JAERI Soft X-ray Beamline for Sciences of RI and Actinide Materials

Akinari YOKOYA
Tetsuhiro SEKIGUCHI
Yuji SAITO
Tetsuo OKANE
Yuden TERAOKA
Takeshi NAKATANI

1. Introduction

Synchrotron radiation has been expected to give fruitful information of electronic structures and magnetc properties of actinides, photochemical reactions of nuclear-related materials and biological risk of the radiation. One of the difficulties in these studies is how to handle the unsealed radioactive materials including actinides. To protect users and experimental devices from an RI pollution, the beamline is preferred to be constructed in an area where radioactive materials are well controlled.

Recently, we have installed a beamline for the radioactive materials in a second generation SR facility, the Photon Factory, Laboratory for High Energy Physics (KEK-PF). This beamline provides photons emitted from a bending magnet whose energy ranges from 1.8 to 6.0 keV [1] . An undulator beamline covering 80 to 1200 eV is under operation in ALS, U.S.A [2]. This achieved high flux and small size beam which is available for photoemission spectroscopy of trace amount of actinides. The photon beams from both of them are just linearly polarized.

We are planning to advance the nuclear-energy-researches by utilizing circularly polarized beam to measure circular dichroism spectrum of magnetic materials and organic molecules as well as high resolution spectrum of photoelectron, photoion and/or intermediate product of photochemical reaction by using linearly polarized beam. This beamline will be equipped with a new type of undulator which can generate variably-polarized soft X-rays, and will be in operation in December, 1997.

2. Layout of Beamline

The whole beamline system of BL22IN is schematically drawn in Fig. 1. The beamline has three experimental stations in a tandem fashion: photoelectron spectroscopy, surface photochemistry and radiation biology. The photoelectron-spectroscopy station at 130m from light source is located at an RI-controlled area in a building which is separated from the normal experimental hall.

As to the RI protection/inspection, the beamline is particularly devised to have some mechanisms to protect the storage ring from the intrusion of RI materials. Three RI inspection ports [1] and a vacuum chamber equipped with radiation detectors enable the inspection of radioactivity inside the beamline without breaking the ultra-high vacuum.

3. Light Source

To obtain soft X-rays at each experimental stations, a variably-polarizing undulator called "APPLE II type" is installed in the low-emittance electron storage ring, SPring-8 [3]. The undulator emits both linearly and circularly polarized X-rays [4-6]. The energies of the soft X-rays are from 0.3 to 1.5 keV in horizontal- polarization mode and from 0.5 to 1.5 keV in circular-polarization mode. The magnetic structure of the APPLE II is shown in Fig. 2. The specifications are listed in Table 1.

Table 1. The specification of variably-polarizing undulator.

Parameter	Value
Type	variably-polarizing undulator
Period length	120 mm
Number of periods	16 poles
Overall length	1920 mm

Circular-polarization mode			
Magnet gap (mm)	39	54	58
K value	3.0	2.0	1.5
1st harm. (keV)	0.5	1.0	1.5
Power(W)	1.1	0.49	0.27
Horizontal-polarization mode			
Magnet gap (mm)	38	63	73
K value	5.5	2.8	2.2
1st harm. (keV)	0.3	1.0	1.5
Power(W)	1.9	0.49	0.27
Brilliance	$2-6\times10^{17}$ (photons/s/mrad^2/mm^2 /0.1% b.W/100mA)		

The spectral data calculated by the synchrotron-radiation calculation program [7] are shown in Fig. 3.

4. Optical System

Soft X-rays emitted from the undulator are monochromatized by a high-resolution-type monochromator equipped with four varied spacing plane gratings which cover the energy region from 0.3 to 1.5 keV. The energy resolution, $E/\Delta E$ of the monochromator will be over 10000 in the energy range used.

To focus the undulator beams, two pre-focusing mirror, Mh and Mv, and two post-focusing mirror, M3 and M4, are used. The cylindrical, Mh, and the spherical mirror, Mh, are placed at 39 and 40m from the source respectively. The former focus the beam in horizontal direction on photoelectron-spectroscopy station, and the latter in vertical direction on entrance slit placed at 10m downstream from the Mv. The incident angles of them are the same, 88.5 degree. Both mirror systems have a water-cooled mirror holder and a mechanical bending system. The cylindrical mirror M3 and M4 are used to focus the monochromatized beams in vertical direction on the photoelectron-spectroscopy station and the surface-photochemistry station. Two reflecting mirrors is also used for changing the beam direction to guide it in the RI-controlled area.

Acknowledgments

We are grateful to Prof. S. Suga of Osaka University and Dr. Fujisawa of University of Tokyo for their helpful assistance for designing the monochromator.

References

[1] H. Konishi, A. Yokoya, H. Shiwaku, H. Motohashi, T. Makita, Y. Kashihara, S. Hashimoto, T. Harami, T.A. Sasaki, H. Maeta, H. Ohno, H. Maezawa, S. Asaoka, N. Kanaya, K. Ito, N. Usami and K. Kobayashi, Nucl. Instr. Meth. A372, 322-332 (1996).

[2] Advanced Light Source Report 7, 1 (1994).

[3] H. Kobayashi, S. Sasaki, T. Shimada, M. Takao, A.. Yokoya and Miyahara, Proc. European Accelerator Conference '96, in press.

[4] S. Sasaki, K. Miyata and T. Takada, J. Appl. Phys., 31, L1794-L1796 (1992).

[5] S. Sasaki, K. Miyata, T. Takada, T. Shimada, K. Yanagida and Y. Miyahara, Nucl. Instr. Meth. A331, 763-767 (1993).

[6] S. Sasaki, Nucl. Instr. Meth. A347, 83-86 (1994).

[7] H. Kitamura, Synchrotron Radiation Calculation Program, Spectra V.2.0.

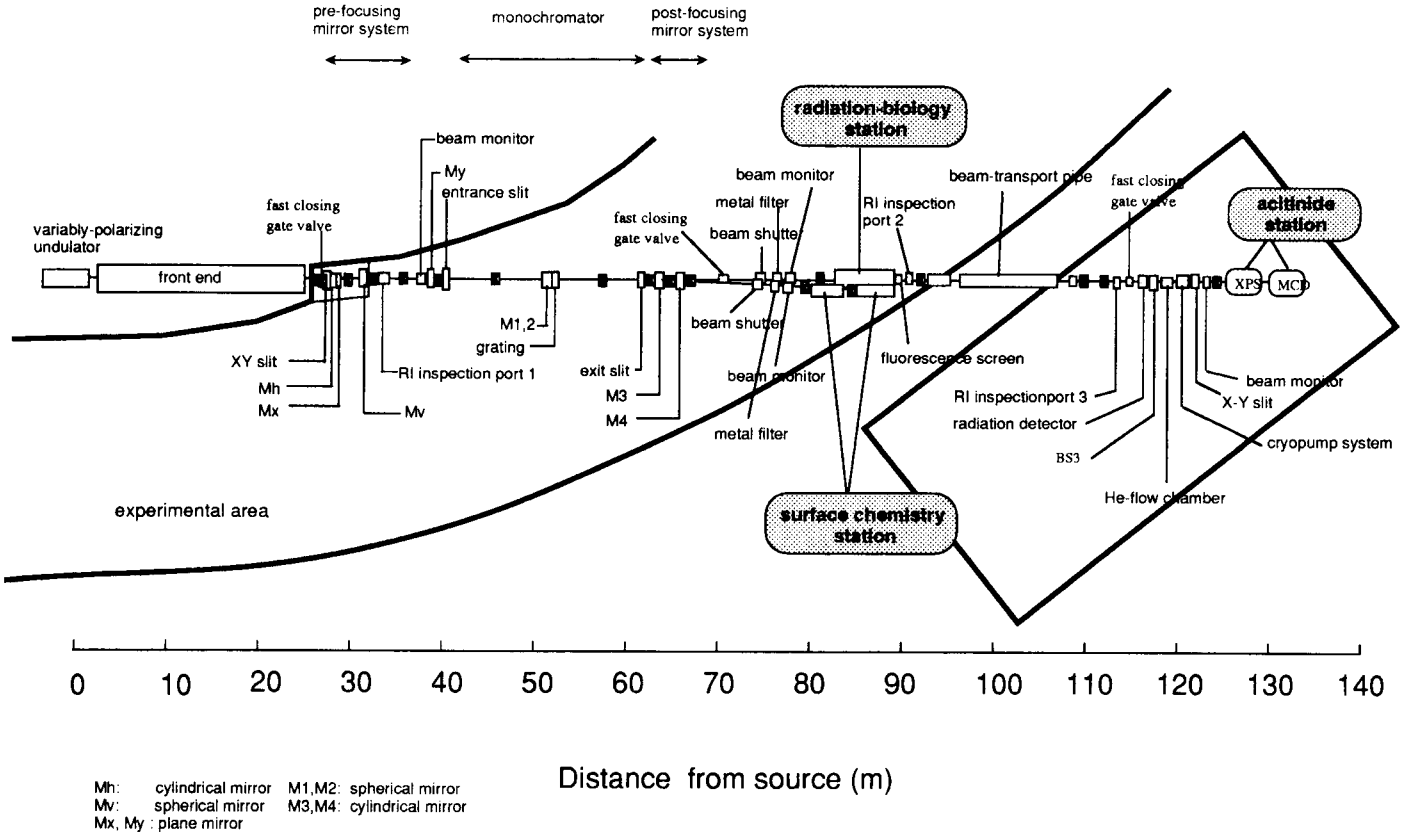

Fig. 1 Schematic illustration of a layout of the whole beamline system on BL-22IN.

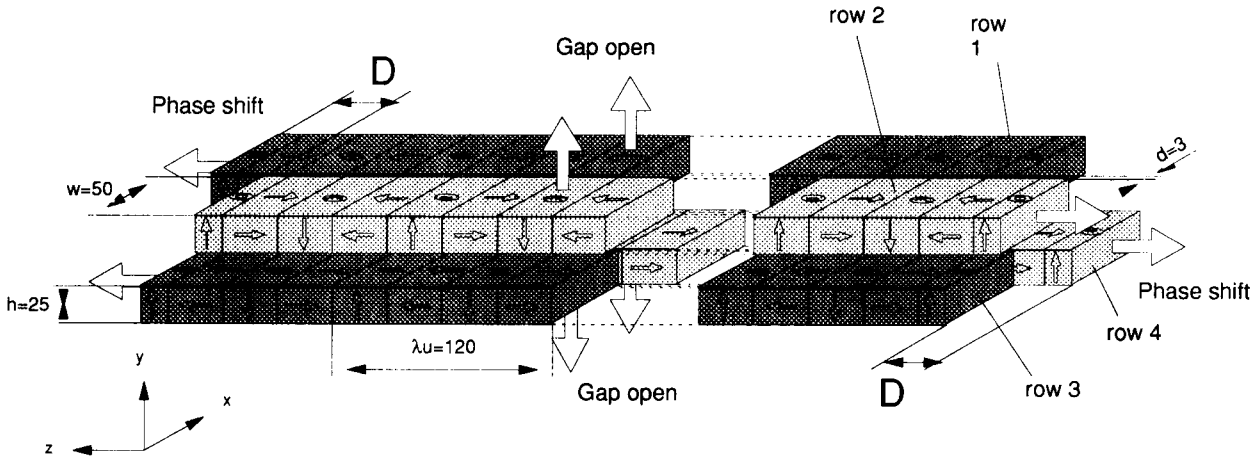

Fig. 2 The magnetic structure of the APPLE II consists of two pairs of arrays of permanent magnets.

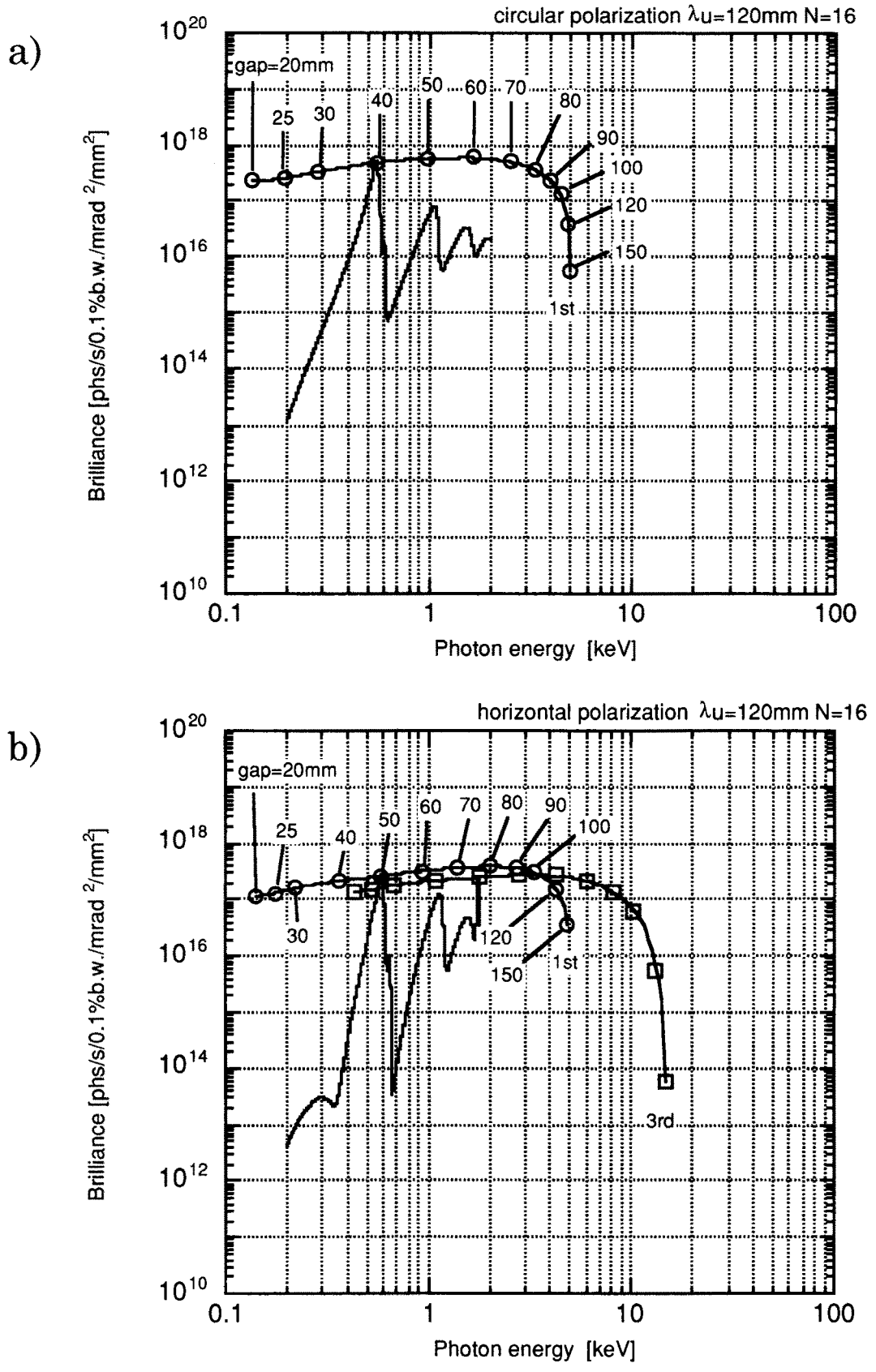

Fig. 3 The spectral data calculated by the synchrotron-radiation calculation program by Kitamura, KEK-PF; a) brilliance of 1st harmonics at circular polarization, b) brilliance of 1st, 3rd and 5th harmonics at horizontal polarization as a function of gap distance.