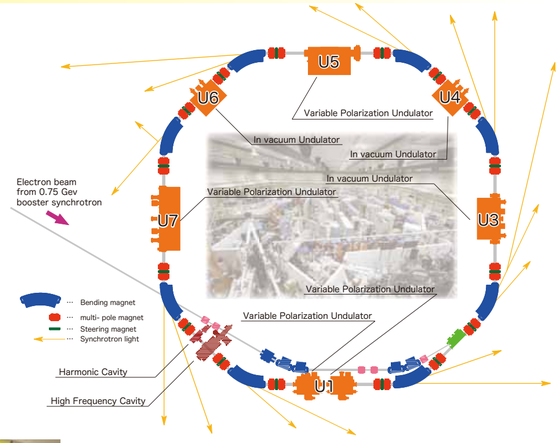
Accelerators and Beamlines of UVSOR-III

The UVSOR-III is composed of three accelerators: a 15 MeV linear accelerator for electron injection, a booster synchrotron for acceleration of the electron beam up to 0.75 GeV, and a 0.75 GeV electron storage ring, 53 m in circumstance. Synchrotron light is produced from 8 pairs of bending magnets and 6 units of undulators.

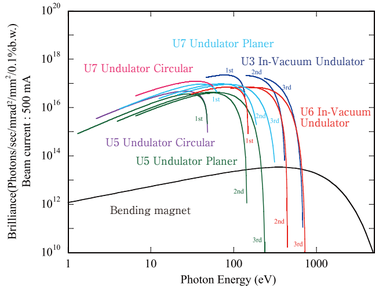


Injector

Electron beams are generated by a liear accelerator and are accelerated by a booster synchrotron, 26.6 m in circumstance. As the beam current of the storage ring decreases, the electrons are injected immediately to keep the current almost constant. This is called top-up injection.

Undulator

An undulator is a device with periodic magnetic sequence. The device is inserted into linear sections between the bending magnets. 6 units of undulators are installed in the UVSOR-III storage ring. 3 units out of the 6 are in-vacuum soft X-ray undulators, where the magnets are in the vacuum chamber.



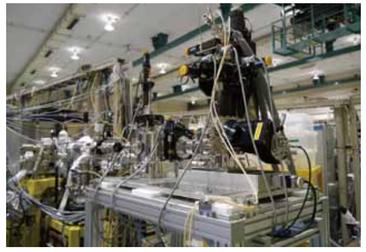
Beamlines

The UVSOR-III can generate radiation from THz waves to 4 keV soft X-rays from 8 bending magnets and VUV and <1 keV soft X-rays from 6 units of undulators. The synchrotron light is guided to each unique experimental equipment. Each beamline consists of a monochromator to select the wavelength or photon energy and a focusing mirrors to collimate and focus the light.

Experimental Stations on UVSOR-III

[BL4U] Scanning Transmission X-ray Microscope (STXM)

The STXM focuses X-rays onto a sample as a ~30 nm spot size and measures the intensity of the transmitted X-rays. By changing the energy of the X-rays, 2-dimensional chemical state mapping with high spatial resolution can be obtained. Samples in atmospheric or wet conditions can also be observed.



[BL3U] In Situ Soft X-ray Absorption Spectroscopy of Liquid Samples

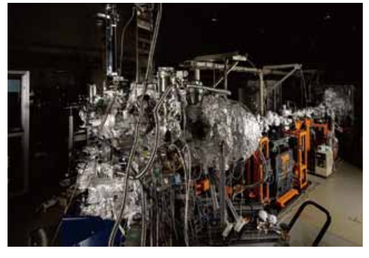
This apparatus is used for in-situ/operando observation of liquids, catalytic reactions, and electrochemical reactions. Local structures around target atoms in liquid, such as hydration structures, reaction intermediates, and electrode surfaces, are investigated by T-mode soft X-ray absorption.

[BL4B] High Magnetic Field, Low Temperature Soft X-ray Magnetic Circular Dichroism (XMCD)

Element specific magnetization in magnetic materials is observed in a magnetic field up to ±7 T at temperatures as low as 5 K. Magnetic thin films prepared in a connected sample preparation chamber can be investigated under an ultrahigh vacuum condition without the exposure to air.

[BL6U] Molecular High-Resolution Angle-Resolved Photoelectron Spectrometer (HR ARPES)

When a molecule is irradiated by linearly polarized monochromatic soft X-ray photons, photoelectrons are emitted due to the photoelectric effect. In order to record the angular distributions of the photoelectrons, a new apparatus which is rotatable around the photon beam axis has been developed.



[BL5U] High-Resolution Spin-, Space-, and Angle-Resolved Photoemission Spectroscopy (HR spin- and μ-ARPES)

The electronic states of small and inhomogeneous materials can be obtained by micro-focused VUV light. Spin-resolved ARPES will be available soon.

[BL7U] High-Resolution Angle-Resolved Photoemission Spectroscopy (HR ARPES)

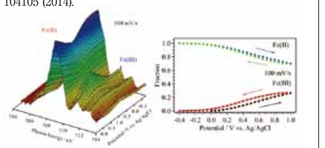
High energy- and momentum-resolution ARPES is available using low energy photons (6-40 eV). Measurements with extremely low energy photons (<10 eV) provide the bulk electronic structure of solids.

Research Outputs from UVSOR-III

[BL3U] In Operando Observation of Electrochemical Reaction by Soft X-ray Absorption Spectroscopy with Potential Modulation Method

An in operando observation system for electrochemical reactions under the same scan rate as in cyclic voltammetry (CV) (100 mV/s) by X-ray absorption spectroscopy (XAS) with a potential modulation method was developed successfully. The electrode potential of 100 mV/s at a fixed photon energy, and soft X-ray absorption coefficients at different potentials are measured at the same time. Figure shows the three-dimensional plots of Fe L-edge XAS spectra for electrochemical reaction of iron sulfate solutions at 100 mV/s. Change in valence of Fe ions during the electrochemical reaction at the same scan rate as in CV was obtained. electrochemical cell opens a possibility to reveal the local structures of electrolytes and electric double layers in electric devices under in operando conditions.

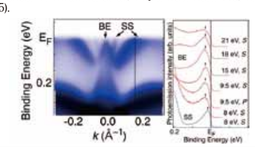
Reference: M. Nagasaka et al., *Rev. Sci. Instrum.* **85**, 104105 (2014).



[BL7U] Role of Quantum and Surface-State Effects in the Bulk Fermi-Level Position of Ultrathin Bi Films

High-resolution photon-energy and polarization-dependent ARPES measurements were performed on ultrathin Bi (111) films formed on Si(111). In addition to the extensively studied surface states (SSs), the edge of the bulk valence band was clearly measured by using S-polarized light. Direct evidence was found that this valence band edge, which forms a hole pocket in the bulk Bi crystal, does not cross the Fermi level for the 180 bilayers (BL) thick film. This is consistent with the predicted semimetal-to-semiconductor transition due to the quantum-size effect. However, it became metallic again when the film thickness was decreased below 30 BL. A plausible explanation is the size effect of the SS, which can modify the charge neutrality condition and can change the bulk Fermi level.

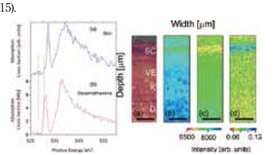
Reference: T. Hirahara et al., *Phys. Rev. Lett.* **115**, 106803 (2015).



[BL4U] Observation of Drug Uptake into Human Skin

A scanning X-ray transmission microscope (STXM) enables to analyze 2-dimensional chemical status with high spatial resolution about 30 nm. In this research, penetration of drug, dexamethasone, into human skin was observed by using the STXM. Then, difference of chemical structure between the human skin and the dexamethasone was used as a chemical label. As a result, dexamethasone distributes in the outermost horny layers of skin, stratum corneum. By using the STXM, 2-dimensional chemical status of the various samples, such as living cells, nano-materials, star dusts and fuel cells, are also investigated.

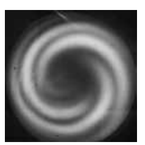
Reference: K. Yamamoto et al., *Anal. Chem.* **87**, 6173-6179 (2015).



[BL1U] Developments and Applications of New Light Sources

Apart from spin angular momentum associated with circular polarization, photons can carry orbital angular momentum. Such photon beam has been intensively investigated in the visible wavelength range using lasers. Recent years, it was predicted theoretically that helical undulators could produce optical vortex in the UV and X-ray range. UVSOR BL1U is one of very few beamline in the world which can provide diffraction limited ultraviolet light. Using this high quality beam, experimental studies on the properties of the optical vortex beam and its applications to material sciences are in progress.

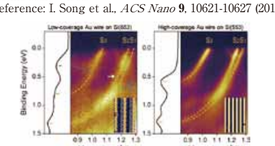
Reference: S. Sasaki, *J. Particle Acc. Soc. Jpn.* **11(4)**, 221 (2014).



[BL6U] Realization of a Strained Atomic Wire Superlattice

A superlattice of strained Au-Si atomic wires was successfully fabricate on a Si surface. At a reduced density of Au, a regular array of Au-Si wires in alternation with pristine Si nanoterraces was found. nanoterraces imposed a strain on the neighboring Au-Si wires, which modified both the band structure of metallic chains and the magnetic property of spin chains. This is an ultimate 1D version of a strained-layer superlattice of semiconductors, defining a direction toward the fine engineering of self-assembled atomic-scale wires.

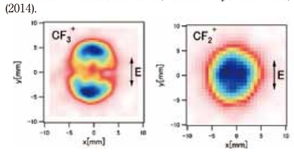
Reference: I. Song et al., *ACS Nano* **9**, 10621-10627 (2015).



[BL6U] Dissociation Dynamics of Core Excited Molecules

A molecule consists of more than two atoms held together by chemical bonds. The electron in the molecules can be classified into two categories: valence and core electrons. While the valence electrons participate in the formation of the chemical bonds, the core electrons are localized to particular atoms and not involved in any chemical bonding. The core electron excitation and subsequent Auger decay often result in multiple bond-breaking, which is hardly seen in the valence excitation. New experimental techniques can explore the dissociation dynamics in core-excited or core-ionized molecules.

Reference: Y. Hikosaka et al., *Chem. Phys. Lett.* **603**, 46 (2014).



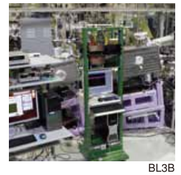
Beamlines and Stations on UVSOR-III

	U: Undulator Line A,B: Bending Line
BL1U	Circular Polarized UV Free Electron Laser (FEL) [199-800 nm, ~1W] UV Coherent High-Harmonic Generation from Laser (HHG)
BL1B	Terahertz Spectroscopy with Coherent Synchrotron Radiation (THz-CSR) [Martin-Puplett FT-FIR 0.5 – 30 meV]
BL2A	Soft X-ray Absorption Spectroscopy (XAS) [Double Crystal 585 – 4000 eV]
BL2B	Photoelectron Spectroscopy dedicated to Organic Solids (Molecular PES) [18m Spherical Grating 23 – 205 eV]
BL3U	In situ/operando Soft X-ray Absorption Spectroscopy (Molecular XAS) [Varied-line-spacing (VLS) Plane Grating 60 – 800 eV]
BL3B	Vacuum Ultraviolet Spectroscopy (VUV) [2.5m Off-plane Eagle-type Normal Incidence 1.7-31 eV]
BL4U	Soft X-ray Spectro-microscopy (STXM) [Varied-line-spacing Plane Grating 130 – 770 eV]
BL4B	Soft X-ray Absorption Spectroscopy (XAS, XMCD) [Varied-line-spacing Plane Grating 25 – 1000 eV]
BL5U	High-Resolution Spin-, Space- and Angle-Resolved Photoemission (HR spin- and μ-ARPES) [VLS Plane Grating 20 – 200 eV]
BL5B	VUV/Soft X-ray Spectrometer dedicated to Calibration of Optical Elements and Detectors [Plane Grating 6 – 600 eV]
BL6U	Molecular Angle-Resolved Photoemission Spectroscopy (Molecular ARPES) [Varied-line-spacing Plane Grating 30 – 500 eV]
BL6B	Infrared and Terahertz Spectroscopy (IR/FIR/THz) [Michelson FT-IR 4 meV – 2.5 eV]
BL7U	High-Resolution Angle-Resolved Photoemission Spectroscopy (HR ARPES) [10-m Normal Incidence 6 – 40 eV]
BL7B	Vacuum Ultraviolet Spectroscopy (VUV) [3m Normal Incidence 1.2 – 25 eV]
e-beams	Electron Injector/Storage Ring/Laser Compton gamma-rays

Green indicates beamlines open to public users.
Orange indicates beamlines dedicated to joint research with in-house members.


BL1B

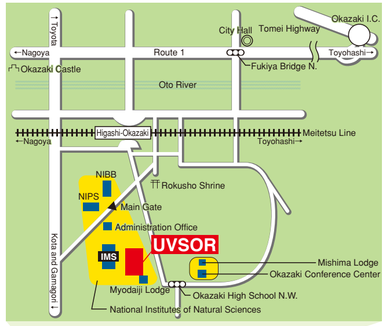

BL2A


BL3B


BL5B


BL7B


BL6B



UVSOR Users

★Academic and Public Users

UVSOR Synchrotron belongs to the Institute for Molecular Science (IMS), which is dedicated to academic researches as one of the inter-university national research institutes. IMS is open to the world. Academic use of UVSOR Synchrotron is free of charge. Travel and local expenses for the registered users (even from abroad) are fully or partly covered by IMS.

★Private Users : charged

★Please check UVSOR for details.

UVSOR Search

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UVSOR Synchrotron

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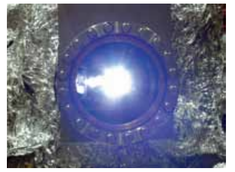
https://www.uvsor.ims.ac.jp/eng/index.html

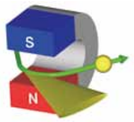
July 2016

UVSOR Synchrotron
Institute for Molecular Science
National Institutes of Natural Sciences

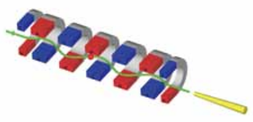
Synchrotron Radiation



Synchrotron radiation is a bright light with a wide wavelength range including; the microwave, infrared rays, visible light, ultraviolet and vacuum ultraviolet rays, and soft and hard X-rays. It is highly directional, pulsed, and polarized light, which is used for research in broad fields, such as molecular science, solid-state physics, materials physics, life science, and planetary science.



Synchrotron radiation (SR) is emitted from high energy electron beams which are bent by a strong magnetic field of a bending magnet. This is called bending radiation.



Semi-monochromatic and semicoherent SR are emitted from high energy electrons passing through a periodic magnetic sequence with small gaps. The wavelength and polarization are variable by controlling this sequence and gaps. This is called undulator radiation.

UVSOR-I 1983, UVSOR-II 2003, UVSOR-III since 2012

The original UVSOR Synchrotron was constructed in 1983 for application to molecular science and for its promotion to the world. The UVSOR Synchrotron is a rather small (53 m circumference) and low-energy (0.75 GeV) facility providing highly focused and bright IR, VUV and soft X-rays which intract strongly with materials. It serves as a powerful photon source to research the origin of chemical and physical phenomena, such as chemical reactivity, conductivity, and magnetism. During operation over 30 years, new technologies, such as diffraction limit beam emittance and top up injection, have been strategically introduced by two major upgrade projects from UVSOR-I to UVSOR-III. The performance level in the VUV and soft X-ray region is still one of the highest in the world, as a small and low-energy synchrotron light source.