JAERI BL11XU

Hideaki SHIWAKU
Taikan HARAMI
Yoshinori KATAYAMA
Tatsuo FUKUDA
Masamitsu TAKAHASHI

1. Beamline

JAERI beamline Ⅲ (BL11XU) for material science using synchrotron radiation from an insertion device has been designed and is now being constructed.

The insertion device of this beamline is a standard in-vacuum type linear undulator with source characteristics of lu=32mm, N=140, tunable energy range 5~70 keV using first, third and fifth harmonics X-rays, and linear polarization.

Almost all of the beamline components are standard at SPring-8 for the X-ray undulator beamline, but two future experimental spaces and the focusing instruments' space are prepared upstream and downstream of the monochromator. X-rays monochromatized $\Delta E/E = \sim 10^{-4}$ by the Si double crystal monochromater is led to the experimental stations. Fig.1 shows the layout of the beamline hutches. It consists of one optical hutch and three experimental hutches. It will be commissioned in September 1998.

2 Experimental Stations

We have mainly developed four experimental plans for this beamline. Details are as follows.

2.1 Mosbauer Spectroscopy

To conduct an experiment on inelastic scattering and microscopic spectroscopy using nuclear resonant scattering, high precision goniometers and versatile goniometers are equipped on a vibration-proof table and are be smoothly moved by air pads.

2.2 High -pressure Science

For high-pressure/high-temperature studies, a large volume multi-anvil type high-pressure apparatus, SMAP180, can be installed in experimental hutch 1. The press is currently installed in optics hutch 2 on BL14B1. It will be used in both beamlines. The accessible pressure and temperature ranges are up to 15GPa and 1500K, respectively. Research plans includes (1) angle-dispersive X-ray diffraction studie of pressure-induced structural changes, especially those in liquid states of light

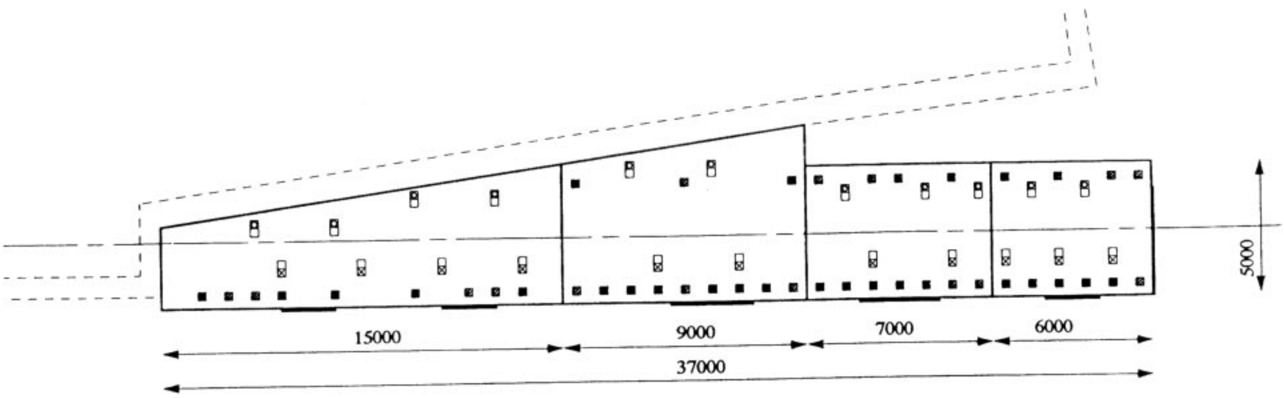

Fig. 1: Layout of beamline hutches.

elements and those accompanying non-metal to metal transition, (2) density measurements of liquids and glasses by means of x-ray absorption, and (3) high-pressure/high-temperature XAFS (XANES) measurements. Bright X-rays are essential for those studies because (1) sample volumes are very small, (2) short data acquisition time is desirable since it is difficult to keep samples stable under extreme conditions for a long time, and (3) accurate intensity determination of diffraction (absorption) profile is needed for structural studies of non-crystalline materials. Using X-rays from an undulator source, reliable data can be obtained.

2.3 Surface Science (1)

Inelastic X-ray Spectrometer

In the design of the second experimental hutch, an inelastic X-ray spectrometer will be installed. The medium energy resolution (≥20meV) is designed for extreme sample conditions; high magnetic field by superconducting magnet, low temperature by dilution refrigerator and high pressure with diamond anvil. Experiments will be carried out under not only one but also under combinations of these extreme environments.

A nested or dispersive channel-cut monochromater will be set in front of the spectrometer to obtain medium energy resolution. After that, a phase shifter will be installed to make the scattering plane horizontal so that heavy equipment (superconducting magnet, dilution refrigerator, etc.) can be held easily. At the analyzer stage, a spherical bent crystal was used in the nearly backscattering geometry to achieve medium energy resolution by sacrificing of **q** resolution. Moreover, we are considering placing a mirror in front of the spectrometer to focus the X-ray beam horizontally at the sample position, and to eliminate higher harmonic components.

2.4 Surface Science (2)

The third experimental station of BL11XU is being designed for surface X-ray diffraction (SXD) study on compound semiconductor surfaces. In spite of the industrial importance of the compound semiconductor devices, the atomic-scale properties of growing surfaces in molecular beam epitaxy (MBE) conditions remain elusive. Structural information given by the SXD technique will be very helpful for a detailed understanding of the MBE growth process.

The experimental apparatus consists of a horizontal axis diffractometer and an MBE chamber. The interface of the chamber and the diffractometer includes bellows and a rotary feedthrough with a differential pumping system so as to transmit the precise motions of the diffractometer to the sample in a vacuum.

Figure 2 shows a schematic of the diffractometer. This is a (2+2) diffractometer [1] that has two axes (ω and α) for orienting the sample and two axes (δ and γ) for positioning the detector. On the detector arm a detector slit that can be rotated about the normal of the slit plane is mounted as shown in fig. 3 [2,3]. With the help of the rotational slit, this diffractometer works in tne same way as the z-axis diffractometer. The sample is attached to the w circle via the sample positioning system shown in fig.4. Three translational (x, y, z), one tilting (χ) and one rotaional (ϕ) motion allow the sample to be

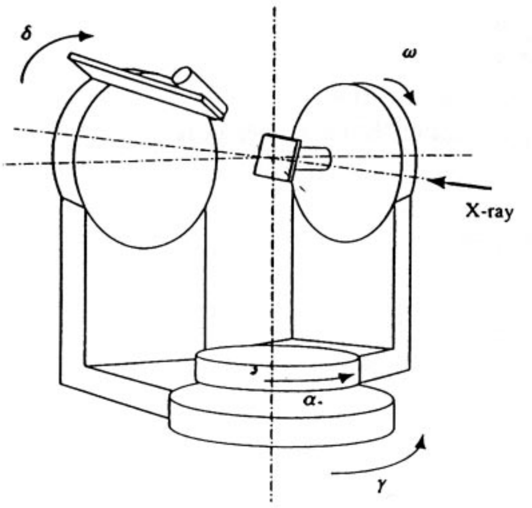

Fig. 2: Schematic of diffractometer.

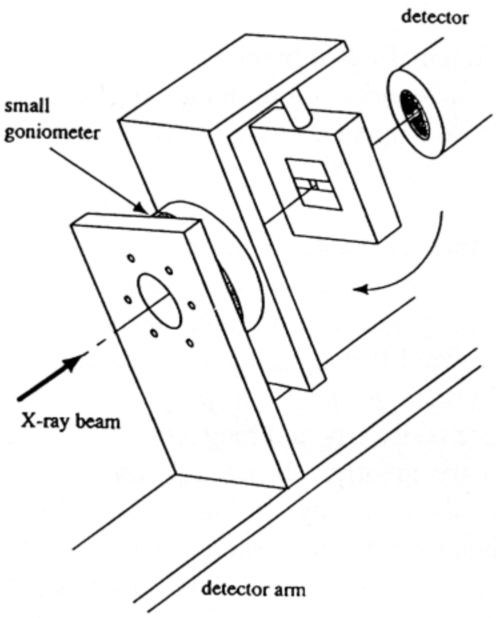

Fig. 3: Illustration of the rotational slit mounted on detector arm.

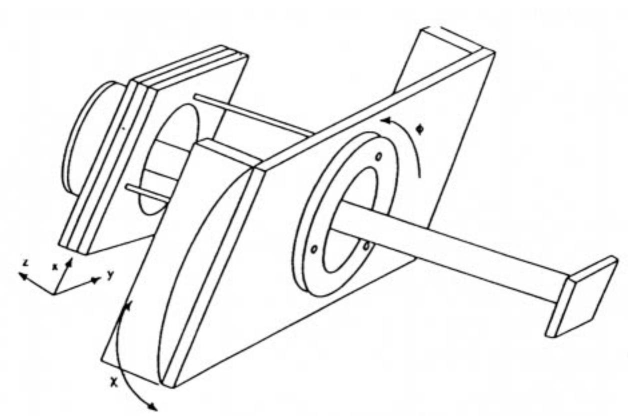

Fig. 4: Sample positioning system attached to ω-circle.

located at the center of the diffractometer and adjusted so that the surface normal coincides with the w-axis. The whole setup is aligned with the incident beam using two translation stages along the two directions perpendicular to the incident beam.

The MBE chamber is composed of a measurement chamber and a sample loading chamber. The measurement chamber is equipped with a Be window and an MBE facility for growing III-V semiconductors, which allows in situ SXD study on growth surfaces.

References

[1] K. W. Evans-Lutterodt and M. T. Tang, J. Appl. Cryst. 28 (1995) 318.
[2] M. Takahashi and J. Mizuki, J. Synchrotron Rad. to be published.
[3] E. Vlieg, J. Appl. Cryst. to be published.

Contributing members:

Hideaki Shiwaku (person in charge), Hiroyuki Konishi, Motoharu Marushita, Takaya Mitsui, Shinji Kitao, Haruhiko Motohashi, Yoshihiro Asano, Masamitsu Takahashi, Kentaro Suzuya, Takeshi Emoto, Yasuhiro Yoneda, Norimasa Matsumoto, Tatsuo Fukuda, Toshiya Inami, Yasuo Nishihata, Yukio Hayashi, Yoshinori Katayama, Jun'ichiro Mizuki, Taikan Harami, and Osamu Shimomura.