SPring-8 BL25SU Evaluation Report

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1. Preface

This report describes the evaluation of the SPring-8 beamline BL25SU, on the basis of materials submitted to the SPring-8 BL25SU Evaluation Committee, a comprehensive report at the committee meeting held on October 28 and 29, 2003, inspection of facilities, the Beamline Report, and subsequent discussions among committee members. When drafting this report, we referred to the written evaluation by C. T. Chen who was unable to attend the committee meeting.

2. Beamline and experimental devices

○ Beamline

The beamline is one of the world's best soft X-ray beamlines, which covers photon energy region of 220 - 2000 eV, connected to a third-generation synchrotron radiation source. There are several points to be improved to realize better beamline performance such as reduction of energy drift by the water cooling of optics; whereas, the beamline has already attained excellent performance which exceeds design values of the monochromater resolution and other specifications. Users are allowed to replace diffraction gratings, mirrors, and other elements by themselves so that the beamline is ease of use. With a twin helical undulator, the beamline has recently enabled polarization switching at 10 Hz. The beamline provides distinctive synchrotron-radiation soft X-rays at world-class level. We can expect future developments in such a beamline.

○ Experimental devices

The experimental device for photoelectron spectroscopy has a high resolution of 80 meV at 860 eV, and enables bulk-sensitive high-resolution experiments in photoelectron spectroscopy. A user support system is well provided.

The MCD experimental device originally used a system which inverted polarity by moving a permanent magnet (with a fixed magnetic field of 1.4 T). It has recently become possible to use the twin helical undulator for polarization switching. Movement of the samples due to the eddy current during the magnetic pole inversion in the former permanent magnet system is now avoided in the polarity switching system. The porality switching also is estimated to shorten the measuring time to approximately one-third. We can expect high precision and efficient measurements for higher quality of research results. As part of the five years Nanotechnology Support Project, which has been commenced by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in fiscal 2002, introduction of an electro-magnet has enabled users to apply a magnetic field of up to 1.9 T. It is possible to measure element-specific magnetization in a variable-intensity magnetic field.

The display type two-dimensional photoelectron analyzer is used in the station for experiments of photoelectron diffraction and imaging based on the photoelectron diffraction. However, as substantially only one group conducts such experiments, the two-dimensional photoelectron spectroscopy experimental station has a lower rate of operation than other experimental devices.

3. Research results

Regarding the BL25SU, 67 papers have appeared in refereed journals. Number of invited talks, which are given by the users on their experimental results at this beamline in the international conferences, is large enough. Twelve papers regarding the BL25SU appeared in scientific journals that have an impact factor of three or more. Approximately two-thirds of the 67 papers appeared in scientific journals that serve as proceedings of international conferences. This indicates that activity in international conferences is high enough. At the same time, however, it must be noticed that the first reports are remarkably few.

○ High-resolution photoelectron spectroscopy

Success of bulk-sensitive high-resolution photoelectron spectroscopy at high excitation photon energy (approximately 1 keV) is a remarkable result. This research result is highly appreciated not only because the research solves the problem to distinguish the electronic states of bulk from those of surfaces in materials with strongly correlated electron system, but also because the research pioneers application field of soft X-ray for the photoelectron spectroscopy, which has not been intensively conducted.

○ MCD

Excellent research results have been produced from experiments on bulk magnetic substances, non-magnetic substances, magnetic thin-film, and other materials.

Magnetic anisotropy study of nickel thin-film, using photoemission electron microscope (PEEM) images of the spin reorientation, is one of the most important results in this station.

○ Display type two-dimensional photoelectron analyzer
The display type two-dimensional photoelectron analyzer has been developed on the basis of original idea of H. Daimon, and successfully provided stereomicroscope images of atomic arrangement. This pioneer contributed to public relations because the research results are easy to understand.

4. Support for public use
○ The beamline is well equipped with hardware utilities. As part of the Nanotechnology Support Project, the staff has recently been increased so as to strengthen the technical support system for each of experimental devices associated with the beamline. In order to maintain high research activity, it is desired that a permanent support system for experiments is established so that the present support system will not be diminished even after the Nanotechnology Support Project ends.

○ There are a large number of applications for the available beam time. The BL25SU has a lower adoption rate of approximately 50% than other beamlines. The limited beam time is allocated to users on the Nanotechnology Support Project subjects, users on long-range subjects, and the public users on selected subjects. Such sharing causes chronic beam time shortage. At present, it is difficult to carry out new research that requires relatively longer beam time, and to continue a high level of improvement in the beamline. In addition, such sharing may lead to the support staff's overwork, and to inferiority of research results. It is necessary to divide the beam time carefully, and consume it more efficiently.

5. Experimental devices and future of research
Trends in the beamline research development may include angle resolved XPS (X-ray photoelectron spectroscopy) based on bulk-sensitive photoelectron spectroscopy, improvement in experimental accuracy of bulk-sensitive photoelectron spectroscopy, widening of the MCD sample temperature range to low temperature (10 K or lower), an increase in research subjects due to the intensification (5 T or more) of the applied magnetic field, intensive promotion of photoelectron energy microscope experiments using high brilliance and low emittance, and taking positive steps to apply two-dimensional photoelectron spectroscopy to materials science. However, because the beamline has four experimental devices in tandem arrangement, it is difficult to develop new experimental devices such as equipped with MBE and/or PLD facilities to prepare samples. Because the two-dimensional photoelectron spectroscopy experimental

device has a lower utilization factor than other experimental devices, it is necessary to develop new applications especially for this station, and to discuss whether or not it should be connected to the shared beamline.

At present, there are not enough resources to satisfy the need for soft X-rays. In order to solve the present problem, systematic sharing of the entire soft X-ray beamline at the SPring-8, and construction of new beamlines are strongly desired.

6. Summary

This beamline is one of the world's highest-performance soft X-ray beamlines located at the third-generation synchrotron radiation source facilities. The BL25SU produces distinctive and excellent research results in soft X-ray science. Users should publish original papers regarding BL25SU research results, and take positive steps to contribute to scientific journals that have a high impact factor.

In order to increase subjects of research using this beamline, and to produce high-quality research results, it is necessary to improve the sample-preparing device. Improvements include widening of the variable sample temperature range, improvement in vacuum quality, and provision of surface evaluation equipment. Because the beamline has four experimental devices in tandem arrangement, it is difficult to develop new experimental devices and to equip the beamline with sample-preparing devices.

In order to satisfy the need for synchrotron-radiation soft X-rays, it is necessary to share systematically the entire soft X-ray beamlines at the SPring-8. At present, in Japan, there are not enough resources for soft X-rays. To solve the present problem, construction of new beamlines is strongly desired.