WEBRAM (BL15XU)

1. Introduction

Research on advanced materials using synchrotron radiation was started by NIRIM (National Institute for Research in Inorganic Materials, Science and Technology Agency, Japan) as a research project called "research on ultra-precise materials analysis using third-generation light source" in the 1997 fiscal year. The contract beamline at SPring-8 is an important part of this project and was constructed to actively promote the project. This contract beamline was designed to provide wide use for advanced substance/materials and was the most important determiner of the success or failure of the project. It was installed in the 1998 fiscal year for a period of two years.

2. Outline

The formal name of the contract beamline is Wide Energy Range Beamline for Research in Advanced Materials (WEBRAM). The outline of the beamline is shown in Fig.1, and the overall is about 69.5 m.

The concept of WEBRAM is "wide, bright and simple". Monochromatic photon flux ($\Delta\lambda/\lambda \cong 0.01$ %) on sample can be obtained from 0.5 keV and 60 keV at about 10^{13} photon/s based on the concept of wide energy. Minimum photon energy 0.5 keV is nearly equal to the *K* absorption edge of the oxygen, and the maximum 60 keV covers *K* absorption edge of almost all the rare earth elements. This beamline consists of only slits and monochromator. The structure is simple and the extracted beam axis is kept constant. It is now possible to carry out the following tasks in substance / material research such as analysis of atomic arrangement (10~20 keV highly monochromatic photons for crystal structure analysis *etc.*) and analysis of atom configuration and electronic structure (0.5~2 keV for photoelectron spectroscopy of valence electron, 0.5 ~60 keV for XPS, XAFS). This is very advantageous for experiments using special test equipment for analyzing material behavior under extra-high pressure.

The beamline has two instrumental features. One is the insertion device as a high-brightness monochromatic light source in the wide energy region. In WEBRAM, the revolver type undulator is adopted. In the early stage, in-vacuum revolver type undulator was investigated. This type of undulator has two sets of magnet columns and turret cylinders, all of which are in the vacuum tank connected to the storage ring. However, this type of undulator was found to have difficulties in handling, maintenance, change operation of magnet columns, and so on. On the other hand, by 1998 much progress had been made in the technology, which was sufficient for the demands of WEBRAM with the out-of-vacuum type, and subsequently the specifications were fully determined.

The other important feature is the 1st stage monochromator system for WEBRAM, it is necessary to monochromatize the high-brightness light with a wide range of 1~60 keV, to the level of $\Delta E/E$~10^{-3} or less (10^{-4} or less for structure analysis). Therefore, several crystal monochromators are used according to the energy region. Until now, only a grating monochromator could be used for the high brightness light in the 1~2 keV region. In this region, we adopt YB_{66}, which is a highly thermostable optical crystal that NIRIM originally developed. It is the first attempt in the world that the crystal is used as the monochromator of a third-generation light source. This involves monochromatization of the region over 2 keV by modifying the rotating tilt type monochromator, which is the SPring-8 standard for the wide energy band. The optical systems (the W/B_4C multilayer mirror for the rough monochromatization of 0.5~1 keV photons uses the same mount as the monochromator of YB_{66}) of these two sets are combined in one enormous spectroscopic system of about 7 tons gross weight and installed in the optical hutch. Confirming the performance after installation will require several years of R&D.

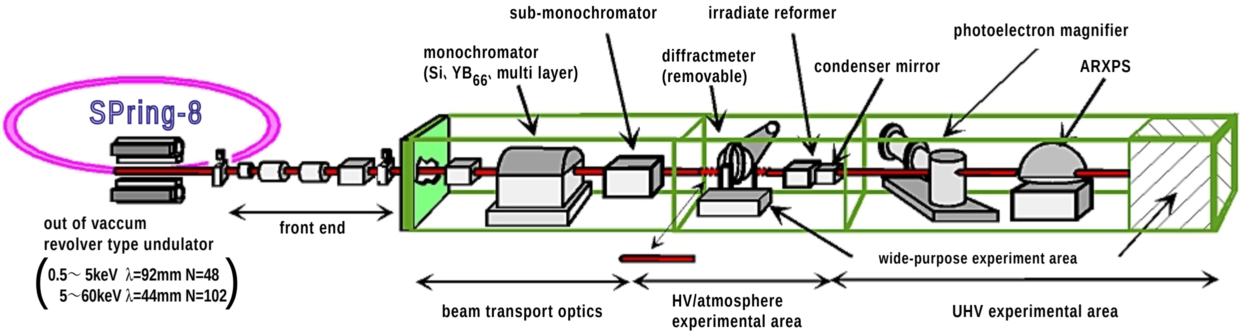

Fig. 1. Outline of WEBRAM.

The support monochromator is used to get highly monochromatic light ($\Delta E/E \sim 10^{-3}$) at 0.5~1 keV region. This is utilized in the ultra-high-vacuum experimental area and installed downstream in the farthest part of the optical hutch.

The experimental hutch is divided into two regions: a high-vacuum and atmospheric experimental area in the upstream part and an ultra-high-vacuum experimental area in the downstream part. High-precision powder X-ray diffraction equipment and other components are installed in the high-vacuum atmosphere experiment area in the upstream. The X-ray diffraction equipment needs not be fixed. It can be changeable to simple pipe when the ultrahigh-vacuum experimental area is used. Therefore, this part also plays the role of a wide-purpose experimental area.

The chamber for X-ray irradiation experiments and the condenser mirror are installed downstream. The condenser mirror is installed for the high-resolution photoelectron microscope.

Angle-resolved photoelectron spectroscopy equipment and a high resolution photoelectron microscope are installed in the ultrahigh-vacuum experimental area. The equipment to be installed in the wide-purpose experimental area in the farthest part of this hutch will also be formally decided this year.

3. Present State of Construction

The construction of WEBRAM is to be completed in March 2000. In the following, the present status is briefly shown.

3.1 Revolver Type Undulator

The design has already been completed, and this component is ready for production. The installation will be finished in the beginning of September 1999.

3.2 Hutch

Shape, size, door and duct position of the hutch will be decided in March 1999, and verification by calculation of the radiation shielding is needed. The hutch is shown in Fig. 2. The optical hutch consists of the wall in the iron-lead-iron module, and the experimental hutch only consists of the steel plate. In May 1999 we will start the foundation work.

3.3 Front End

In the low-energy region, a revolver type undulator installed in WEBRAM operates as a helical type. However, it operates in the high-energy region as a conventional linear type. Therefore, it is unique as the part of the main mask in the front end. That is to say, two parts, one for the helical and the other for the linear types, have been installed as main masks. In WEBRAM, only on-axis radiation is used. Thus, the main mask for the helical type is installed before the one for the linear type. In addition, the beam position monitor (XBPM) installed upstream at the main mask is a special type to observe the off-axis radiation.

3.4 Beamline Components

Be window cannot be used because WEBRAM is used in the wide energy band. However, the high-vacuum (not ultrahigh) is sufficient for the 1st stage monochromator system in the optical hutch immediately after the shielding wall in consideration of production costs and maintenance. On the other hand, the ultra-high-vacuum is necessary in the downstream part of the experimental hutch, where several experiments of photoelectron spectroscopy

Fig. 2 Hutch of WEBRAM

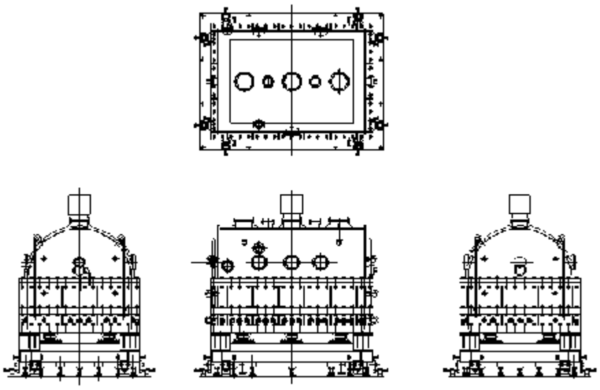

Fig. 3. Appearance of 1st stage monochromator.

will be carried out. Therefore, the differential evacuation system is used in two places, which is another feature of WEBRAM.

At the end of April 1999, all the design work will be completed. The 1st stage monochromator system is shown in Fig. 3. Installation is scheduled in the end of September.

The other components will be installed as soon as the hutch is completed.

3.5 Experimental Equipment

Among the experimental equipment shown in Fig. 1, the X-ray diffractometer and angle-resolved photoelectron spectroscopy equipment were completed during fiscal 1998 and await the installation of the beamline. The structure of the goniometer of this diffractometer is identical to that of the diffractometer at the BL4C of KEK-PF. Our diffractometer does not have a multiple-detection part. In the meantime, it has an arm for detector installation in which the moving range is very wide. The angle setting accuracy is confirmed as 0.005 degrees, and the reproducibility is also equivalent. This device is installed and has been temporarily operated in the experiment hall (Fig. 4).

The angle resolved photoelectron spectroscopy equipment, as shown in Fig. 5, was specially manufactured in order to complete the experiment of the coincidence spectroscopy. It is a spectrometer with two movable angle-resolved photoelectron spectroscopy systems for measurement that are independent of each other for one sample.

The FE-SEM (Fig. 6), infrared ray furnaces, RF magnetron sputtering system and other components will be installed in the future.

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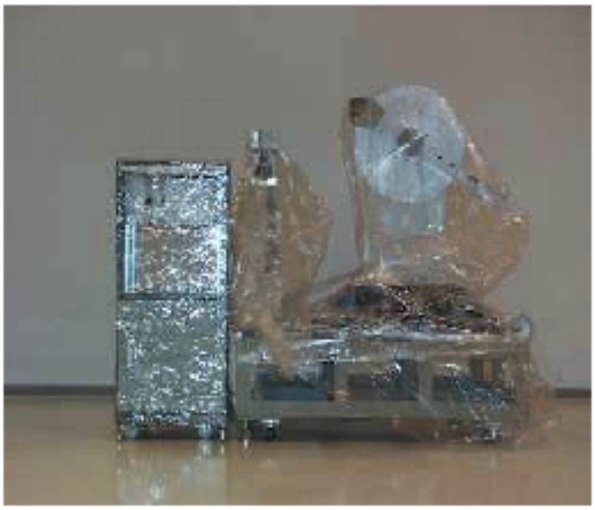

Fig. 4. Photograph of the X-ray powder diffractometer.

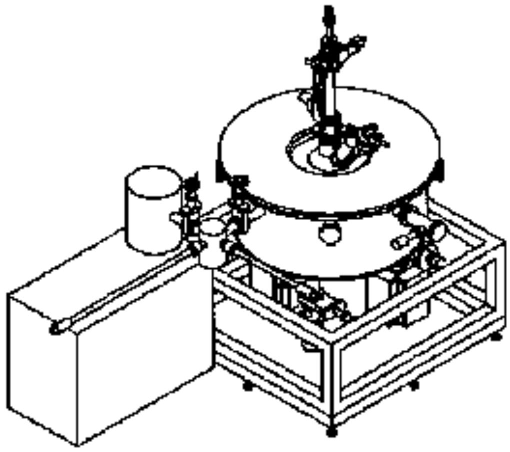

Fig. 5. Appearance of ARXPS.

Fig. 6. Photograph of the FE-SEM.