SPring-8 BL13XU Review Committee Report
on
Surface and Interface Structures
(BL13XU)

Report for Director General of
Japan Synchrotron Radiation Research Institute

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1. Introduction

This review committee meeting was held on October 30 and 31, 2006 at SPring-8. The committee members received the "Beamline Report BL13XU (Surface and Interface Structures)" and "SPring-8 Overview 2006," and submitted individual reports before the meeting. Over the two days, domestic members attended the meeting. The meeting began with JASRI's guidance on the beamline review, followed by their presentation on the overview of the SPring-8 facility and a tour of the BL13XU beamline. After the tour, the committee received explanations of the beamline facilities, research outcomes and future plans from the beamline staff, followed by a question-and-answer session. The report was compiled on the basis of discussion among the domestic members and the reports from Professor Sinha and Professor Zegenhagen.

2. Technical Status of Beamline and Experimental Facilities

* Evaluation

The Surface and Interface Structures (BL13XU) beamline is made up of the following components: an in-vacuum undulator of the standard SPring-8 type, a liquid-nitrogen-cooled Si 111 monochromator and a pair of mirrors for horizontal focusing. Stable X-ray beams were strongly requested for the following two reasons: one is that the heat load on the optics varies with each user's experiment since a different user uses a different wavelength of incident X-rays, and the other is that the experiment usually measures a few hundred weak X-ray diffraction spots from the surface or interface of a sample. For this, a temperature stabilizer has been installed at the second crystal of the monochromator and an X-ray position stabilizer with a feedback system has been installed into the beamline. Public-use instruments are 1) a large X-ray diffractometer and three ultrahigh-vacuum (UHV) chambers for surface structure analyses, 2) a high-precision multiaxis diffractometer for the structural analyses of thin films and the interface in a liquid, 3) a two-axis diffractometer using X-ray microbeams for crystal distortion measurements of a local area of a sample, 4) a compact imaging-plate-based X-ray camera for obtaining X-ray reciprocal-lattice-space images of a buried interface and 5) a commercial diffractometer for thin-film analyses.

The BL13XU beamline is evaluated highly since unique outcomes have been achieved using the various instruments mentioned above.

*Recommendations

(1) The beamline staff should continue to upgrade the optics, although the current performance is sufficient for users' experiments. The installation of a refractive lens deserves further consideration since X-ray flux is expected to be enhanced by three orders.

(2) Considering the small number of beamline staff, it is difficult to operate the five instruments. For example, JASRI should consider whether the commercial diffractometer for thin-film analyses, mainly used by industrial users, is needed.

(3) One of the characteristics of this beamline is that three UHV chambers are available for users' experiments. Regarding the UHV chamber system, the committee recommends that the beamline staff should consider upgrading the system on the basis of their experience. For this upgrade, the staff should design the system together with experienced users and establish an efficient environment for surface and interface preparation, so as to contribute to more efficient beamline operation. Two UHV chambers are sufficient for the second system.

(4) The high-precision four-axis diffractometer is evaluated highly since sample cells have been developed for various purposes. For further development, APD and two-dimensional X-ray detectors should be provided.

(5) A multilayer monochromator should be considered for flux-oriented experiments.

3. Research Activities

*Evaluation

Significant research outcomes have been achieved at BL13XU, considering the small number of staff.

Noteworthy outcomes include the following studies: 1) the structural analysis of water molecules on a metal surface by Nakamura *et al.*; this study is evaluated highly as an example of the successful determination of the two-dimensional structure of light atoms on a heavy metal, 2) the structural analysis of indium atoms on a silver surface by the Ariga group and Sakata; this study showed that the two-dimensional phase transition is Ising-like, 3) the structural study of a buried interface by Sakata *et al*., 4) the development of a transmission X-ray diffraction technique for surfaces by Tajiri *et al*. It has taken some time to begin producing experimental data since some of the special apparatuses required for surface and interface analyses had to be assembled. The assembly of the apparatuses has now been completed and the number of research outcomes has started to increase. Considering the papers currently submitted or in preparation, the number of publications is expected to increase further.

*Recommendations

(1) More potential users involved in frontier research should be invited to this beamline.

(2) More scientists who can review proposals involving X-ray diffraction and scattering should be appointed to the program review committee and as reviewers.

(3) Both of the in-house staff who specialize in X-ray diffraction and scattering, and surfaces and interfaces, are needed.

(4) JASRI should consider moving some research activities, such as GISAXS in the second hutch, to another beamline, since the activities in BL13XU are too diverse.

4. Public-use Support System

*Evaluation

Users have been supported well, considering the small number of beamline staff.

*Recommendations

(1) About five staff members are needed for the BL13XU beamline since the research aims are diverse and many instruments are installed. For the main instrument, which prepares surfaces or interfaces, one staff member is needed to operate and develop the instrument. Two skilled staff members are needed to operate, maintain and upgrade the diffractometers. Two technical staff members are needed to help the three staff members.

(2) An increase in the number of staff is also needed to attract potential users.

(3) The beamtime per accepted proposal should be increased.

(4) The existence of three hutches is helpful for efficient beamline operation. More efficient use of the second experimental hutch (EH2) should be considered in the future.

5. Instrumentation and Research in Future

*Evaluation

More diverse ideas seem to be needed for future use of the beamline.

*Recommendations

(1) The two-dimensional structural analysis of light atoms on a solid surface should be developed further since some pioneering studies, such as the study of a water monolayer, have started to be published. This will help to increase the presence of SPring-8 in the field of surfaces and interfaces.

(2) New techniques, such as real-time observation, should be developed with due consideration of recommendation (1).
(3) The aims of research should be extended to influential fields, such as high-k materials. For this, JASRI should provide staff and instruments.
(4) When JASRI considers the opportunities of inelastic X-ray scattering at this beamline, it should carefully proceed by considering its importance compared with other techniques to be developed and the possibility of its development at another beamline.
(5) Appropriate research targets should be fully considered for time-resolved experiments with a resolution of nanoseconds, since the experiment makes the best use of the characteristics of synchrotron radiation.
(6) Element-selective experiments should be developed since SPring-8 is able to lead in this research field.

6. Summary

It has taken some time to begin producing experimental data since some of the special apparatuses required for surface and interface analyses had to be assembled. The assembly of the apparatuses has now been completed and the number of research outcomes has started to increase. Considering the papers currently submitted or in preparation, the number of publications is expected to increase further.

Studies of surfaces using UHV chambers that make the best use of the characteristics of SPring-8 and studies of interfaces that are only accessible to X-ray diffraction should both be extensively developed as the main areas of research at BL13XU.

If the number of staff could be increased, they should be assigned to developing the beamline facilities for the expanding research fields that will be important in the future. For example, the analyses of liquid surfaces and soft matter are important for developing new fields. If the BL13XU beamline continues to be managed with the current number of staff, the range of research fields should be reduced.