Current Status of Light Source and Beamlines

UVSOR Light Source in 2002

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1. Machine Operation

In 2002, the UVSOR accelerator complex was operated for 36 weeks (including machine tunings). Monthly statistics of the operation time are shown in Figure 1. Two weeks in this year were assigned to single bunch users operation. One week for users and another week for machine studies were canceled because of an accident on the storage ring vacuum as described later. We had four shut down periods, around the new years day (two weeks), in spring (six weeks), in summer (three weeks) and in autumn (one week). The spring shut down period was longer than usual for installing a new undulator.

The operation pattern and the filling beam current were changed in May. New weekly operation pattern is as follows. Mondays (from 9:00 to 16:30) are assigned to machine tunings and machine studies. From Tuesday to Friday, the machine is operated for users. The beam is injected twice a day, at 9 and 15 o'clock. The beam is stopped at 21 o'clock. The filling beam current is 300 mA in multi-bunch mode, and 70 mA in single bunch mode.

We had a few troubles on the injector. The most serious one was on the power supply of the booster synchrotron magnets in June. A transistor control unit was malfunctioned and many transistors were broken. It took about four days to recover as lacking some transistors. It was in August that the power supply completely recovered with a complete set of transistors. There were a few minor troubles on the power supplies for the synchrotron magnets and for the electron gun. Since both of these occurred not so frequently and lacked reproducibility, it took long time to find their origin. Fortunately, users time was not affected so much on these troubles except for that the beam injections were delayed several times.

In November, a vacuum leakage happened. The cooling water of a SR beam shutter at a beam-line came into the ultra-high vacuum system of the storage ring. We must have restarted the users time as soon as possible, hopefully within one month. This was because that the shutdown for the upgrade project described later had been scheduled to start in March.

Fortunately, we could recover the vacuum of the storage ring within five weeks. The users run was restarted late in December. We decided to delay the start of the reconstruction works for the upgrade project by one month. The machine operation for users was extended until the end of March. More details of the accident will be described in the next section.

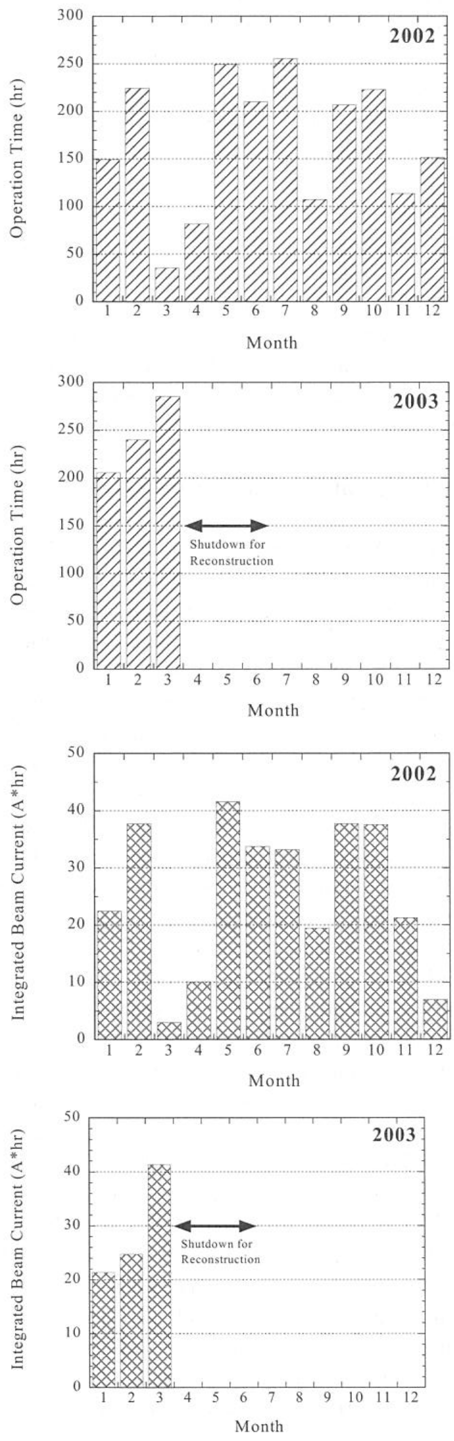

Fig. 1 Operation statistics in 2002 and 2003

2. Vacuum Leakage in November

In 13th November, a vacuum leakage happened. The origin was a beam shutter at the front-end of a beam-line (BL1B). Its cooling water came into the ultra-high vacuum (UHV) system through a pinhole between the water channel and the surface of the shutter in UHV. The water vapor went around the whole ring.

We had completed preparing for baking of the vacuum chambers of the whole storage ring within a week. It took about two weeks for baking the whole ring. Fortunately no vacuum component was malfunctioned. However, it was found that the UHV pressure of the main RF cavity rose by several orders of magnitudes when the RF power was introduced. By observing the occurrence of the pressure rises in various operating conditions, we concluded that electric discharge happened at the input coupler. We removed the coupler and found traces, which indicated the occurrence of electric discharge. We replaced the coupler with a new one and baked the cavity. It was supposed that the coupler was damaged during the leakage. Later it was found that the interlock system of the RF cavity against the vacuum accident was insufficient. We improved it immediately.

Finally, we could restart the operation middle of December. It took about one week for vacuum conditioning with SR irradiation to recover the beam lifetime marginally long enough for users operation, as shown in Figure 2. The users time was restarted on 24th December.

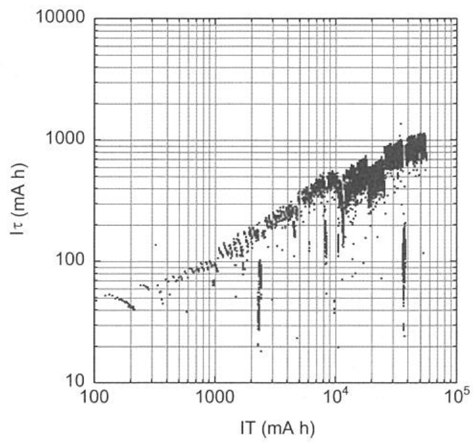

Fig.2 Recovery of the beam lifetime after the vacuum leakage in November
The product of the lifetime and the beam current ($I\tau$) is shown as a function of integrated beam current (IT). The users time started at around 10^4 (mAh). Some discontinuities are due to the change of operating conditions.

3. Status of Upgrade Project (UVSOR-II Project)

The UVSOR upgrade project (UVSOR-II project)[1, 2] was funded in FY2002. In this project, the magnetic lattice of the storage ring is going to be changed to produce more straight sections and to reduce the beam emittance. We are going to have four 4 m straight sections and four 1.5m straight sections, six of which would be available for insertion devices. We are going to reduce the beam emittance to be 27 nm-rad, which is almost one sixth of the present value. We will have second in-vacuum undulator of 2 m long, new electron gun and power supplies of injection linac. There will be several improvements on beam-lines, as described elsewhere in this report.

We have started construction of accelerator components. All the quadrupole and sextupole magnets are being replaced with combined function magnets [3], which can produce both quadrupole and sextupole fields. Sixteen vertical steerers are being installed, which is almost twice larger in number than present. All the power supplies of the storage ring magnets, including that of bending magnets, are being replaced as well as their control system. All the beam ducts at quadrupoles and sextupoles are being replaced [4]. In addition, three of the beam ducts at the bending magnets are also being replaced.

New in-vacuum undulator for BL3U (previously called BL3A) is being installed at the straight section between the bending magnets, B2 and B3. The undulator period is 38 mm and the number of periods is 50. It will cover the spectral region between 50 eV and 120 eV with its first harmonic radiation. The third harmonic radiation will come close to the K-edge of carbon.

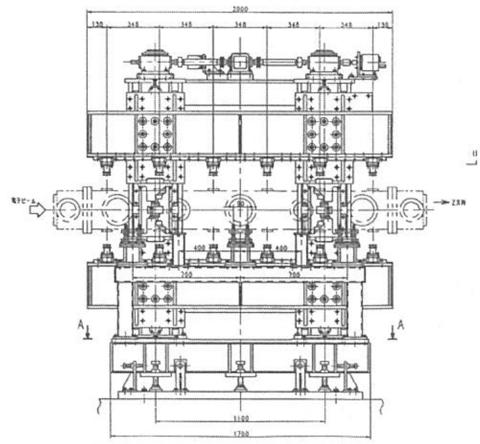

Fig. 3 Design of In-vacuum undulator for BL3U
This is the second in-vacuum undulator. The period length is 38mm and the number of periods is 50. The magnetic length is about 1.9 m and the overall length is 2.4 m.

The injection linac has been used for about 20 years. It has got more and more troubles in recent years. In the upgrade project, the electron gun will be replaced as well as its power supplies. It will be capable of producing short pulses for single bunch injection into the 90 MHz RF buckets of the booster synchrotron and the storage ring. Also the pulse modulator of the klystron will be replaced.

Until the end of March 2002, the fabrications of all these components were completed. The installation was started in April 2003, delayed by one month as described previously. All the reconstruction works will be completed until the end of June. In July 2003, the commissioning of the upgraded UVSOR, UVSOR-II, will be started.

4. Improvements

2-1. New operation pattern and increase of filling beam current

The weekly operation pattern of UVSOR was changed in May. Previously, from Tuesday to Friday, UVSOR had been operated for users, for 9 hours a day (9:00-18:00) with twice injection. Only on Thursday, UVSOR had been operated for 12 hours (9:00-21:00) with three time injections. Since last May, from Tuesday to Friday, UVSOR has been operated for 12 hours a day with twice injection.

To keep average beam current as high as before against the longer injection interval, the filling beam current was increased from 250 mA to 300 mA. Last year, we had already tested this high current operation and found no problem [5]. Previous and recent beam current histories are shown in Fig. 5. Even though the injection interval is longer than before, the average beam current is slightly higher.

2-2. Installation and commissioning of in-vacuum undulator

Construction of an in-vacuum undulator was completed until the end of February [6]. It was installed at the straight section between the bending magnets, B6 and B7, in March after removing the super-conducting wiggler as shown in Fig. 6. After the in-situ baking, the pressure reached 2×10^{-8} Pa.

The magnet arrays are coated by copper foil of 50 micron thick to reduce the surface resistivity and water-cooled. There are RF shields on both ends, which are connecting the surface of the arrays and the neighboring beam ducts smoothly. The shields themselves are not water-cooled. We did not observe any noticeable temperature rises both on the arrays and the shields for the beam current up to 300mA. We also have not seen any beam instability, such as resistive wall instability.

The change in beam lifetime was observed as making the magnetic gap narrower. It had been expected that the lifetime would reduced for the gap narrower than 20 mm in the present operating condition. The result was slightly narrower than expected. When the gap came to be around 16 - 18 mm, the lifetime began to decrease.

We have developed a control system for the undulator. A schematic diagram of the system is shown in Fig. 7. The undulator can be controlled from a personal computer at a beam-line connected to the local area network for machine operation. The system is capable of correcting the orbit distortion due to the change of magnetic gap automatically. The orbit distortion could be corrected to be smaller than 10 microns for entire ring both in horizontal and vertical [7]. The users can change the magnetic gap any time from their experimental station. Same system is being prepared for the

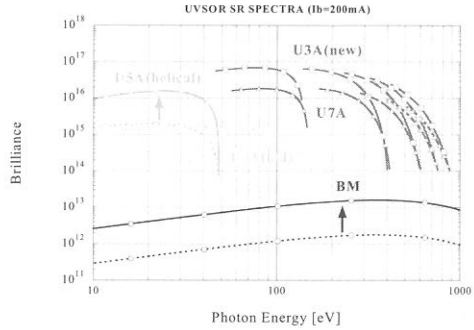

Fig. 4. SR Spectra after the upgrade project

We will have three undulators just after the upgrade, a helical undulator/optical klystron of 2.35 m for BL5U (previously called BL5A), an in-vacuum undulator of 0.94 m for BL7U (previously 7A) and the second in-vacuum undulator for BL3U (previously 3A). With these undulators, highly brilliant SR in the energy range from 10 eV to several hundred eV would be provided.

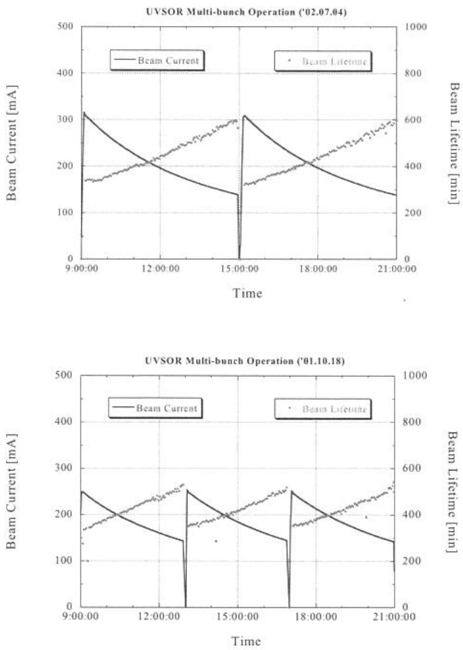

Fig. 5. Typical beam current history in a day

The upper is for the present operation pattern with twice injection a day and the lower for the previous one with three times injection a day. The filling beam current is 300 mA and 250mA respectively.

second in-vacuum undulator for BL3U.

2-3. Baking method of beam ducts in bending magnet

In the early stage of the UVSOR, the beam ducts were baked by producing electric current directly on the ducts. Although this method was simple, we must have paid much attention to confirm electrical insulation of the ducts. In 1990's, it was changed to use heaters mounted on the ducts except for the bending section. There put many ceramic breaks on the ducts to separate the bending sections electrically. It was observed that electrical noises leaking from these breaks. In addition, the breaks might be origins of some kind of beam instabilities.

In the upgrade project, we are planning to change the baking methods at the bending sections to the normal methods utilizing heaters. We are going to put the heaters on the bending duct except for there facing to the magnetic poles to avoid the influence on the field quality. We are going to put aluminum coated polyimide film on the duct for thermal insulation. We made a test in spring 2002. When the temperature near the heaters rose to 200 degree C, the temperature of the surface facing to the magnetic poles was around 120 degree C. The temperature of the surface of the magnetic poles was well below 100 degree C.

2-4. Input coupler of main RF cavity

The RF power amplifier has capability of producing 20 kW output power to the main accelerating cavity of the storage ring. However, in daily operation, the output power has been limited below 7 kW for many years. This was because of the heat problem of the input coupler. It happened that the ceramic window at the coupler was broken in the past high power test.

The smaller beam emittance after the upgrade would inevitably result shorter lifetime because of the stronger Touschek effect. Thus, it is desirable to increase the RF accelerating voltage by increasing the RF input power.

We have constructed a new coupler and installed it during the spring shutdown in March 2002. In the high power test, it was found that the temperature rise at the coupler was greatly reduced. The details are described elsewhere in this report [8].

2-5. Power supply of extraction kicker magnet

The power supply of the extraction kicker magnet in the booster-synchrotron has been used for about 20 years and the troubles have been more frequent in these years. Thus, we have replaced the power supply during the spring shutdown in 2002.

2-6. Vacuum monitoring system

In spring 2002, we have replaced the vacuum monitor system. The old system was based on VAX computers and CAMAC interface [9], which had been used for about ten years. The new system is based on a personal computer and programmable logic controllers (PLC). In adding to the storage ring, the pressure of the linac, booster synchrotron and the beam-line front-ends can be monitored. All the data are sampled every 1 second and stored in the hard disk of the server. The real time data can be displayed on any personal computer, which is connected to the local area network for machine operation. An example of the display is shown in Figure 8.

2-7. RF knockout system

We have been used two RF knockout (RFKO) system, one

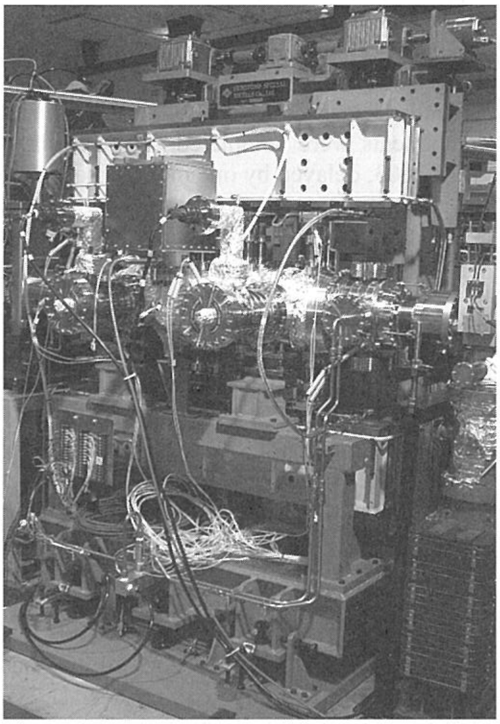

Fig. 6 In-vacuum undulator for BL7U installed at the straight section between the bending magnets, B6and B7

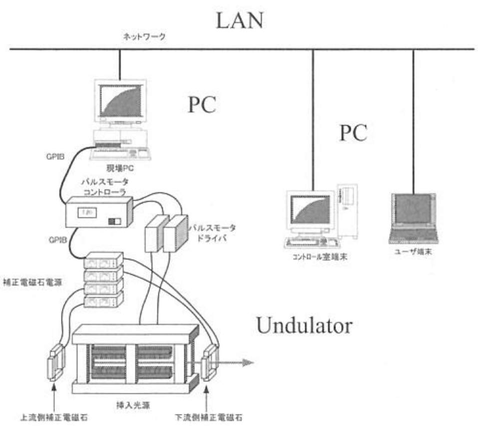

Fig. 7. New control system of the undulator (U7)

for the tune measurement and another for controlling filling pattern. After the upgrade, there are fewer spaces to install devices for beam monitors and beam handlings. Thus, we have changed the latter RFKO system to be available for tune measurement. The detail of the new system is described elsewhere in this report [10]. It has been working well and another system can be removed.

2-8. SR Position Monitor

By using the beam position monitor system introduced in 2001 [11], we found rather large orbit drift in scale of a few hundred microns. However, since the present beam position monitors are mounted on the beam duct of the bending magnets, the measurements might be influenced by the thermal deformation of the ducts due to SR irradiation.

We have installed a SR beam position monitor at a beam-line BL7B during the summer shutdown. The details of the monitor are described elsewhere in this report [12].

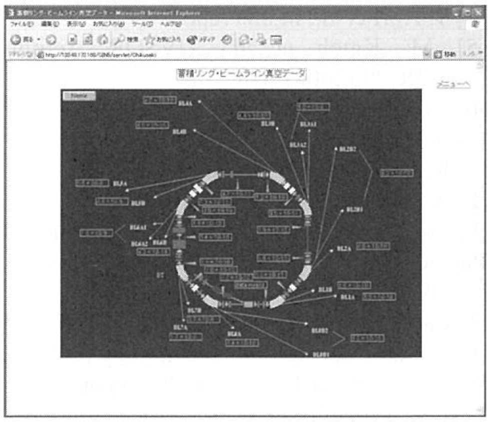

Fig. 8 An example of the display of new vacuum monitoring system

5. Researches and Developments

3-1. Ion trapping phenomena

The ion trapping phenomena at UVSOR have been intensively studied theoretically and experimentally [13, 14, 15]. By using the newly developed RF knockout system [10], it was found that the betatron tune in vertical shifted depending on the beam current and the pressure in the beam ducts. These facts could be explained as the results of the change in number of trapped ions.

3-2. Free electron laser

We are continuing the two photon excitation experiments on Xe atoms by using the high power free electron laser and the undulator radiation in collaboration with the beam-line division [16]. This year, we have changed the wavelength of free electron laser to 420 nm from 570 nm. The average power of several hundred milli-watts could be easily achieved.

Our next step will be to realize higher output power in shorter wavelength, hopefully in VUV. We are expecting that the low emittance electron beam after the upgrade of the storage ring would make this possible.

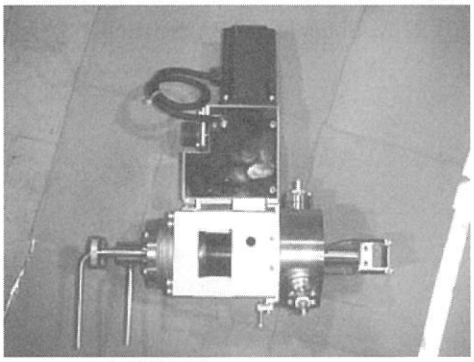

Fig. 9. SR Beam Position Monitor for BL7B

3-3. Coherent FIR radiation

We have been continuing the feasibility study on the bunch slicing on UVSOR [17]. It was predicted and demonstrated by some authors that a part of an electron bunch can be sliced out by using an undulator and a femto second laser [18]. It was also suggested that this technique might be applicable to produce coherent far infrared radiation. This year, we have investigated the possibility to produce coherent far infrared radiation on UVSOR by using this technique. It seems to be possible to produce coherent far infrared radiation which may be much more intense than normal synchrotron radiation by many orders of magnitudes [19].

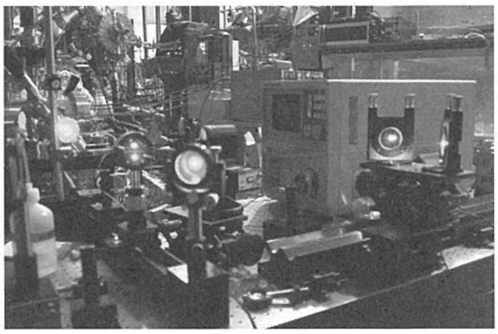

Fig. 10. Optical bench at BL3A for two photon excitation experiment using undulator radiation and free electron laser

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Control Room of UVSOR

UVSOR Accelerator Complex

Parameters of UVSOR-II Storage Ring

	(Upgraded UVSOR)
Circumference	53.2 m
Lattice	DBA ×4
Straight Sections	4m×4 + 1.5m×4
Beam Energy	750 MeV
Bending Radius	2.2 m
RF Frequency	90.115 MHz
Harmonic Number	16
RF Voltage	~75 kV
Mom. Comp. Factor	0.028
Betatron Tunes	(3.75, 3.20)
Natural Energy Spread	4.2×10^{-4}
Natural Emittance (a goal)	27 nm-rad
Natural Bunch Length	~130 psec
Max. Beam Current (a goal)	500mA (multi-bunch) 100 mA (single bunch)

Parameters of UVSOR Injector

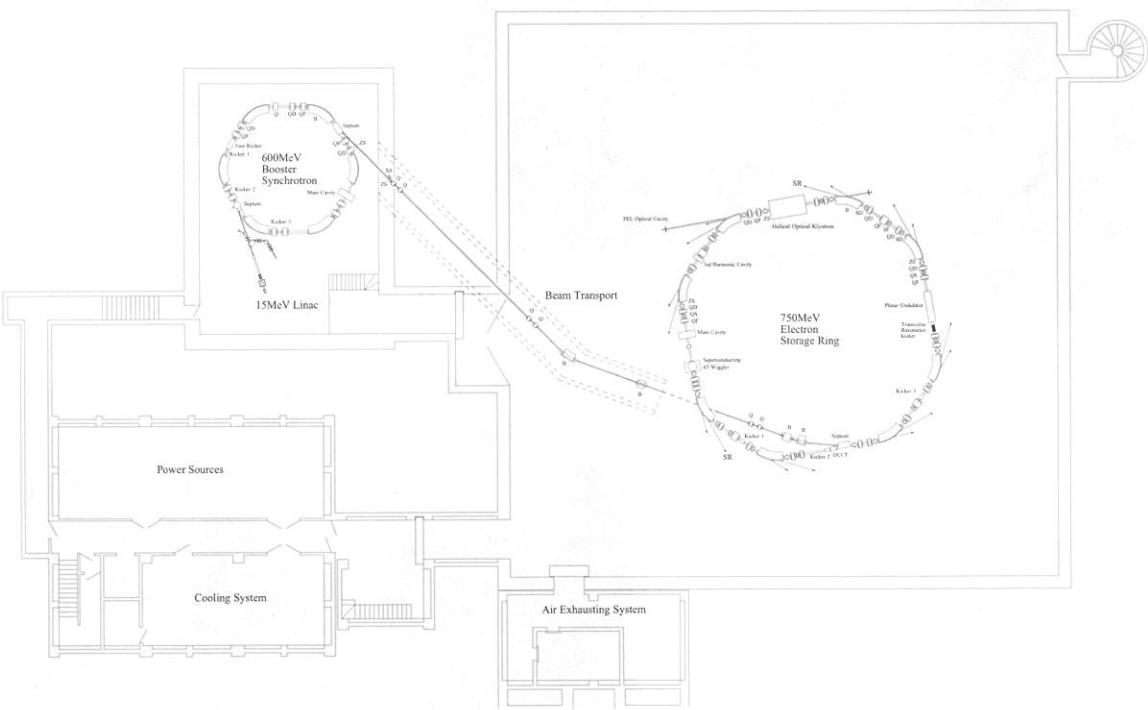
Injection Linac

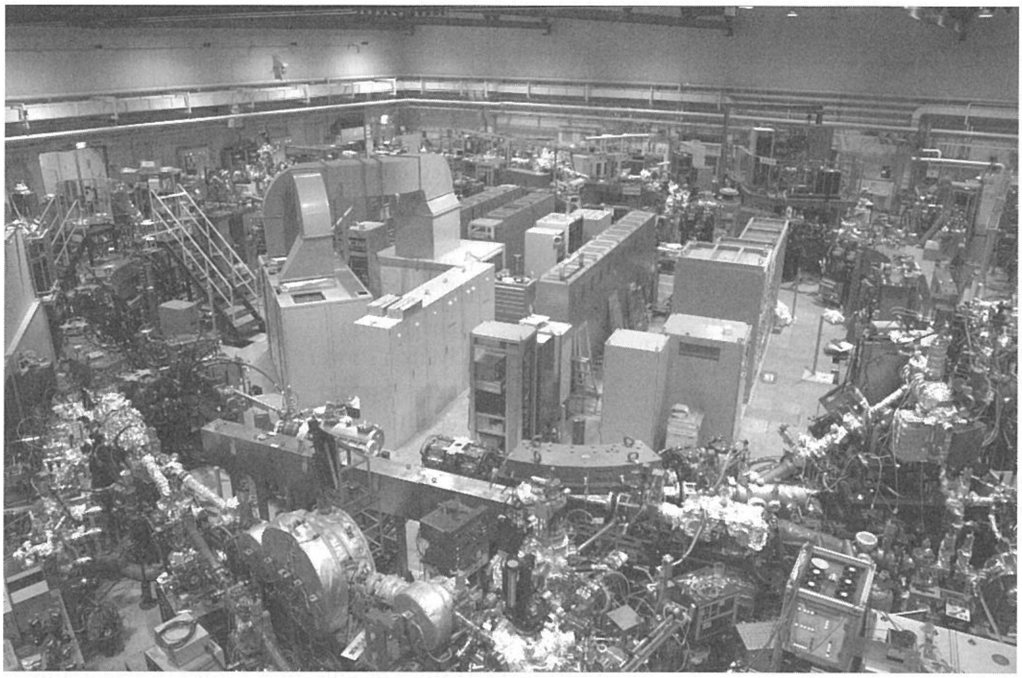
Energy	15 MeV
Length	2.5 m
Frequency	2856 MHz
Acceleration	2π/3Traveling Wave
Klystron Power	1.8 MW
Energy Spread	~1.6MeV
Repetition Rate	2.6 Hz

Booster Synchrotron

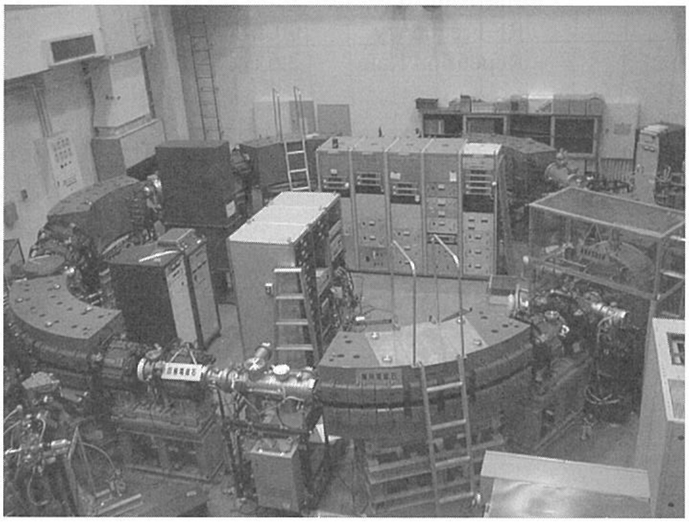
Energy	600 MeV
Lattice	FODO ×8
Circumference	26.6 m
Beam Current	32 mA (8-bunch filled)
Bending Radius	1.8 m
Betatron Tune	(2.25, 1.25)
Mom. Comp. Fac.	0.138
Harmonic Number	8
RF Frequency	90.115 MHz
Repetition Rate	2.6 Hz

Plane view of the UVSOR Facility

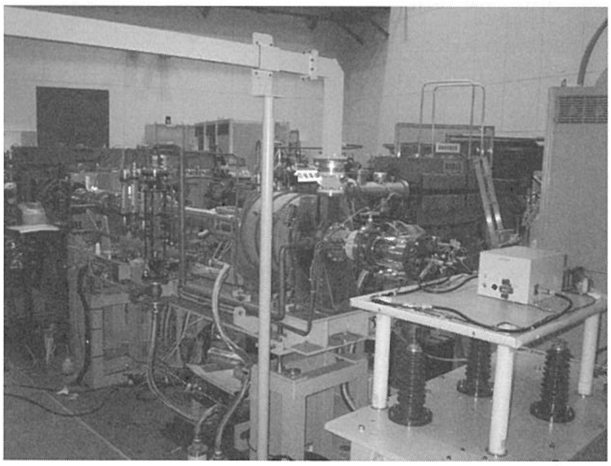




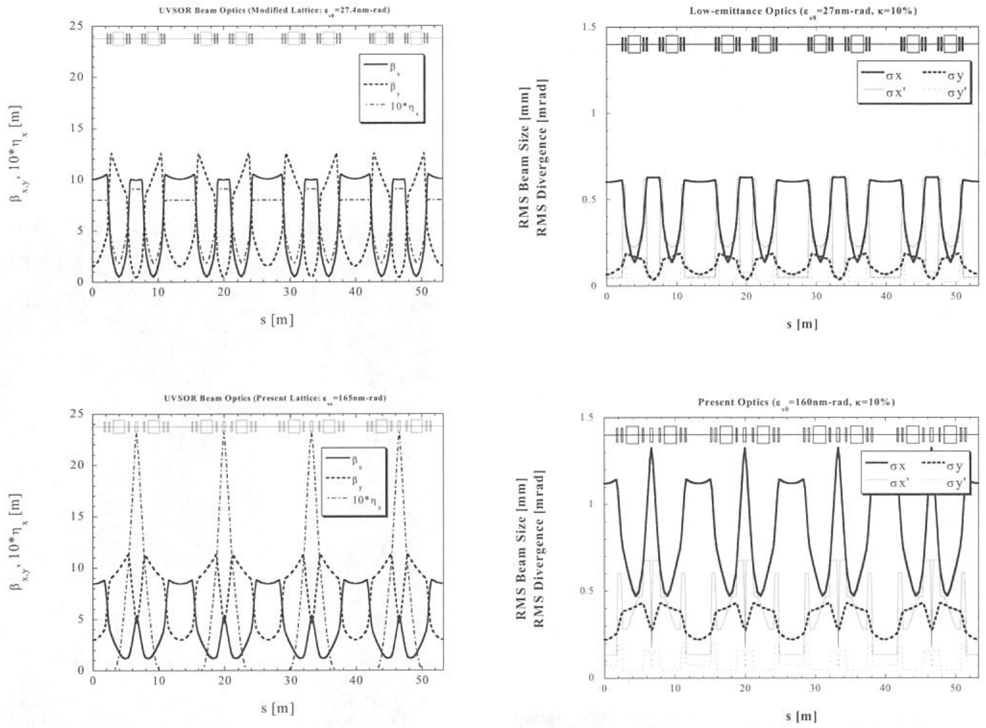
UVSOR-II Storage Ring (under reconstruction)



Booster Synchrotron

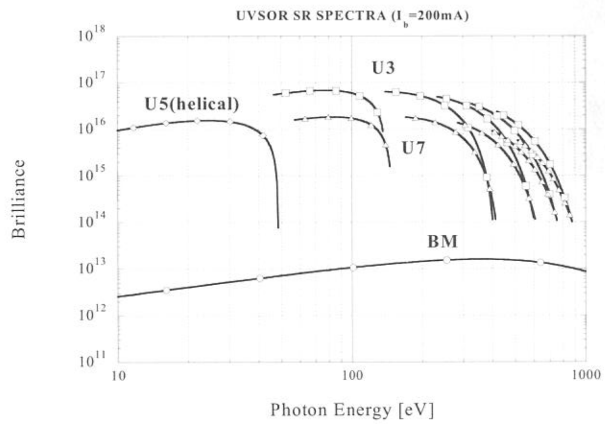


Injection Linac



Electron Beam Optics of UVSOR Storage Ring

before (lower) and after (upper) the upgrade



Synchrotron Radiation Spectra of UVSOR

before (dashed lines) and after (solid lines) the upgrade

Light Source Parameters

Bending Magnets

Bending Radius	2.2 m
Critical Photon Energy	425 eV

BL3U In-vacuum Linear Undulator (U3A)

Number of Periods	50
Period Length	3.8 cm
Pole Length	1.9 m
Pole Gap	15 - 40 mm
Deflection Parameter	2.0 - 0.24

BL5U Helical Undulator /Optical Klystron (U5A)

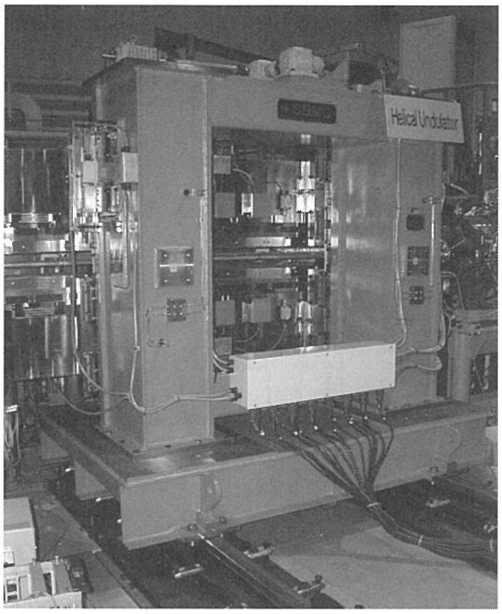
Number of Periods	18
Period Length	11 cm
Pole Length	2.35 m
Pole Gap	30 - 150 mm
Deflection Parameter	4.6 - 0.07 (helical)
	8.5 – 0.15 (linear)

BL7U In-vacuum Linear Undulator (U7A)

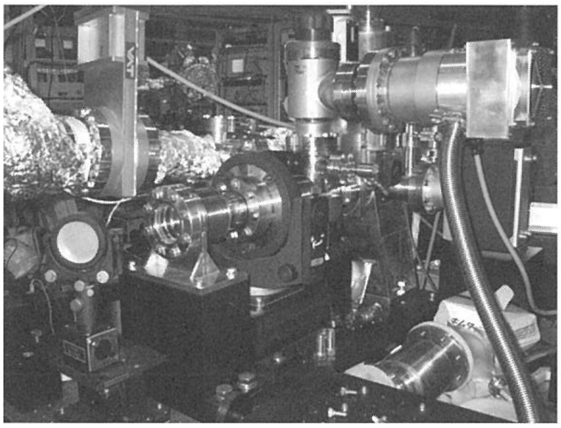
Number of Periods	26
Period Length	3.6 cm
Pole Length	0.94 m
Pole Gap	15 - 40 mm
Deflection Parameter	2.0 – 0.19

Basic Parameters of UVSOR-FEL

Free Electron Laser	
Wave Length	240～570 nm
Spectral Band Width	$\sim 10^{-4}$
Polarization	Circular
Pulse Rate	11.26 MHz
Maximum Average Power	1.2 W (at 570nm)
Optical Cavity	
Type	Fabry Perot
Cavity Length	13.3 m
Mirror	HfO_2, Ta_2O_5 multi-layer
Optical Klystron	
Polarization	Circular
Length	2.35 m
Period Length	11 cm
Number of Periods	9 + 9



BL5U Helical Undulator (Optical Klystron for FEL)



Optical Cavity for FEL at BL5U

Beamlines in 2002

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Eight bending magnets and two insertion devices are available for utilizing Synchrotron Radiation (SR) at UVSOR. There is a total of 20 operational beamlines, which are classified into two categories. 11 of them are so-called "Open beamlines", which are open to scientists of universities and research institutes belonging to the government, public organizations, private enterprises and those of foreign countries. The rest of the 9 beamlines are so-called "In-house beamlines", and are dedicated to the use of research groups within IMS. We have one soft X-rays (SX) station equipped with a double-crystal monochromator (DXM), nine extreme ultraviolet (EUV) and SX stations with a grazing incidence monochromator, four vacuum ultraviolet (VUV) stations with a normal incidence monochromator (NIM), one infrared (IR) station equipped with FT interferometers, one station with a multi-layer monochromator, and four non-monochromatized stations for irradiation of white-light. Discussion with users, concerning the improvements and upgrades of the beamlines at UVSOR, has been continuously held as series of UVSOR workshops. Recently, discussion for the reconstruction and rearrangement of several old beamlines has been initiated, on the basis of the review and evaluation report on the present status of UVSOR in 2000. The upgrade project of the UVSOR storage ring, in which the creation of four new straight sections and the achievement of much smaller emittance (27 nm-rad) have been planned, has been approved in the fiscal year of 2002. Keeping pace with this project, it has been determined that a new in-vacuum undulator and monochromator for BL3 and a new high-resolution photoelectron energy analyzer for the end station of BL5 will be introduced. The following is a summary list concerning the status of the beamlines in 2002.

<Open beamlines>

BL1A was initially constructed for SX photoabsorption spectroscopy, and then a high-resolution hemispherical electron energy analyzer (SCIENTA SES200) for photoelectron spectroscopy on solids was installed on this beamline in 1994. This beamline is equipped with a focusing premirror and a DXM. The monochromator serves SX in the photon energy range from 0.6 to 4 keV using several kinds of crystal-pairs such as β-Al_2O_3, beryl, KTP, quartz, InSb, Si, and Ge. In 2001, the experimental system for photoelectron spectroscopy was removed from BL1A. All activity on BL7A was transferred to BL1A till the end of March 2002 and BL1A has been completely converted to one of the open beamlines since May 2002.

BL1B covers the wavelength region ranging from 650 to 30 nm with the use of a Seya-Namioka type NIM. Standard measurements such as photoabsorption, reflection, and luminescence can be conducted at low temperatures down to 10 K. A variety of sample materials such as liquid, high pressure gases, and bio-specimens etc. can be measured easily by introducing appropriate windows.

The computer control system of the monochromator as well as the motor drivers has been renewed recently. It was found that the intensity of the monochromator output ranging from 40 to 200 nm becomes considerably smaller than that just after the installation of new gratings. New gratings will be installed during the shutdown in 2003.

BL2B1 consists of a Grasshopper monochromator, which covers the photon energy region from 20 to 800 eV, a double-pass cylindrical mirror analyzer (CMA), and an electroñion coincidence apparatus. This beamline has been used mainly for surface science because the experimental chamber is equipped with useful instruments for surface science such as LEED, Auger, Ar-ion gun, and gas-inlet system. Photoelectron spectroscopy and electroñion coincidence spectroscopy have been carried out on adsorbed surface and bulk material. No serious problem with the monochromator and photoelectron spectrometer has been met. However, the performance of the monochromator is far from satisfaction, comparing to modern monochromators. Discussion with users, concerning future plans for this beamline, has been initiated in 2001. Finally, it has been decided that BL2B1 will be shutdown in 2003.

BL3A1/BL3A2 can share intense synchrotron radiation from a planar-type undulator. At BL3A1, the intense undulator radiation has been used without the monochromator for SR stimulated processes such as etching and chemical vapor deposition (CVD), light-amplification, desorption, and luminescence experiments. BL3A2 is composed of a constant-length Spherical Grating Monochromator (SGM) and a rotatable time-of-flight (TOF) mass spectrometer for gas samples. Either undulator radiation or dipole radiation can be used as a light source at this beamline. It has been decided that the undulator and beamlines will be renewed in 2003, and accordingly all the activity on BL3A has been terminated until the end of March 2003. The reconstruction program for the new undulator based beamline BL3U has just begun.

BL5A is utilized for photoemission spectroscopy on solids and surfaces in the photon energy ranging from 5 to 250 eV using an SGM-TRAIN monochromator. The beamline is fitted for experiments on both valence bands and shallow core levels. Apart from SR from a bending magnet, circularly polarized radiation from a helical undulator is available at this beamline. The combined experiments with SR and the powerful laser system consisting of a TiS laser, RegA and OPA have been continuously performed in recent years. The original end station (a photoelectron spectrometer, and a spin- and angle-resolved photoelectron spectrometer) was removed from BL5A by the end of 2002. The preparation to use the undulator radiation in the low energy region is under way. A novel high-resolution photoelectron analyzer (MBS-TOYAMA A-1) will be installed in 2003.

BL5B is mainly used for the calibration of various optical elements and detectors in the photon energy region from VUV to SX. There are no similar beamlines at other facilities in Japan. BL5B has been contributing to many fields of research such as astro-science, nano-science, synchrotron science and technology for a long time. The beamline consists of a plane grating monochromator (PGM) and three experimental chambers in tandem, which are utilized for the calibration of optical elements using a goniometer, optical measurements of solids, and photo-stimulated desorption experiments. The control systems for the goniometer and monochromator, which have become too old for use, will be improved during the shutdown in 2003.

BL6A1 is used as a unique IR and FIR beamline. This beamline is composed of FT-IR and FT-FIR interferometers, which covers a wide wavelength range from sub-milli to near IR region. Numerous research work on molecular sciences, using different experimental techniques such as high-pressure with a diamond anvil cell, magnetic circular dichroism, and time-dependence, have been carried out. In 2002, new adjusting systems for two mirrors were introduced, in order to make beam alignment much easier. Reflection and transmission spectroscopy at low temperatures became feasible with the use of a newly introduced cryostat. Parallel to the UVSOR upgrade project, the renewal of the vacuum duct at BL6 was initially scheduled in the spring of 2003, but has been postponed until the regular shutdown in spring 2004.

BL7B consists of a 3-m NIM working in the photon energy range from near IR to VUV with a high resolving power. This beamline is mainly used for absorption, reflection, and fluorescence spectroscopy on solids. Although the installation of the monochromator was time-consuming, it has been shown that the performance of BL7B is sufficiently high enough to carry out spectroscopic investigations on solid samples with high resolution. In addition to the previously introduced photodiode in the sample chamber, a photomultiplier and an electronmultiplier are ready for use as a detector. Small modification to the manipulator with a cryostat has been made, to irradiate the whole area of the sample holder by SR. The 600 l/mm grating is planned to be replaced during the shutdown in 2003, since its photon intensity in the wavelength region from 80 to 150 nm is too low.

BL8A has no monochromator and is simply equipped with a differential pumping stage that makes it useful for measurements on gases as well as on solids. A focusing mirror having toroidal shape can be used to obtain a smaller irradiation area, if necessary. There is no permanent end-station installed at this beamline, which enables users to install their own instruments brought from their institute or university. The UVSOR facility will support the installation of the users' experimental setup. Experiments on SR-CVD and SR-etching have extensively been carried out on this beamline in recent years. A collaboration study between UVSOR and KEK for investigating the mechanism of the carbon contamination on mirror surfaces has been conducted here.

BL8B1 is used for coincidence spectroscopy on gas samples in the photon energy range from 30 to 800 eV, where the K-shell ionization thresholds of chemically important elements like C, N, and O lie, using a high-resolution constant-deviation constant-length SGM. The experimental chamber at the end-station is composed of a TOF and a CMA, which makes it possible to perform the coincidence measurements between energy-analyzed electrons and photoions. Total electron yield measurements on solid samples are also possible. The gas phase experiments have been finished. Modification to the scanning mechanism of the monochromator, which can improve its reliability and reproducibility, is scheduled during the shutdown in 2003.

<In-house beamlines>

BL2A was constructed for spectroscopic investigations on gas samples and have produced many scientific results. The monochromator installed at BL2A is a Seya-Namioka type NIM. Recently this beamline has been rearranged for bioscience and has been utilized by bio-scientists in the Okazaki organization. However, it is unfortunate that there has been no activity on this beamline since 2001, and it has been decided that no maintenance fee for this beamline will be provided any further.

BL2B2 is an EUV and SX beamline used for gas phase experiments. The monochromator is a Dragon-type SGM, which has commissioned in 1999. There was a serious problem on the scanning mechanism of the monochromator, which has been already fixed. Photoionization efficiency curves and time-of-flight mass spectra for some fullerene samples have been measured in 2002. Some structures at the higher energy side of the giant resonance peak in C_{60} were newly found.

BL3B consists of a 3-m NIM and an angle-resolved electron energy analyzer with a two-dimensional detector. This beamline has been used for spectroscopic investigations in the gas phase, and has been providing interesting results for a long time. Adjustment of the analyzer has been continuously performed. In 2002, oxygen and chlorine radicals have been investigated using photoelectron spectroscopy.

BL4A1/4A2 are used for investigations on the reaction mechanism of SR stimulated processes. A multilayered-mirror monochromator for studying the SR etching processes is installed at BL4A1. There is no monochromator, but there are two branch lines (scanning tunneling microscopy (STM) and infrared reflection absorption spectroscopy) on BL4A2. Modification to the beamline components has been made for switching SR utilization from monochromatic to white light easily. SR irradiated ablation processes of glass as well as Teflon have been observed lately.

BL4B is a high-resolution beamline in the SX region (100□1000 eV). The monochromator is a Varied-line-spacing PGM. This beamline is utilized for various spectroscopic studies with high resolution in the SX range. There is no permanent experimental instrument installed at this beamline. Spin-forbidden shake-up satellites of small molecules have been observed using high-resolution resonant Auger spectroscopy in recent years. Inner-shell excitation spectra of diatomic molecules and rare gas atoms trapped in rare gas matrices have been extensively investigated. Very recently, a new spectroscopic technique for probing multielectron processes in molecular inner-shell photoabsorption spectra has been tested.

BL6A2 was composed of a PGM and a photoelectron spectromicroscopy equipment (micro-ESCA, VG ESCALAB 220i-XL). In order to create a blank port preparing for future construction of a new undulator based beamline, the monochromator and the apparatus were detached from the beam in 2002. The responsibility for the micro-ESCA apparatus has been transferred to Prof. Yokoyama's group (Department of Molecular Structure).

BL6B has been renewed for nano-scale photochemical reaction experiments. There is no monochromator on this beamline. An STM apparatus that can be operated under ultra high vacuum condition (UHV-STM) has been installed at BL6B, in order to make in situ observation for the photochemical reaction processes on Si(111) surfaces stimulated by SR irradiation. The transference of the UHV-STM instrument to BL7A, where the new in-vacuum undulator is available, was completed in April 2003.

BL8B2 is utilized for angle-resolved photoelectron spectroscopy on various organic solids such as molecular crystals, organic semiconductors, and conducting polymers. This beamline consists of a PGM, which covers the photon energy region form 2 to 150 eV, a sample preparation, a measurement, and a cleaning chamber. A high-performance multi-channel photoelectron spectrometer has been installed and its coordination has been terminated. There are 6 users' groups for utilizing this beamline. The introduction of a new cryostat for low temperature experiments is under preparation.

All users are required to refer to the beamline manuals and the UVSOR guidebook (latest revision in 1999), on the occasion of conducting the actual experimental procedures. Those wishing to use the open and in-house beamlines are recommended to contact the stationmaster/supervisor and the representative, respectively. For updated information of UVSOR, http://www.uvsor.ims.ac.jp/.

Table I. Station masters and supervisors of open beamlines in 2002

Beamline	Station Master	Sub Master	Supervisor
1A	N. Kondo	E. Shigemasa	E. Shigemasa
1B	M. Hasumoto	S. Kimura	S. Kimura
2B1	K. Takahashi	E. Nakamura	S. Kimura
3A1	E. Nakamura	E. Shigemasa	E. Shigemasa
3A2	N. Kondo	T. Gejo	E. Shigemasa
5A	K. Takahashi	S. Kimura	S. Kimura
5B	M. Hasumoto	E. Nakamura	E. Shigemasa
6A1	S. Kimura	E. Nakamura	S. Kimura
7B	M. Hasumoto	S. Kimura	S. Kimura
8A	T. Gejo	E. Nakamura	E. Shigemasa
8B1	T. Gejo	N. Kondo	E. Shigemasa

Table II. Representatives of in-house beamlines in 2002.

Beamline	Representative	Affiliation
2A	N. Kosugi	Dep. VUV Photoscience
2B2	K. Mitsuke	Dep. VUV Photoscience
3B	K. Mitsuke	Dep. VUV Photoscience
4A	T. Urisu	Dep. VUV Photoscience
4B	E. Shigemasa/N. Kosugi	UVSOR/Dep. VUV Photoscience
6A2	T. Urisu	UVSOR
6B	T. Urisu	Dep. VUV Photoscience
8B2	K. Okudaira	Dep. VUV Photoscience

Beamlines at UVSOR

Beam Line	Monochromator, Spectrometer	Wavelength Region	Acceptance Angle (mrad) Horiz.	Vert.	Experiment
BL1A	Double Crystal	2.1 - 0.3 nm	4	1	Solid (absorption)
BL1B	1-m Seya- Namioka	650 - 30 nm	60	6	Solid (absorption)
BL2A	1-m Seya- Namioka	400 - 30 nm	40	6	photoabsorption
BL2B1	2-m Grasshopper	60 - 1.5 nm	10	1.7	Solid &surface (photoemisson)
BL2B2	18-m Spherical Grating	60 - 6 nm	15	6	Gas (photoionization, photodissociation)
BL3A1	None (Filter, Mirror)	(U)	0.3	0.3	Solid &irradiation (photodissociation)
BL3A2	2.2-mConstant Deviation Grazing Incidence	100 - 10 nm (U)	10 0.3	4 0.3	Gas &solid (photoionization & photodissociation)
BL3B	3-m Normal Incidence	400 - 30 nm	20	6	Gas (photoemission)
BL4A1	Multi-Layered-Mirror Monochromator	13 - 23 nm Mo/Si MLMs	16.6	12.8	Irradiation
BL4A2	None				SR-CVD
BL4B	Varied-line-spacing Plane Grating Monochromator	15 - 1.5 nm	7.5	2	Gas (photoionization, photodissociation) & solid (photoemission)
BL5A	None SGM-TRAIN	(OK) 250 - 5 nm	 10	 3	FEL Solid (photoemission)
BL5B	Plane Grating	200 - 2 nm	10	2.2	Calibration, gas (photodissociation) & solid (absorption)
BL6A1	Martin-Puplett FT-IR Michelson FT-IR	3000 - 30 μm 100 - 1 μm	80 80	60 60	Solid (absorption)
BL6A2	Plane Grating	650 - 8 nm	10	6	Solid &surface (photoemission)
BL6B	None		8.3	6	Irradiation
BL7A	None	(U)	Under construction		
BL7B	3-m Normal Incidence	1000 - 50 nm	65	10	Solid (absorption)
BL8A	None (Filter)		25	8	Irradiation & user's Instrum.
BL8B1	15-m Constant Deviation Grazing Incidence	40 - 2 nm	10	1.5	Gas (photoionization, photodissociation) & solid (absorption)
BL8B2	Plane Grating	650 - 8 nm	10	6	Solid (photoemission)

SGM-TRAIN: spheri cal grating monochromator with translating and rotating assembly including normal incidence mount

U: with an undulator

OK: with an optical klystron

BL1A

Soft X-Ray Beamline for Photoelectron-Photoabsorption Spectroscopy

BL1A is a soft X-ray beamline for photoabsorption spectroscopy. The beamline is equipped with a focusing premirror and a double crystal monochromator [1]. The monochromator serves soft x-rays in the energy range from 585 to 4000 eV by using several kinds of crystals such as β-Al_2O_3, beryl, KTP ($KTiOPO_4$), quartz, InSb, and Si crystals. The throughput spectra are shown in Fig. 1. Typical energy resolution ($E/\Delta E$) of the monochromator is about 1500 for beryl and InSb. The apparatus for photoelectron and photoabsorption spectroscopies was removed from the beamline last summer. The experimental setup for photoabsorption spectroscopy of BL7A will be moved to this beamline, which will be opened for the researchers outside IMS from May, 2002.

Reference

[1] A. Hiraya et al., *Rev. Sci. Instrum.*, **63** (1992) 1264.

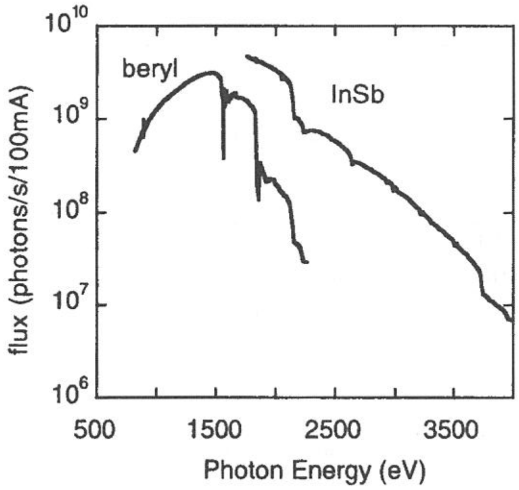


Figure 1. Throughput spectra of the double crystal monochromator at BL1A.

Specification

Monochromator:	double crystal monochromator
Monochromator crystals: (2*d* value, energy range)	β-Al_2O_3 (22.53Å, 585-1609eV), beryl (15.965Å, 826-2271eV), KTP (10.95Å, 1205-3310eV), quartz (8.512Å, 1550-4000eV), InSb (7.481Å, 1764-4000eV), Si (6.271Å, 2104-4000eV)
Resolution:	$E/\Delta E$=1500 for beryl and InSb
Experiment:	photoabsorption spectroscopy for solid

BL1B

Seya-Namioka Monochromator for General Purposes

BL1B has been constructed to perform various spectroscopic investigations such as absorption, reflectivity, and luminescence in a condensed phase. This beamline consists of a pre-focusing mirror, a 1-m Seya-Namioka type monochromator, and post-focusing mirrors with different focal lengths. Three gratings of 600, 1200, and 2400 l/mm can cover the wavelength region ranging from 40 to 650 nm. The post mirror with a longer focal length is usually used with an LiF window to separate the vacuum condition of the monochromator from a main experimental station, which make experiments for liquids and bio-specimens possible, while the other is mainly utilized for solid-state spectroscopy.

The output flux from this monochromator is about 10^{10} photons/sec. around 200 nm with 0.1 mm slit openings. The spectral distributions for two gratings measured by a conventional photomultiplyer are shown in Fig. 1 A second monochromator (Spex 270M) and a LN-cooled CCD detector (Princeton Inc.) are available for luminescence measurements, together with a liquid helium-flow type cryostat. To perform time-resolved experiments, a TAC system is also available.

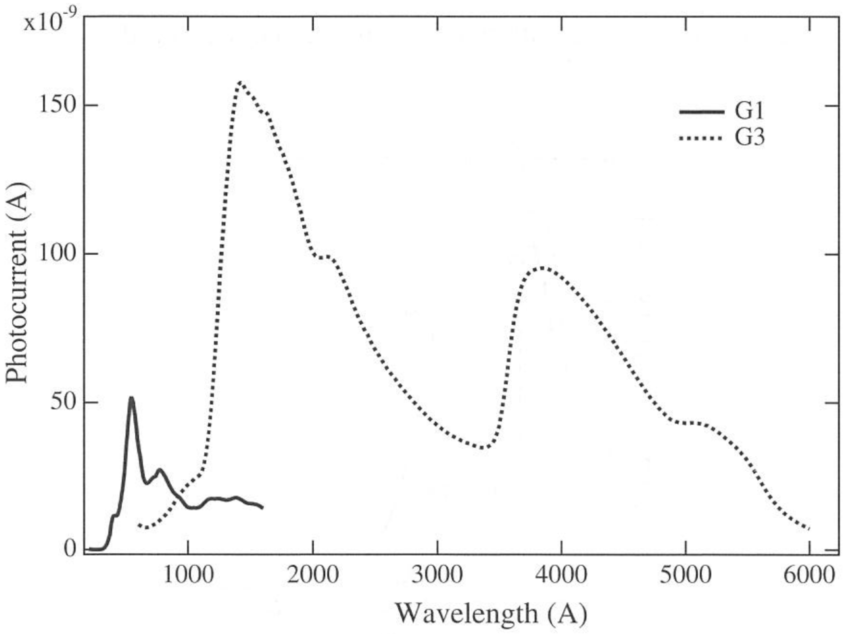


Figure 1. Photocurrent from the Seya-Namioka monochromator on BL1B.

Specification

Monochromator: 1-m Seya-Namioka type

Energy range: 40 to 600 nm (2-30 eV)

Resolution: E/ΔE~1000 at 100 nm

Experiments: Absorption, reflection, luminescence spectroscopy for solids

BL2A

Gas Phase Photoabsorption and Fluorescence Spectroscopy

Photoabsorption cross section and fluorescence excitation spectra of gaseous sample are simultaneously measured in a vacuum cell or effusive jet condition. The primary photons in the 30-400 nm region are dispersed by a 1-m Seya monochromator. Higher order light in the 80-120nm range is suppressed by using a long channel with a cross section 2.5 × 5.0 × 170 mm long filled with argon gas at a pressure ~0.3 Torr as shown in Figure 1. No filter is used between 30 and 80 nm since the photon flux at λ<40 nm is very weak (see Figure 1). The gas filter and cell are placed in a main chamber, which is evacuated by a 600 *l*/s turbo molecular pump (SII, STP600C). A LiF window is used for the measurement at the 105<λ<210 nm range as usual. Thus the total photoabsorption cross section and fluorescence excitation spectra are available in the wide wavelength region 30-210 nm without or with little contamination by the higher order light. Dispersed fluorescence and polarity of emission from the excited fragment are also measurable in addition to the total photoabsorption and emission cross sections. In the single bunch operation of synchrotron radiation with the period of 178 ns, a radiative lifetime can be measured.

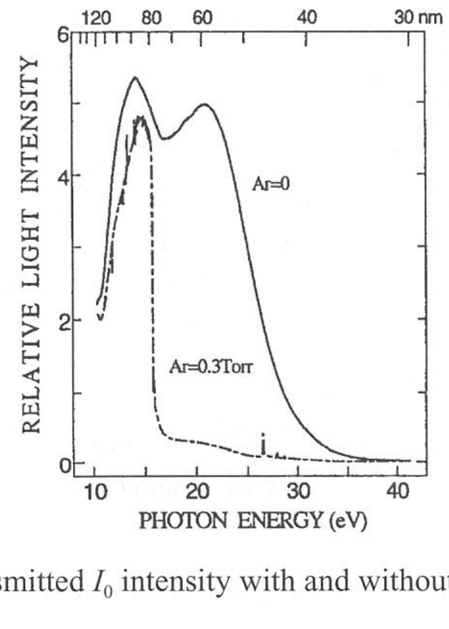


Figure 1. Transmitted I_0 intensity with and without an Ar gas filter.

Specification

Monochromator: 1-m Seya

Wavelength range: 30-400nm

Resolution: $E/\Delta E$=1000 at 100 nm

Grating: 1200 line/mm blazed at 96nm

Experiments: Vacuum cell or effusive jet, Total photoabsorption cross section, Fluorescence cross section, Dispersed fluorescence, Radiative lifetime, Emission polarity

BL2B1

Soft X-ray Beamline for Solids and Surfaces

BL2B1 has been used for soft X-ray absorption and photoelectron spectroscopies of solids and surfaces. A 2-meter grazing incidence monochromator ('Grasshopper' type, Mark XV; Baker Manufacturing Co.) is installed, which serves soft X-rays in the energy range from 95 to 1000 eV using a 1800 l/mm grating. The resolving power is better than 600 at C K-edge (about 290 eV). A double-pass cylindrical mirror analyzer (CMA), a LEED of reverse type, a quadrupole mass spectrometer, and an ion-gun for sputtering are installed in the analyzing chamber. A pulsed leak-valve and a variable leak-valve are also installed. The samples can be cooled with a liquid helium cryostat. The base pressure of the analyzing chamber is better than 1×10^{-10} Torr. The photoelectron spectroscopy including constant initial-state spectroscopy (CIS) and constant final-state spectroscopy (CFS) can be conducted using the double-pass CMA. Besides these standard photoemission measurements, electron-ion-coincidence (EICO) spectroscopy can be carried out on adsorbed surfaces and bulk materials. In 1999, a new version of an EICO instrument has been installed, resulting in better efficiency on collecting data. The users who plan to perform the EICO measurement should make contact with the EICO users group. The sample preparation chamber equipped with a load-lock chamber is connected to the analyzing chamber. Sample treatments such as cleaving, filing, and deposition can be made under the ultra-high vacuum condition.

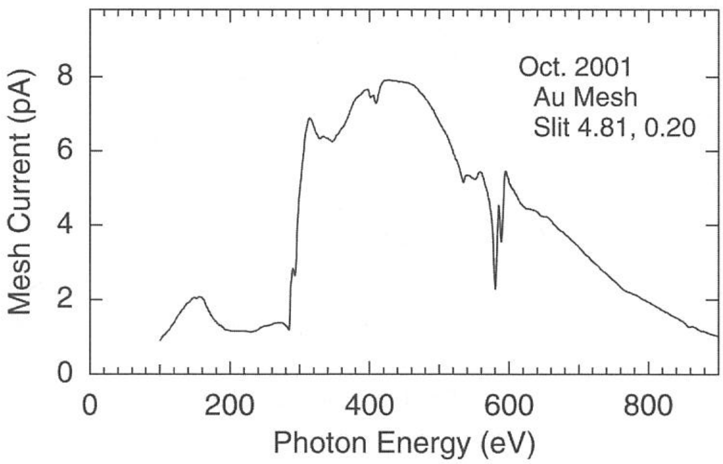


Figure 1. The photoelectron yield from a Au mesh of 90 % transmission located between the refocusing chamber and the sample.

Specification

Monochromator	: 2 m grasshopper type
Energy range	: 95-1000 eV (1800 l/mm)
Resolution of photon	: < 0.4 eV at 300 eV
Resolution of photoelectron	: < 0.3 eV for hν = 150 eV
Experiment	: Photoelectron spectroscopy, X-ray absorption spectroscopy, Electron-ion-coincidence spectroscopy

BL2B2

Beamline for Gas Phase Photoionization and Photodissociation Dynamics

This beamline has been developed for the purpose of studying ionization, excitation and decay dynamics involving inner-valence electrons or $2p$ electrons of the third row atoms. The monochromator is a spherical grating Dragon-type with 18 m focal length. High throughput (1×10^{10} photons s^{-1}) and high resolution ($E/\Delta E$ = 2000 - 8000) are achieved simultaneously under the condition of the ring current of 100 mA [see Fig. 1 and M. Ono *et al.*, *Nucl. Instrum. Meth. Phys. Res. A* **467-468**, 577 (2001)]. A second-order light of 7 % is contained at a photon energy of 45.6 eV (G3).

The optical system consists of two prefocusing mirrors, an entrance slit, spherical gratings (G1, G2 and G3), two folding mirrors, a movable exit slit and a refocusing mirror. The monochromator is designed to cover the energy range of 23 - 205 eV with the three gratings: G1 (2400 lines mm^{-1}, R = 18 m) at 80 - 205 eV; G2 (1200 lines mm^{-1}, R = 18 m) at 40 - 100 eV, G3 (2400 lines mm^{-1}, R = 9.25 m) at 23 - 50 eV. The including angles are 160° for G1 and G2, and 140° for G3. The detailed parameters of the optical elements are described elsewhere [H. Yoshida and K. Mitsuke, *J. Synchrotron Radiat.* **5**, 774 (1998)].

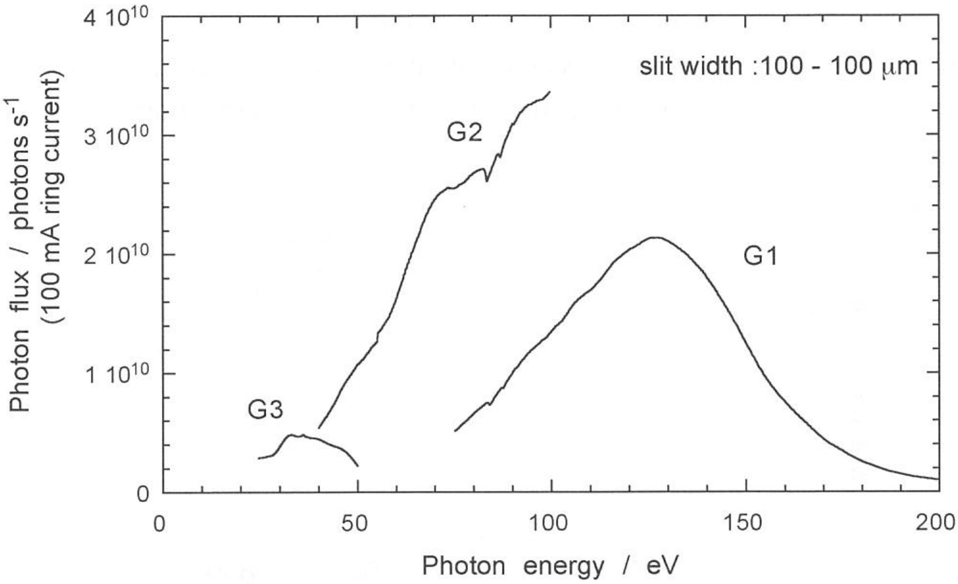


Figure 1. Photon flux at the end station at a 0.1 A ring current when the entrance- and exit-slit widths are set to 100 μm. The SR is provided from a bending magnet.

Specification

Monochromator: 18-m spherical grating grazing-incidence of Dragon-type
Energy Range: 6 – 54 nm (23 – 205 eV)
Resolution: $E/\Delta E$ = 2000 – 8000 (ΔE = 5 – 45 meV)
Experiments: TOF mass spectrometry, Symmetry-resolved photoabsorption spectroscopy, and Two-dimensional photoelectron spectroscopy

BL3A1

Irradiation Port for Undulator Radiation

BL3A1 has been mainly used for irradiation experiments such as photo-chemical reaction, SR-CVD, photo-etching, irradiation damage effects in condensed phase, light amplification induced by core-revel excitation. The experiments that need a very high intensity photon beam, namely, luminescence yield measurements and time-response measurements of SR-induced desorption, are also performed on this beamline.

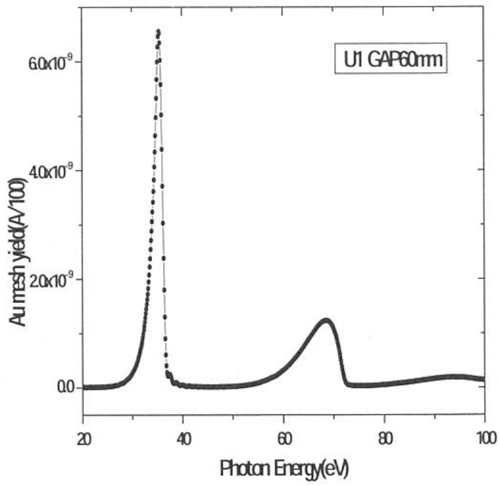
A planar-type undulator installed in a long straight section of the UVSOR storage ring provides an intense quasi-monochromatic radiation to BL3A1. The undulator has 24 periods with a period length of 80 mm. The photon energy ranging from 8 to 52 eV can be covered by the fundamentals with K-values from 0.62 to 3.6, although higher harmonics are also generated at the same time.

This beamline has no monochromator between the undulator and the sample chamber. The radiation is introduced into the sample chamber only by a toroidal focusing mirror through a pinhole with 1 mm in diameter followed by a metallic filter (Al, Sn, or In). A gold mesh is installed in the sample chamber to monitor the photon beam intensity. The photocurrent measured using the monochromator at BL3A2 is shown in the figure below, when the undulator gap was set at 60 mm. The photon flux at the sample position is estimated to be about 10^{14} photons/sec.

A differential pumping system can be utilized for experiments in a gas phase. MgF_2 windows can also be installed to isolate the sample chamber from the beamline, which make experiments for high-pressure gases, liquids, and bio-specimens possible. A monochromator (Jobin-YvonHR-302), a VUV monochromator (home-made, normal-incident type), a helium storage-type cryostat and a TAC system are available.

Specification

Type	: planar-type undulator
Source emittance	: 164 nmrad
Period	: 80 mm
Number of periods	: 24
Magnetic field	: Kmax 3.6
Photon Fulux	: 10^{14} photons/s at 34eV
Energy range	: 8-52eV



BL3A2

Gas-Phase Dissociative Photoionization Apparatus

BL3A2 has been constructed to study the formation of multiply charged molecular ions and their dissociation processes. The monochromator is a constant-deviation grazing incidence type with 2.2-m focal length (2.2-m CDM) and covers wide wavelength region (10-100 nm) where many kinds of molecules and multiply charged ions are effectively measured. Fig. 1 shows the absolute photon flux for each grating installed to CDM, with the use of the dipole radiation. Higher intensity photon beam is available by introducing the undulator radiation to CDM. The apparatus at the end station contains an angle-resolved time-of-flight mass spectrometer equipped with automatic data acquisition system for photoion-photoion coincidence measurements. It has been decided that the undulator and beamline will be renewed in 2003.

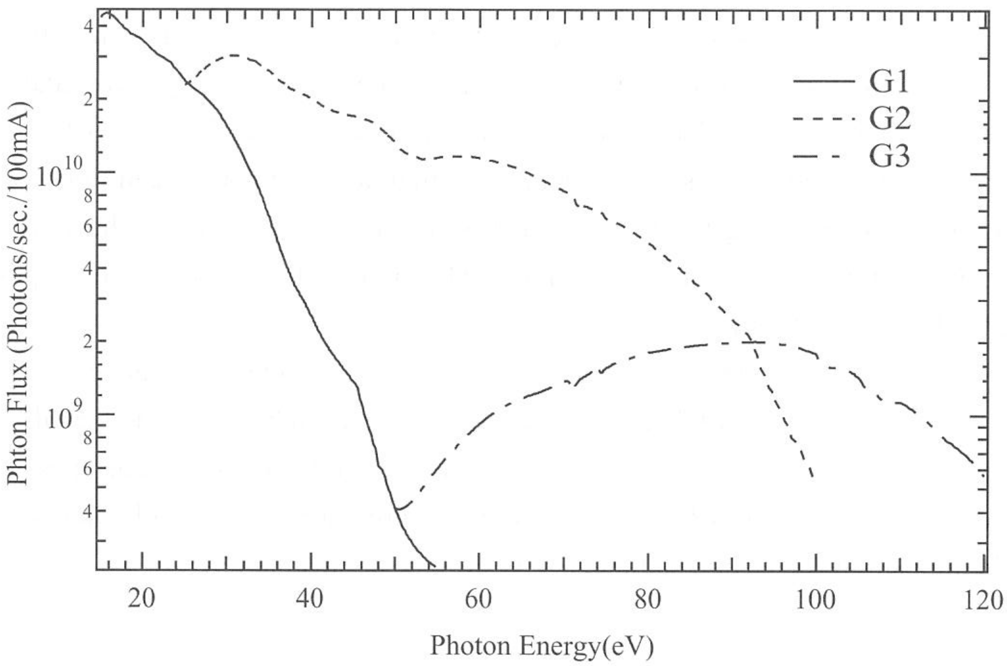


Figure 1. Throughput from the 2.2-m CDM monochromator on BL3A2.
(SR from the bending magnet)

Specification

Monochromator: 2.2-m Constant-Deviation Grazing-incidence
Energy range: 10 to 100 nm (15-120 eV)
Resolution: E/ΔE~550-800 (ΔE~0.03-0.18 eV)
Experiments: TOF photoion spectroscopy for gaseous targets
(variable drift-tube-length: 0.2-1.0 m)
Rotatable angle: 0-90° relative to the electric vector of SR

BL3B

Beam line for Gas Phase Two-Dimensional Photoelectron Spectroscopy

This beam line is devoted to studies of elementary atomic and molecular processes induced by excitation of valence electrons. A monochromator is a vertically dispersed normal incidence type with 3m focal length and 10° angle between the incident and diffracted photon beams. The maximum wavelength resolution of 0.007nm is narrow enough to separate vibrational levels of excited states for various molecules. A main component in an experimental chamber is a spherical sector electrostatic energy analyzer which has been designed and setup for photoelectron spectroscopy. One can perform two-dimensional photoelectron spectroscopy with good resolution (≤ 30meV) in which the photoelectron yield is measured as a function of both photon energy and electron kinetic energy (binding energy). A two-dimensional spectrum, usually represented as a contour plot, contains rich information on photoionization dynamics and properties of superexcited states. For more details, please see the following papers: K. Mitsuke *et al.*, *J. Electron Spectrosc. Rel. Phenom.* **79**, 395 (1996); H. Hattori and K. Mitsuke, *ibid.* **80**, 1 (1996); H. Hattori *et al.*, *J. Chem. Phys.* **106**, 4902 (1997); Y. Hikosaka *et al.*, *ibid.* **105**, 6367 (1996); Y. Hikosaka *et al.*, *ibid.* **107**, 2950 (1997); **110**, 335 (1999); K. Mitsuke *et al.*, *J. Electron Spectrosc. Rel. Phenom.* **112**, 137 (2000).

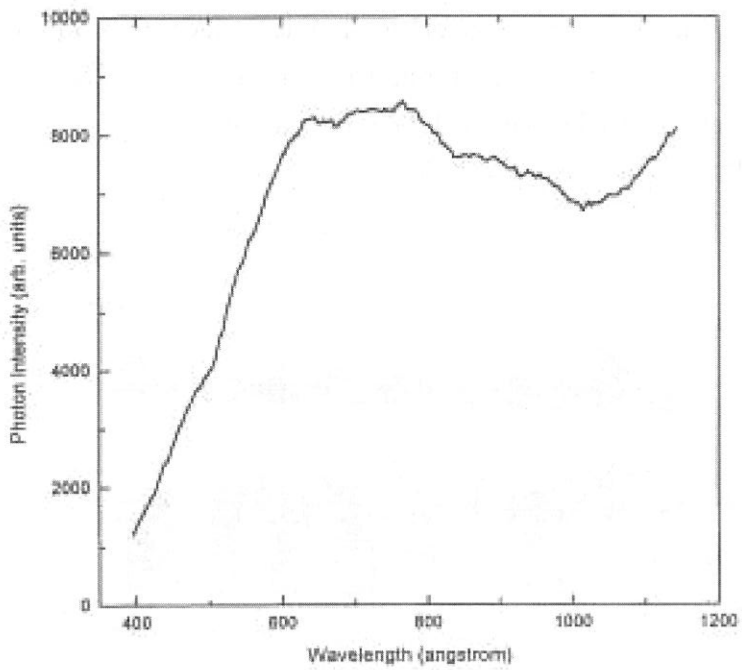


Figure 1. Relative photon intensity at the sample point.

Specification

Monochromator: Vertically dispersed normal incidence type with 3 m focal length

Grating: aberration-corrected concave type with 1200 lines/mm grooves

Energy Range: 30 – 200 nm (6 – 40 eV)

Resolution: $E/\Delta E$ = 14000 at 100 nm (ΔE = 0.9 meV) with the slit widths of 10 μm

Experiments: TOF mass spectrometry and Two-dimensional photoelectron spectroscopy

BL4A1

Multilayered-mirror monochromator beam line for the study of synchrotron radiation stimulated process

A multilayered-mirror (MLM) monochromator beam line designed specially for synchrotron radiation (SR) stimulated process experiments has been constructed for the first time. The most important point in constructing an MLM monochromator beam line for the study of SR-stimulated processes is the optimization of the beam line optics to obtain a large photon flux. The second most important point is to remove the background existing in the low energy region caused by the total reflection. Optimization concerning the reduction of the low-energy background due to the total reflection has been made for the combination of the Mo/Si MLMs and the C filter. Mo/Si MLMs have a (normal incident) reflectivity of over 60% can be made for the energy region around 100eV, which contains the core electron binding energies of Al and Si (important material in semiconductor processes). The beam line was designed by the criteria; a beam spot size on the sample surface $\geq 3 \times 3$ mm^2, a density of total irradiated photons $\geq 10^{18}$ photons/cm^2 (for an irradiation time of a few tens of minutes to a few hours) and low-energy background ≤ 1 % of the output. [1]

[1] H. Mekaru, et. al., Rev. Sci. Instrum., 70, 2601-2605 (1999).

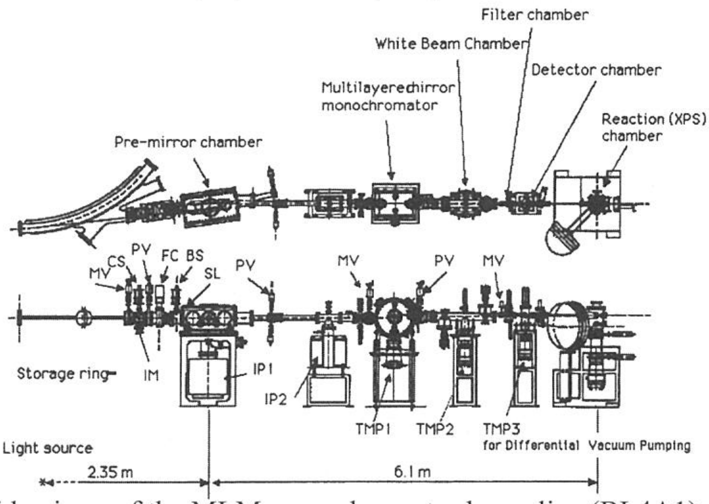


Figure 1. Top and side views of the MLM monochromator beam line (BL4A1) constructed at the UV-SOR facility of the IMS.

Specifications

Monochromator:	Multilayered-mirror monochromator
Wavelength range:	13.3 - 22.5 nm
Resolution:	5 - 9 eV (FWHM)
Experiments:	Excitation energy dependence of the SR processing

BL4A2

SR-CVD beam line

This beam line is used for SR-CVD and photo-etching experiments. The beam line has no monochromator for high photon flux to irradiate and consists of only two mirrors. One is for focussing and the other is for branching. At the beam line, the gas supply and extinction system is equipped for using legally controlled high pressure gasses such as SiH_4, Si_2H_6 and GeH_4. They are commonly used to CVD of semiconductor crystals.

The SR-CVD and photo-etching chambers are connected to the beam line as shown in Fig. 1. In those chambers, IRRAS system is installed to study surface photochemistry on Si surfaces adsorbed by various kinds of molecules.

BL4A2 has one branch for ultra high vacuum STM chamber. Now, the branch is under construction.

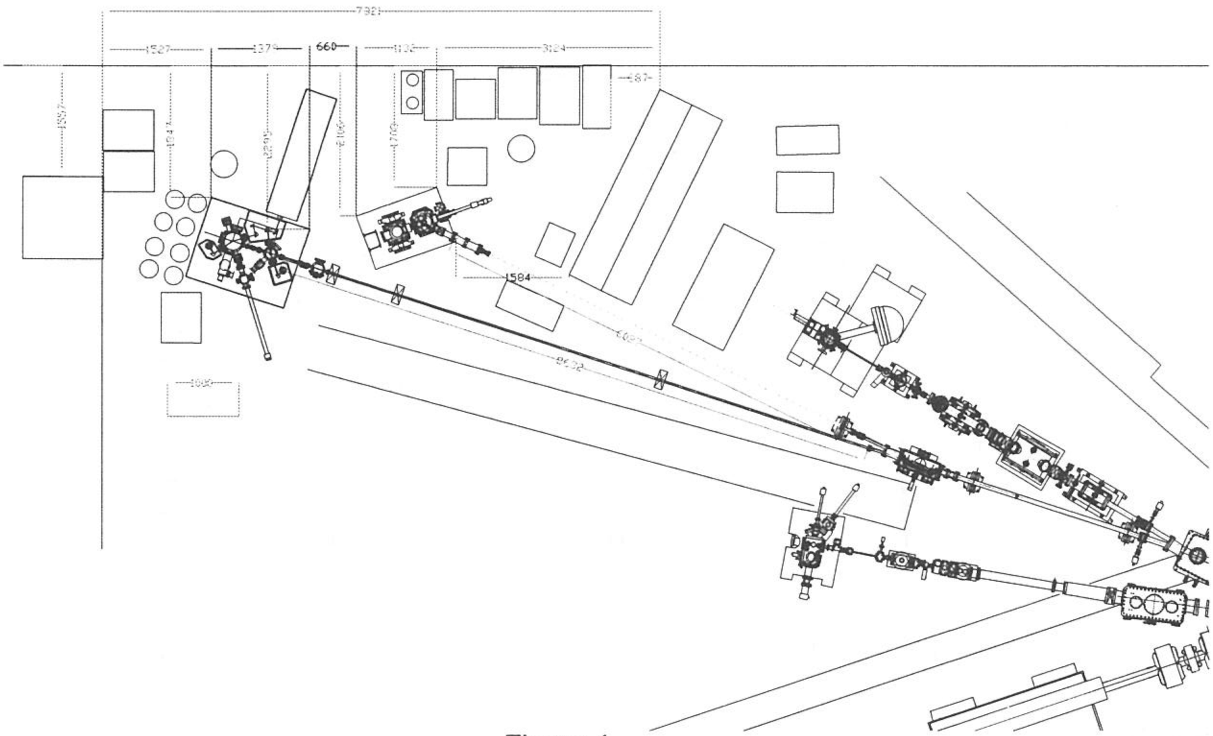


Figure 1.

Specifications

Spectral range: whole range of synchrotron radiation from UVSOR

BL4B

Varied-line-spacing Plane Grating Monochromator for Molecular Soft X-ray Spectroscopy

The beamline BL4B equipped with a varied-line-spacing plane grating monochromator (VLS-PGM) was constructed for various spectroscopic investigations in a gas phase and/or on solids in the soft X-ray range. Two holographically ruled laminar profile plane gratings with SiO_2 substrates are designed to cover the photon energy range from 80 eV to 1000 eV. The gratings with the groove densities of 267 and 800 l/mm cover the spectral ranges of 75-300 and 220-1000 eV, respectively, and are interchangeable without breaking the vacuum. Fig. 1 shows the absolute photon flux for each grating, with the entrance- and exit-slit openings set at 25 and 10 μm, respectively. Under this condition, the corresponding resolving power is expected to be more than 3000.

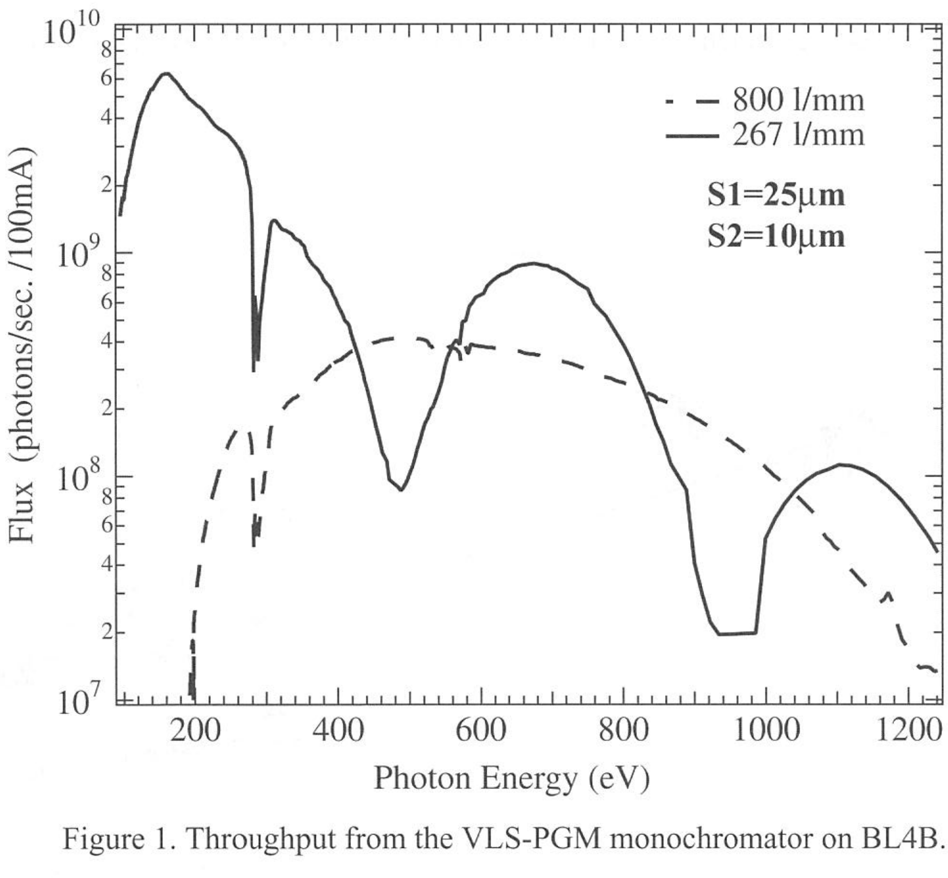


Figure 1. Throughput from the VLS-PGM monochromator on BL4B.

Specification

Monochromator: Varied-line-spacing plane grating monochromator

Energy range: 75 to 1000 eV

Resolution: E/ΔE>5000 (at maximum)

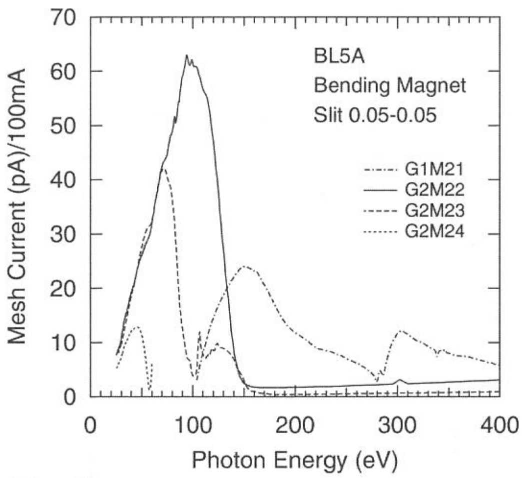
Experiments: Soft X-ray spectroscopy (mainly, angle resolved photoion spectroscopy for gaseous targets and photoelectron spectroscopy for gaseous and solid targets)

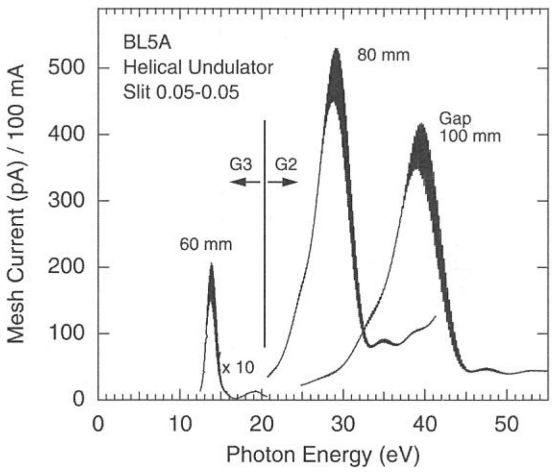
BL5A

Photoelectron Spectrometer for Solids and Surfaces

This beamline is designed for spin- and angle-resolved photoemission study for solids and surfaces with the circularly polarized synchrotron radiation from a helical undulator and for high-resolution photoemission spectroscopy with bending magnet radiation. The beamline consists of a Spherical Grating Monochromator with Translational and Rotational Assembly Including a Normal incidence mount (SGM-TRAIN), a spin- and angle-resolved photoelectron spectrometer, and a high-resolution photoelectron spectrometer.

The SGM-TRAIN is an improved version of a constant-length SGM to aim the following points; (1) wide energy range of 5-250 eV, (2) high resolving power, (3) use of linearly and circularly polarized light, (4) reduction of second-order light, and (5) two driving modes by a computer control. The second-order light is well suppressed by using laminar-profile gratings and combinations of mirrors and gratings.





Specifications

1. Monochromator
   - Type : SGM-TRAIN
   - Energy range : 5-250 eV
   - Resolution : 0.5-80 meV (with slits width of 0.01 mm)
   - Flux : 3×10^{10} photons/s for bending magnet radiation (at 120 eV with slits width of 0.1 mm)
     1×10^{12} photons /s for undulator radiation in MPW mode
2. Main Instruments
   - Two-levels UHV chamber (1×10^{-10} Torr)
   - Hemispherical electron energy analyzer (OMICRON, EA125-HR)
   - Spin- and Angle-resolved spectrometer (low-energy diffused scattering type)
   - LEED of reverse type (OMICRON)
   - Ion-gun (ULVAC-Phi)
   - Low-temperature cryostat (above 30 K)
3. Helical Undulator (Optical Klystron)

Number of periods	18
Period length	110 mm
Fundamentals	2-45 eV (Circularly polarized)

BL5B

Calibration Apparatus for Optical Elements

BL5B has been constructed to perform calibration measurements for optical elements and detectors. This beamline is composed of a plane grating monochromator (PGM) and three end stations in tandem. The most upstream station is used for calibration measurements of optical elements, the middle one for optical measurements for solids and the last for photo-stimulated desorption experiments. The experimental chamber at the most downstream station is sometimes changed to a chamber for photoemission spectroscopy.

The calibration chamber is equipped with a goniometer for the characterization of optical elements, which has six degrees for freedom; X-Y translation of a sample, and interchange of samples and filters. These are driven by pulse motors in vacuum. Since the polaziation of synchrotron radiation is essential for such measurements, the rotation axis can be made in either horizontal or vertical direction (s- or p-polarization).

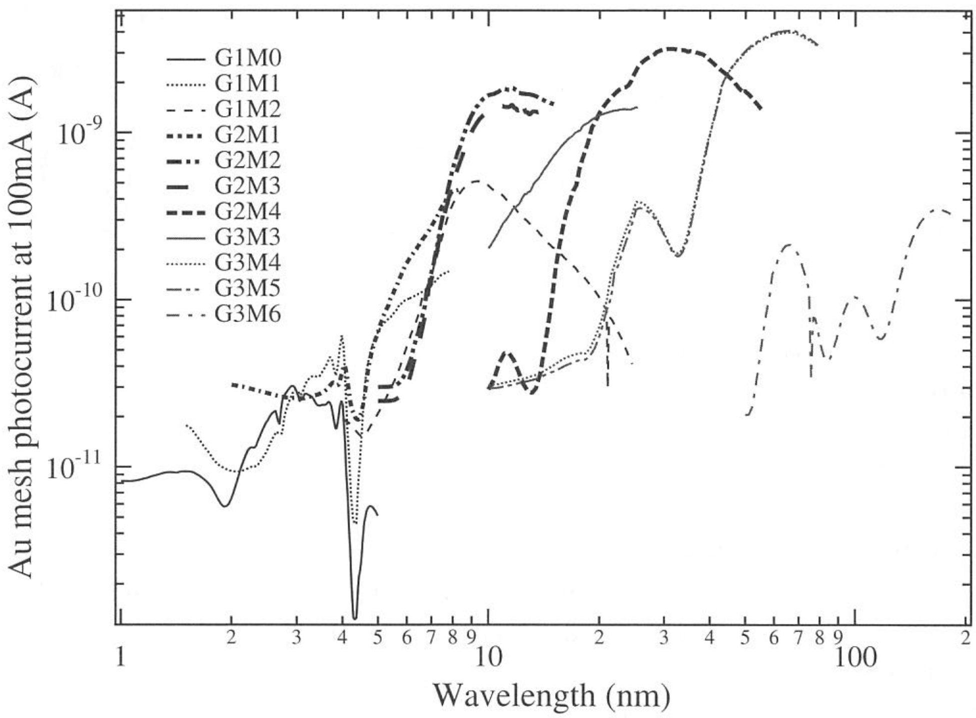


Figure 1. Throughput spectra of BL5B measured by a gold mesh.

Specification

Monochromator: Plane grating

Energy range: 2 to 200 nm (6-600 eV)

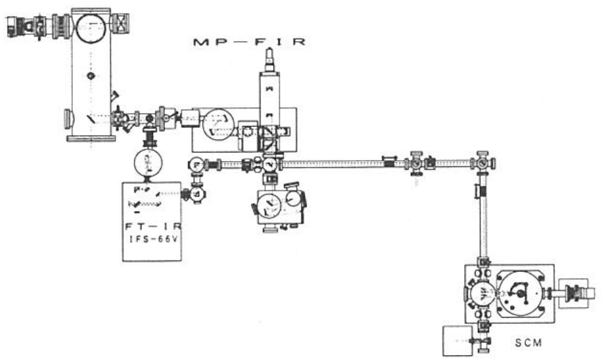
Resolution: E/ΔE~500

Experiments: Calibration of optical elements, absorption of solids, photo-stimulated desorption from rare gas solids

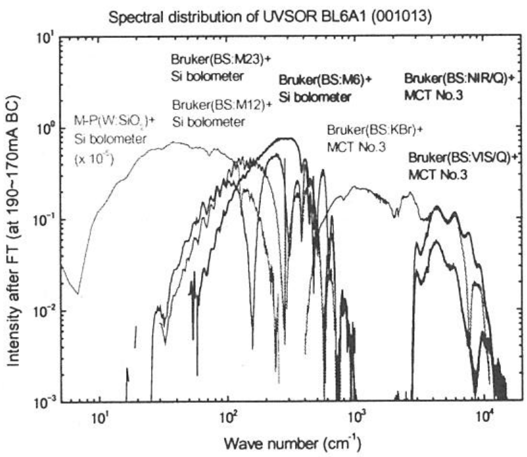
BL6A1

Fourier-Transform Middle and far Infrared spectrometers for solids

UVSOR covers a very wide energy region from a soft-X ray to a millimeter wave. BL6A1 was constructed in order to cover a long wavelength part in the spectral distribution of UVSOR from a near infrared to a milli-meter wave. Beamline are composed of two kinds of interferometers, a Martin Puplett type and a Bruker-IFS66v. The spectrum from 1 μ m to 3 μ m regions is measureable by changing of three kinds of detectors, MCT, Si-bolometer and InSb hot electron detector, according to each available region. Owing to the high brightness of the SR in the long wavelength region, the present spectroscopic system is specially favorable to the transmission and reflection measurements on so tiny specimens..



Top view of BL6A1



Throughput spectra of BL6A1

Spccification

Energy resolution :	500-20000
Energy range :	0.0005-1.5eV
Interferometers :	5-300cm^{-1} by Martin-puplett interferometer
	50-30000cm^{-1} by Michelson type interferometer
Detectors :	Si bolometer(20-1000cm^{-1})
	Ge bolometer(with polyethylene window,30-300cm^{-1})
	Ge bolometer(with quartz window,10-200cm^{-1})
	InSb bolometer(5-50cm^{-1})
	MCT(400-10000cm^{-1}) Photovoltaic type MCT(400-10000cm^{-1},time response10nsec)

BL6A2

Photoelectron Spectro-microscope for Solids and Surfaces

The beamline BL6A2 has been used for photoelectron spectroscopy on solids and surfaces with bending magnet radiation. The beamline consists of a Plane Grating Monochromator (PGM) and a photoelectron spectro-micrometer.

The PGM has several combinations of mirrors and gratings to cover the wide energy range of 2-150 eV with less higher-order light. Since the monochromator has no entrance slit, the resolving power depends on the beam size and the divergence. The beamline has been re-arranged in order to have a small spot for the photoelectron spectro-micrometer. Also the femto-second laser system was installed to conduct the combination experiments with synchrotron radiation and laser.

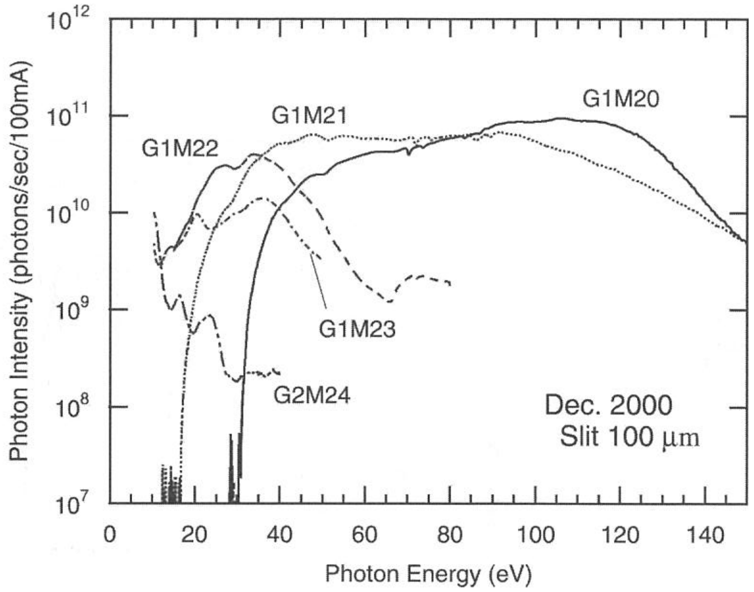


Figure 1. Through-put from the PGM monochromator on BL6A2.

Specifications

Monochromator

- Type : Plane Grating Monochromator
- Energy Range : 2-150 eV
- Resolution : 0.1 eV at 70 eV

Photoelectron spectro-micrometer

- Type : ESCALAB 220i-XL (FISONS Instruments)
- Spatial Resolution : 20 μm for spectroscopy
  : 2 μm for imaging
- Others : XPS, LEED, Ion-gun

Laser

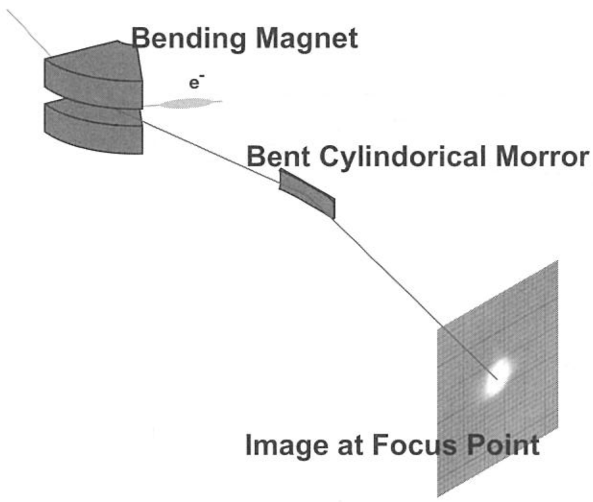
- Type : Hurricane (Spectra Physics)
- Fundamentals : 750-800 nm

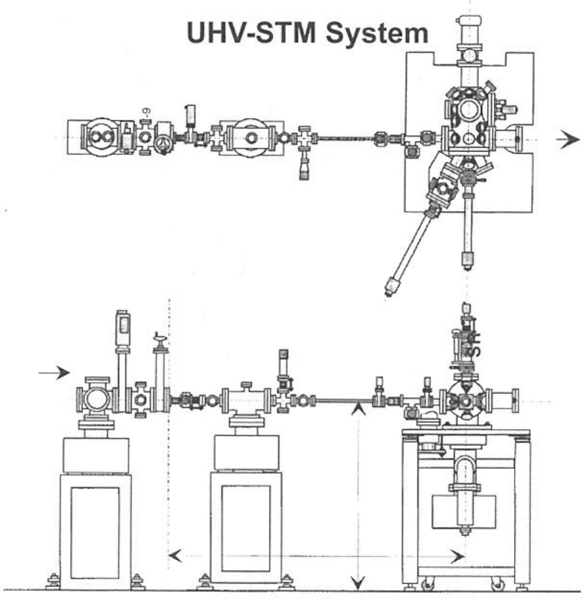
BL6B

UHV-STM beam line

This beam line is constructed for the atom level characterization of the SR illuminated surfaces by the in situ observation of STM. The beam line is very simple and has only one bent cylindrical mirror as optical components for high flux of photons to irradiate.

The STM experimental system designed so that the SR beam can illuminated the sample surface just under the STM chip, the STM observation can be made just after the SR illumination without the sample transfer. The short undulator which is going to be inserted to the strait part of the storage ring and emit the beam for BL7A, is under construction. The beam line and the UHV-STM station are going to be moved to the end of the new BL7A after the completion of the undulator.





Specification

Specification: whole range of synchrotron radiation from UVSOR

Beam spot size at focus point: 4.5 mm x 4.5 mm

BL7B

3-m Normal Incidence Monochromator for Solid-State Spectroscopy

BL7B has been constructed to provide sufficiently high resolution for conventional solid-state spectroscopy, enough intensity for luminescence measurements, a wide wavelength coverage for Kramers-Kronig analyses, and the minimum deformation to the polarization characteristic of the incident synchrotron radiation. This beamline consists of a 3-m normal incidence monochromator which covers the vacuum ultraviolet, ultraviolet, visible and infrared, i.e. the wavelength region of 40–1000 nm, with three gratings (1200, 600, and 300 l/mm). Two interchangeable refocusing mirrors provide two different focusing positions. For the mirror with the longer focal length, an LiF or a MgF_2 window valve can be installed in between the end valve of the beamline and the focusing position.

Fig. 1 shows absolute photon intensity for each grating with the entrance and exit slit openings of 0.5 mm. A silicon photodiode (AXUV-100, IRD Inc.) was utilized for measuring the photon intensitiy and the absolute photon flux was estimated, taking the quantum efficiency of the photodiode into account.

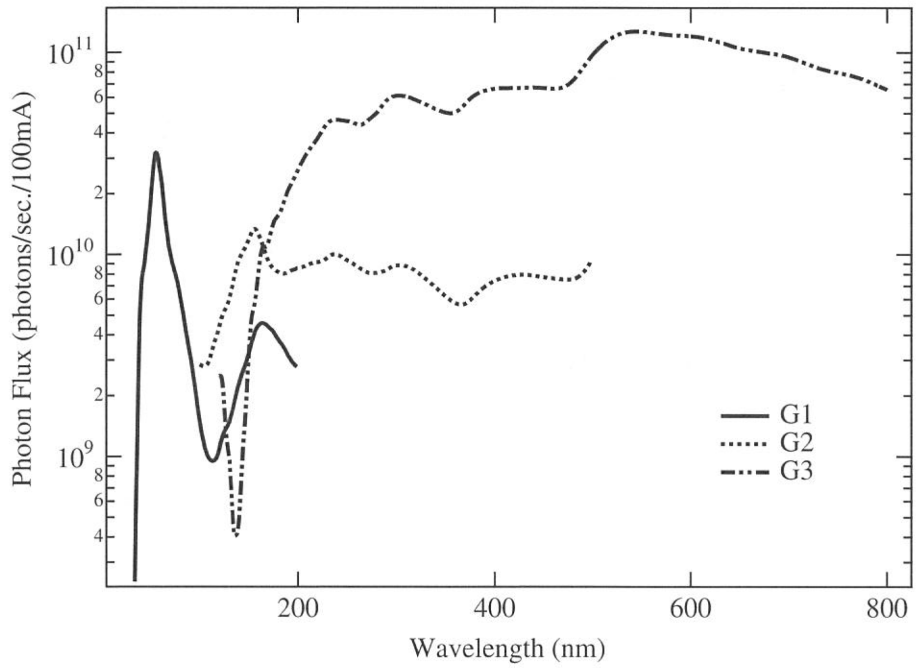


Figure 1. Throughput spectra of BL7B measured by a silicon photodiode.

Specification

Monochromator: 3-m Normal Incidence Monochromator

Energy range: 50 to 1000 nm (1.2-25 eV)

Resolution: E/ΔE=4000~8000 for 0.01 mm slits

Experiments: absorption, reflection, fluorescence spectroscopy, mainly for solids

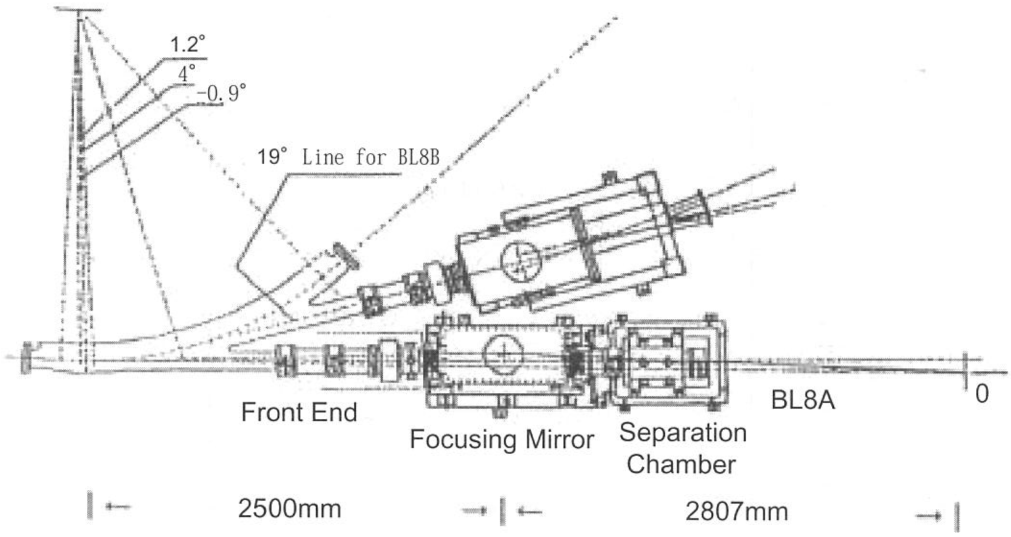
BL8A

Free Port

BL8A was constructed as a free port. Synchrotron radiation is introduced into a sample chamber either directly or through a focusing mirror. Main experiments performed at BL8A are photochemical reaction, SR-CVD, photo-etching, irradiation damage effects in a condensed phase.

Since this beamline has no monochromator between the bending magnet and the sample chamber, the samples brought by users can be irradiated by white light. A gold mesh is installed in the sample chamber to monitor the intensity of the incident radiation.

The beamline consists of a front-end chamber, a focusing pre-mirror chamber and a differential pumping system with three stages. By the use of this system, one can perform various experiments at the reaction chamber under vacuum condition up to 0.5 Torr, while keeping ultra high vacuum at the pre-mirror chamber. This means that any kind of experiment in a gas phase is also possible at the reaction chamber without any windows.



Specification

Acceptal angles (with mirror) : 25 mrad (horizontal) × 8mrad (vertical)
(without mirror) : 7.7 mrad (horizontal) × 8mrad (vertical)
Beam spot size :3mm (horizontal) × 2mm (vertical)
Energy range: Whole energy range of the dipole radiation at UVSOR

BL8B1

Photoabsorption and Photoionization Spectrometer

BL8B1 was constructed for various spectroscopic investigations in a gas phase under high resolution condition in the photon energy range from 30 to 800 eV, where the 1s ionization thresholds of chemically important elements like C, N, and O lie. The monochromator is a constant-deviation constant-length spherical grating type (CDCL-SGM). With three gratings (G1: R = 15 m; 1080 l/mm, G2: R = 15 m 540 l/mm, G3: R = 7.5 m; 360 l/mm), this monochromator is designed to cover the photon energy region of interest mentioned above. The typical resolving powers achieved are about 4000 at 400 eV and 3000 at 245 eV. The absolute photon flux for each grating measured by a silicon photodiode is shown in Fig. 1, with the slit openings of 10 μm.

The experimental chamber with a time-of-flight mass spectrometer and a photoelectron energy analyzer is installed at the downstream of the monochromator. This allows us to carry out photoelectron - photoion coincidence (PEPICO) and photoion - photoion coincidence (PIPICO) measurements. Measurements of absorption, electron yield and emission spectra of solid samples are also feasible.

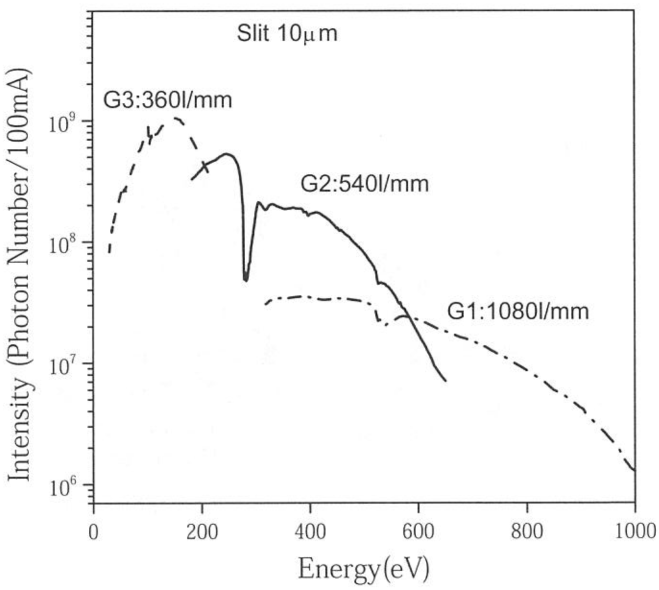


Figure 1. Absolute photon fluxes measured by a Si photodiode

Specification

Monochromator: Constant-deviation constant-length spherical grating type

Wavelength range: 30 to 800 eV

Resolution: E/ΔE = 4000 at 400 eV and 3000 at 245 eV

Available Experiments: Photoabsorption spectroscopy for gas and solid samples, coincidence experiments for gas samples

BL8B2

Angle-Resolved Ultraviolet Photoelectron Spectrometer for Solids

BL8B2 is a beamline for angle-resolved ultraviolet photoemission spectroscopy (ARUPS) system which is designed for measuring various organic solids such as molecular crystals, organic semiconductors, and conducting polymers. The beamline consists of a plane-grating monochromator (PGM), a sample preparation chamber with a fast entry Load-Lock chamber, a measurement chamber with an accurate for temperature dependence (base pressure 1×10^{-10}Torr), a cleaning chamber (base pressure 1×10^{-10}Torr), and a sample evaporation chamber (base pressure 3×10^{-10}Torr). The cleaning chamber is equipped with a back-view LEED/AUGER, an ion gun for Ar^+ sputtering, and an infrared heating unit. The PGM consists of premirrors, a plane grating, focusing mirror, and a post-mirror, with an exit slit. It covers the wide range from 2 to 150eV with exchanging two gratings (G1: 1200l/mm, G2: 450l/mm) and five cylindrical mirrors. The toroidal mirror focuses the divergent radiation onto the sample in the measurement chamber. The spot size of the zeroth-order visible light at the sample surface is about 1×1mm^2. The energy resolution at a slit width of 100μm was found to be 0.004-0.3eV in the wavelength range from 2 to 130eV. A hemi-spherical electron energy analyzer of 75mm mean radius with an angular resolution less than 2° can be rotated around vertical and horizontal axes. The sample mounted on a manipulator can be also rotated around two axes.

Specification

Monochromator:
Plane Grating Monochromator
Energy range: 2-150eV
Resolution: 100meV at 40eV as determined by the Fermi edge of gold
Experiment: Angle-resolved photoelectron spectroscopy (ARUPS) for various organic solids
Polarization: 85~91% at 500nm

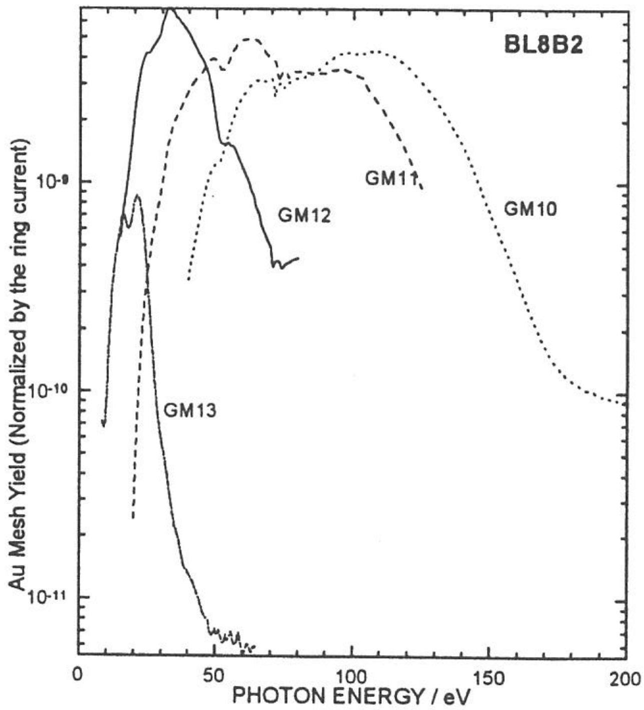


Figure Throughput spectra of plane-grating monochromator at BL8B2 with 100 μm exit slit.