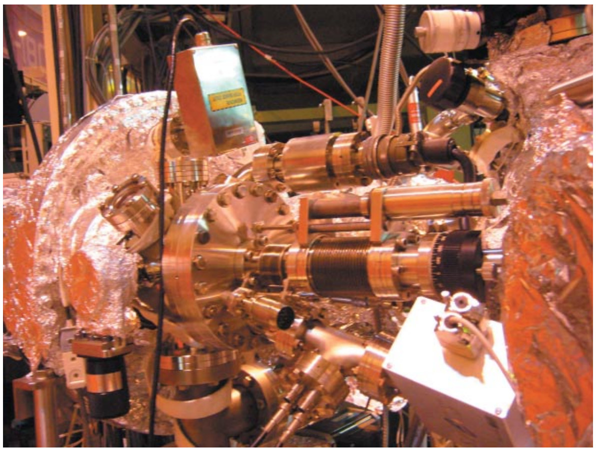

Figure 3
Our homemade VLEED spin-polarimeter combined with a high-resolution hemispherical analyzer.