Hyogo BL (BL24XU)

Junji MATSUI
Yasushi KAGOSHIMA
Yoshiyuki TSUSAKA

1. Introduction

Hyogo prefecture is now promoting the progress of advanced sciences. Since 1992, it has been planned and discussed to posses a synchrotron beamline for material research and medicine at their own expense.This beamline is designed for conducting various experiments for the members of new material development team, minute protein crystal structure analysis team including bio crystallograhy and medical team which are organized by the Hyogo prefecture.

Employing a “figure-8 undulator” [1] which can provide both vertically and horizontally polarized hard X-rays, it is ex- pected that, at most, three experiments for different purposes can be simultaneously performed. Two double-crystal monochromators composed of diamond crystals (resembling the “Trichromator” system installed in BL45XU) are placed on the center of a white beam from the undulator to introduce monochoromatized X-rays to a protein crystal structure analysis hutch and a material characterization hutch. The latter hutch enables us *in situ* grazing incidence X-ray diffraction to observe atom arrangements during epitaxial growth using metal-organic chemical vapor sources. Therefore, a disposal system for exhausting gases will be completed.

Microbeam X-rays of less than 1μm^2 in size or plane wave X-rays will be developed in the last hutch aiming their application to the material research and the medical development including cancer inspection and therapy.

Experimental diffractometers, vacuum chambers or other measurement equipments except already installed ones must be brought mainly by the project teams mentioned above.

2. Specific Features of the Beamline

In order to obtain simultaneously both horizontally and vertically polarized X-rays, an invacuum-type “figure-8 undula- tor” was chosen as a light source. A number of periods and a length of pe- riod are 172 and 26 cm, respectively. The horizontal/vertical polarization can be obtained with integer/half-odd-integer harmonics. For the present case, the horizontally/vertically polarized X-rays with the photon energy of 9.6/14.4 keV at 1st/1.5th harmonics are going to be used.

The beamline is designed to have an optical hutch and three experimental hutches (A,B,C) as shown in Fig.1. The optical hutch has a length over 30 m, which is very huge in comparison with the usual optical hutches. All beamline components will be installed in the optical hutch.

Two hutches (A and B) are for experiments with monochromatic X-rays, while the hutch C has two experimental modes of monochromatic and white X-rays. Two monochromators (A and B) adopt so called ”toroika” conception of the double crystal monochromator with diamond crystals, and therefore, three hutches can be used simultaneously. The two monochromators (A and B) are designed to have a 2 m horizontal offset distance in order to keep a sufficient working space in the corresponding experimental hutches.

The monochromator C is designed to have the mechanism with which the first crystal can be driven ‘on’ or ‘off’ beam axis position so that the experimental mode of ‘monochromatic’ or ‘white’ can be chosen. The detail specifications of the monochromators are under design.

Specifications of the beam at each experimental station are listed in Table. 1. Experimental hutches A, B and C are assigned from upstream to downstream of the beamline to each experiment described be-low.

3. Experimental Stations

Figure 1 is a plane view of the Hyogo Beamline located at BL24IN of SPring-8. The hutches A, B and C are called the crystal structure analysis station, the new ma-

Table. 1 Specification of the Beam at Each Experimental Station

	hutch A	hutch B	hutch C
Photon energy (keV)	14 (roughly fixed)	10 (roughly fixed)	20~50
Energy resolution (ΔE/E)	10^{-3}~10^{-4}	10^{-3}~10^{-4}	~10^{-3}
Beam size	1 mm^2	1 mm^2	1 μm^2
Photon flux (photons/s)	10^{10}~10^{11}	10^{10}~10^{11}	10^8

terial production station, and the medical application station, respectively.

3-1 Crystal Structure Analysis (Experimental Hutch A)

The aims of this station are to develop the techniques of structure analysis for macromolecular protein crystals of small size and to spread the analytical techniques to the industry.

X-rays with the energy of about 14.4 keV chosen from the 1.5th harmonic of the figure-8 undulator and collimated by a slit, illuminate a sample crystals set on a goniometer. Diffracted X-rays are detected by an imaging plate with a camera length ranging from 100 to 500 mm. The temperature of the sample crystals is controlled in the range of 100 to 330 K by a nitrogen gas blower. In order to fix the readout noise, the temperature in the station is preserved at about 290 K. The humidity is also kept less than 30% to avoid dew on the samples. For selection and manipulation of the sample crystals, a laboratory table and a microscope will be prepared in this hutch. This station is also equipped with a CCD camera for monitoring the sample crystals from outside of the hutch.

3-2 New Material Production (Experimental Hutch B)

From a view point of electronic device performance, it is important to investigate a relashionship between a surface/interface atom arrangement and device characteristics. In order to see how atoms are arranged during a real epitaxial growth of the materials, *in situ* grazing incidence X-ray diffraction is appropriate to an atmosphere of metal-organic chemical vapor. Surface and interface diffractions for AlGaAs/GaAs systems will be developed by the use of monochromatized X-rays with energy of about 9.6 keV (the 1st harmonic). Taking advantages of the anomalous dispersion, atom-specified (*e.g.* As, Zn, Se) surface diffraction will be performed in near future. Metal-Insulator-Semiconductor interface diffraction experiments will also be tried.

A grazing incidence X-ray diffractometer and an X-ray fluorescence spectrometer for metals and inorganic compounds are now under design to be installed in front of the epitaxial growth apparatus in this hutch.

3-3 Medical Applications (Experimental Hutch C)

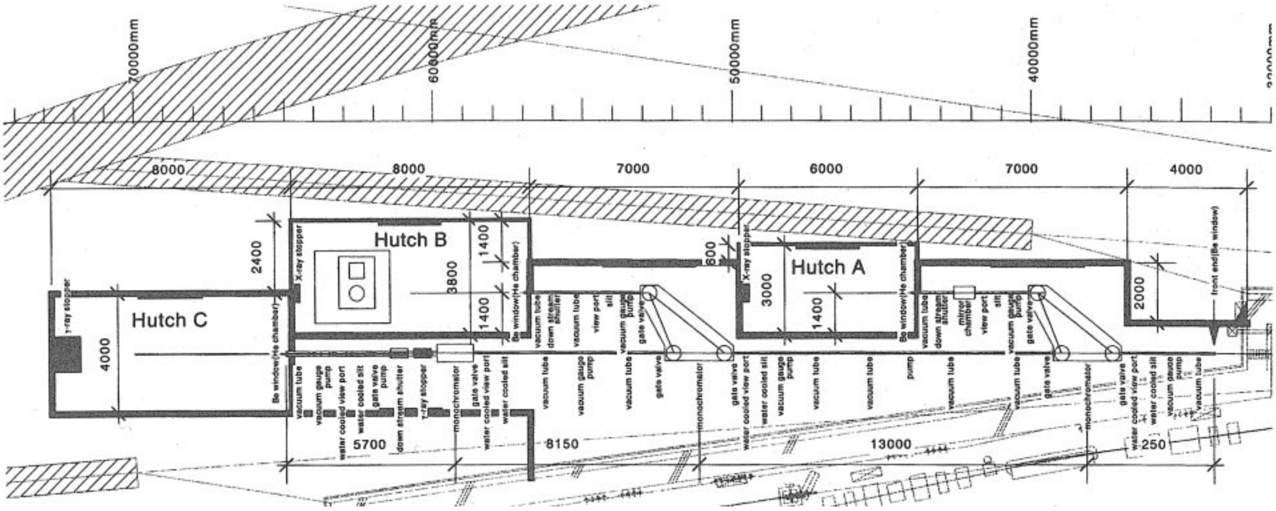
Hyogo prefecture will build the Heavy Ion Medical Treatment Center in the Harima Science Garden City. Because a cancer part grown-up lager than 1 mm may transfer from an original site of disease to other parts of the body, then it is important to find out the small cancer part even after therapy by the heavy ion irradiation.

It will become easy to detect the small cancer part amaller than 1 mm in size if a decoration technique for the cancer cells with a chemical element susceptible to specified X-rays and a high resolution X-ray CT are both succeeded. As a typical X-ray source for imaging the cancer part, we are considering fluorescent X-rays from a small piece of metal exited by a capillary-collimated synchrotron radiation. Further-more, phase contrast radiography is being discussed for the next stage. These experi-ments will be done by the use of phantoms as a tentative work in this hutch and actual diagnoses will be made at another medium-long beamline in future.

In addition, microbeam X-rays of less than 1 μm^2 or plane wave X-rays will be also developed in this hutch.

4. Acknowledgements

Dr. J. Chikawa (President of Center for



Advanced Science and Technology), Prof. M. Ando, Drs. H. Sugiyama, X. Chan and, K. Hyodo of Photon Factory are acknowledged for the beamline design at the initial stage of this plan. Profs. N. Yasuoka and N. Sakai of Himeji Institute of Technology also contribute to accept this plan as an cooperative work of HIT. Drs. M. Motoyama, Y. Ono,Y. Katsuya of Hyogo Prefectural Institute of Industrial Research are joining us to discuss the design plan of the equipments. Drs. H. Kamitsubo, H. Ohno, T. Ueki, H. Kitamura, T. Ishikawa, J. Mizuki and other persons of JAERI-RIKEN SPring-8 Project Team are greatly appreciated for their valuable suggession and support. Finally, it should be noted that Mr. H. Ochiai of Hyogo Prefecture has made much effort for budgetary works.

Rererenses

[1] T. Tanaka and H. Kitamura, Nucl. Instr. Meths. **A364**, 368 (1995).