J. Synchrotron Rad. (1998). **5**, 536–538

Construction of the JAERI soft X-ray beamline for actinide material sciences

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(*Received 4 August 1997; accepted 6 January 1998*)

An undulator beamline for spectroscopy studies focusing on the electronic structure of actinide materials is under construction. Linearly or circularly polarized soft X-rays are provided by employing a variably polarizing undulator. Varied-line-spacing plane gratings and a sagittal-focusing system are used to monochromatize the undulator beam, whose energy ranges from 0.3 to 1.5 keV. A resolving power of 10^4 is expected in the whole energy region. These components are methodically operated by the SPring-8 beamline control system. There are three experimental stations in the beamline. In one of the stations the photoemission spectroscopy experiments are carried out at a radioisotope-controlled area where actinide compounds as well as unsealed radioactive materials are usable. Other experimental stations are planned in the beamline for surface photochemical reactions and biological applications.

Keywords: variably polarized soft X-rays; actinides.

1. Introduction

We are constructing a soft X-ray beamline mainly aiming at actinide material sciences. The beamline located at BL23IN in SPring-8 has three experimental stations: electron spectroscopy of actinide compounds, surface photochemical reactions, and observations of the photoabsorption effect on a biological molecule in tandem. Although the photochemical and biological stations are located in the normal experimental hall, the actinide experimental station is located downstream in a different building called the RI experimental hall (Yokoya *et al.*, 1998). The photon beam is conducted over a very long distance and control of the beamline components extends over the two buildings. In this report, a control system for the polarization of the undulator as well as the optics is introduced.

2. Beamline components

Variable polarized and monochromated light is required in a wide variety of applications on the experimental stations. We have employed the following beamline components.

The light source is a double-array undulator of the APPLE (advanced planar polarized light emitter) type (Sasaki *et al.*, 1992, 1993; Sasaki, 1994). This insertion device (ID) produces many kinds of polarization in the soft X-ray region. We can obtain horizontally and vertically linear, circular and elliptical photon beams by changing the phase shift of two pairs of permanent-magnet arrays.

The front-end components constitute gate valves, screen monitors, shutters, Pb collimators, absorber, fixed mask, XBPMs (X-ray beam-position monitors), *XY* slit, and so on. There are two wire-scan-type XBPMs for the axis adjustment of the photon beam. Because the *XY* slit removes the off-axis ingredient of the photon beam as well as the upstream bending magnet, only the centre of the photon beam is able to pass to the experimental hall.

We adopted the basic concept of the optics of the SPring-8 public beamline (BL25SU) (Saitoh *et al.*, 1998). In order to minimize the thermal effect of the mirror surface, the beam is sagittally focused onto the entrance slit, S_1, by the first mirror, M_v, in contrast to BL25. Evaluation of the monochromator performance has been carried out by Saitoh *et al.* (1998); the energy resolution was estimated to be better than 10^4 in the whole energy region. A schematic diagram of the optics is shown in Fig. 1. A monochromated beam passing through the exit slit, S_2, is turned horizontally by a post-focusing mirror, M_3. A beam size of 0.5 mm^2 at the actinide station is obtained by using the toroidal mirror M_4. These optical elements are listed in Table 1.

Because our beamline is able to handle unsealed radioactive materials, we have to prevent the intrusion of the RI pollution into the upstream beamline. Some special apparatus is installed in the RI building to protect the upstream building from RI pollution. One is an acoustic delay line set in the space between the two buildings (Yokoya *et al.*, 1998). The mechanism delays the shock waves during sudden air leakage of the vacuum chamber located in the RI controlled area. Another is the pneumatic fast-closing gate valve (FGV). There are three FGVs in the beamline. These are promptly closed within 10 ms when the sensors of the FGVs detect the pressure rise in the vacuum

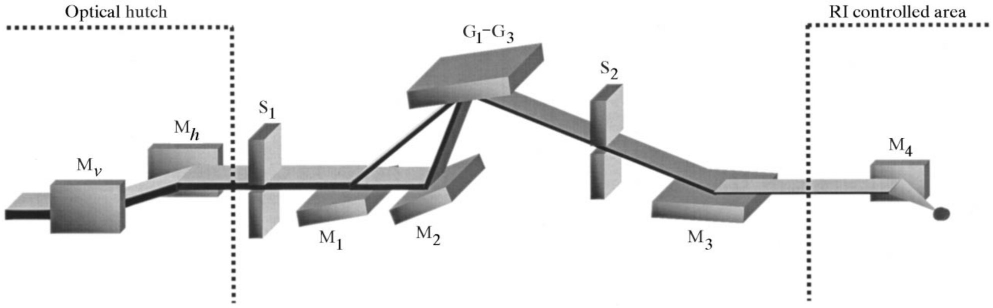

Figure 1
Schematic layout of the BL23SU at the SPring-8, consisting of the pre-focusing mirrors (M_v and M_h), a monochromator (S_1–M_1 or M_2–G–S_2) and the post-focusing mirrors (M_3 and M_4). A sagittally focusing system is employed as the pre-focusing system. The monochromator is a constant-deviation type in combination with the spherical mirror (M_1 or M_2) and the varied-line-spacing plane gratings.

chamber. The other is the RI inspection chamber. When a β-ray counter attached to the RI inspection chamber detects that the signal exceeds the criterion, the warning light rotates.

3. Beamline control

As mentioned above, we have three experimental stations located at the two separated buildings. The client/server architecture connected *via* SPring-8 networks is indispensable for the beamline control system. Fig. 2 shows a schematic diagram of the BL23SU control system, which is based on that of the public beamline concept in SPring-8.

The hardware components of the system are four elements, namely the beamline workstation (BL-WS), BL-VME, beamline X-terminal (BL-X) and ID-VME (Ohata *et al.*, 1998). The BL-WS (operation system: HP-UX, version 10.10, of HP9000 712/100 workstation) unifies all the beamline components. The client/server architecture of the software of the system makes it possible to control many devices in the front-end or transport channel as well as the undulator from another building, while keeping robustness of the system. The application software, such as undulator-gap/phase exchange or grating rotation for wavelength exchange, has a sophisticated graphical user interface (GUI), *X-Mate* (version 3.09) developed by a commercial GUI builder. An illegal operation is prevented by an access control procedure using the *Message Server* (*MS*) and *Access Server* (*AS*) programs. The data communication between GUI and *MS*, *MS* and *AS* uses the *Message Queue* method.

BL-X (Windows NT Workstation, version 4.0, on IBM PC/AT compatible) is an X-terminal for the BL-WS arranged at each experimental station. The X-terminals are connected to the BL-local-LAN, which is a private network inside the beamline. We can select the photon energy or polarization of the beam using the BL-X at each station independently.

BL-VME and ID-VME (HP-RT, version 2.20, on HP743rt) mainly control the pulse motor devices and obtain the beamline status in the front-end, transport channel or the undulator. These VMEs are connected to the SR-LAN, which is the control network for the storage ring. Software called *Equipment Manager* (*EM*) running on the VMEs controls the GPIB, ADC, DIO and so on. Data communication between *AS* and *EM* uses the *Remote Procedure Call* method. Because all the controlled components are operated individually, the users at the experimental stations are able to combine synchronously several components with their own programs.

Undulator phase control is one of the unique subjects in our beamline. The undulator was designed to switch the photon polarization at a rate of 0.5 Hz by a phase shift of the magnetic arrays to improve the signal-to-noise ratio in circular-dichroism experiments. The phase-position signals are made at the undulator as rectangular trigger signals. Right-circular polarization is indicated by positive DC pulses, and left-circular polarization by negative DC pulses. We are able to use the signals at the experimental stations to control the gate or window of a detector system. To cancel the electron-beam instability caused by the phase-shift drive as well as the gap drive, a fast-feedback system combining four steering magnets and the XBPMs will be completed in the near future.

Table 1
Optical elements of the beamline.

Optical element	Distance from source (m)	Incident angle (°)
Cylindrical mirror, M_v	40	88.5
Plane mirror with bent system, M_h	42.5	88.5
Entrance slit, S_1	50	–
Spherical mirror, M_1	60.955	88.5
Spherical mirror, M_2	61.338	87.5
Varied-space plane gratings, G_1–G_3	61.9	$\alpha + \beta = 176$ (M_1) $\alpha + \beta = 174$ (M_2)
Exit slit, S_2	71.91	
Cylindrical mirror, M_3	73.91	89.5
Toroidal mirror, M_4	114	88.5

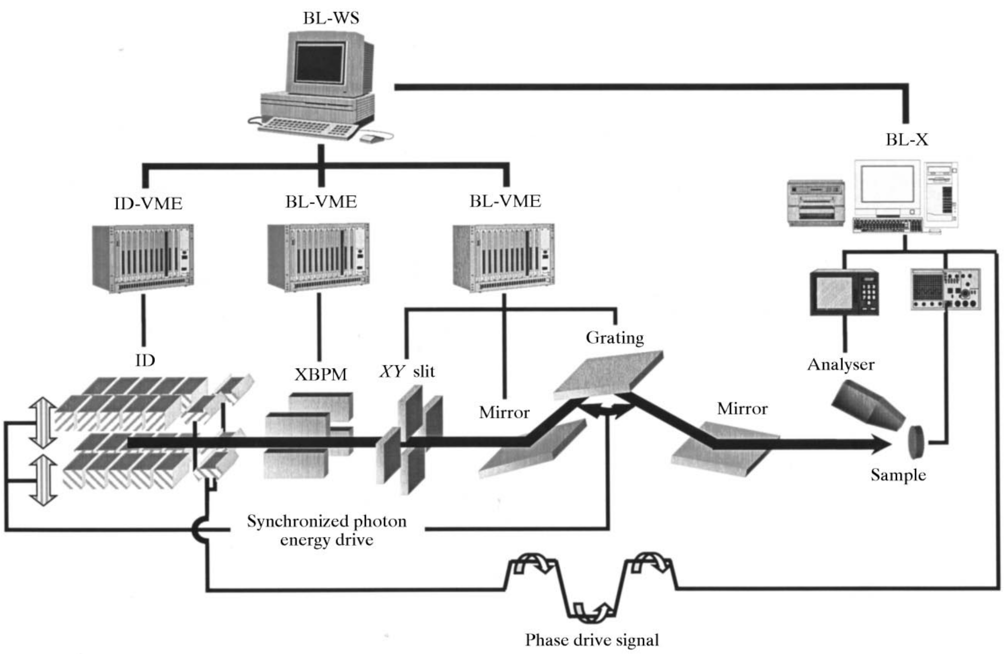

Figure 2
Schematic layout of the BL23SU beamline control system. The beamline users are able to control all the beamline components using this system.

The beamline and experimental apparatus will be commissioned in early 1998.

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

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