UVSOR Facility

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Outline of UVSOR Synchrotron

Since the first light in 1983, UVSOR Synchrotron has been successfully operated as one of the major synchrotron light sources in Japan. After the major upgrade of the accelerators in 2003, UVSOR was renamed to UVSOR-II and became one of the world brightest low energy synchrotron light sources. In 2012, it was upgraded again and has been renamed to UVSOR-III. The brightness of the electron beam was increased further. Totally, six undulators were installed. The storage ring is operated fully in the top-up mode, in which the electron beam intensity is kept almost constant.

The UVSOR accelerator complex consists of a 15 MeV injector linac, a 0.75 GeV booster synchrotron, and a 0.75 GeV storage ring. The magnet lattice of the storage ring consists of four extended double-bend cells with distributed dispersion function. The storage ring is normally operated under multi-bunch mode with partial filling. The single bunch top-up operation is also conducted for about two weeks per year, which provides pulsed synchrotron radiation (SR) for time-resolved experiments.

Eight bending magnets and six undulators are available for providing SR. The bending magnet with its radius of 2.2 m provides SR with the critical energy of 425 eV. There are eight bending magnet beamlines (BL1B–BL7B, BL2A). Three of the six undulators are in-vacuum soft X-ray linear-polarized undulators (BL3U, BL4U, BL6U) and the other three are VUV circular-polarized undulators (BL1U, BL5U, BL7U). Totally, fourteen beamlines (= fourteen endstations) are now operational in two categories: eleven of them are so-called "public beamlines," which are open to scientists from universities, governmental research institutes, and public and private enterprises, and also to overseas scientists; the other three beamlines are so-called "in-house beamlines," which are dedicated to some strategic projects conducted by a few IMS groups in tight collaboration with external and overseas scientists. From the viewpoint of photon energies, we have 1 soft X-rays (SX) station equipped with a double-crystal monochromator, 7 SX stations with a grazing incidence monochromator, 3 VUV stations with a normal incidence monochromator, 2 infrared/tera Hz station equipped with FT interferometers and 1 beamline for light source development without monochromator.

Figure 1. UVSOR electron storage ring and synchrotron radiation beamlines.

Collaborations at UVSOR Synchrotron

A variety of molecular science and related subjects have been carried out at UVSOR Synchrotron by IMS and external/overseas researchers. The number of visiting researchers per year tops > 1,200, whose come from > 60 different institutes. International collaboration is also pursued actively and the number of visiting foreign researchers reaches > 100 from >10 countries. UVSOR Synchrotron invites new/continuing research proposals twice a year. The proposals both for academic and public research (charge-free) and for private enterprises (charged) are acceptable. The fruits of the research activities using UVSOR Synchrotron are published as the UVSOR ACTIVITY REPORT annually.

Recent Developments

BL7U, a high energy resolution ARPES beamline, is one of the most popular beamlines in UVSOR and it has been hard to get beamtime these days. For users who need sample surface preparation such as annealing, Ar-sputtering, deposition and so on, one or two week beamtime is not enough to prepare samples. To make the beamtime efficiently, "Offline-ARPES system" with helium discharge lamp at IMS (Nanotechnology Platform Japan program) has been open for users who requested. Three user groups used the offline-ARPES system before their beamtime to prepare sample in 2015.

The construction of a new soft X-ray beamline BL5U began in January 2014. The beamline performance had been once tested and it had been confirmed that the resolving power and photon intensity were very close to the expected values. However, in December 2014, it was found that the photons below 30 eV hit the grating mount and could not reach the endstation. The grating mount has been taken out, modified and attached again in March 2015. During the second beamline performance test, we found that the first mirror and probably the grating surfaces were covered by the carbon contamination, which made the photon intensity one order of magnitude smaller than the first test. The *in situ* cleaning method, which was used at BL4U, has been applied and photon flux has recovered to a half of the first test level. BL5U will be officially open for users from 2016.

Reserch Highlight

Microbial bioleaching of metal sulfides has been used as a low-cost engineering process for extracting metals from sulfidic ores due to its fast dissolution rate. The microbial bioleaching of metal sulfide also contributes to formation of environmentally detrimental acid mine drainage (AMD), whose acidic nature and heavy-metal constituents cause serious contamination of soil and groundwater in the world. Thus, a better understanding of the mechanisms is of crucial importance for improvement of both industrial bioleaching and AMD formation. Mitsunobu, *et al.* investigated the mechanisms of the bioleaching process in bacterial pyrite leaching by leaching bacteria (*Acidithiobacillus ferrooxidans*) by scanning transmission X-ray microscopy (STXM) based C and Fe near edge X-ray absorption fine structure (NEXAFS) analyses at UVSOR BL4U.[1)]

Carbon NEXAFS analysis directly showed that attached *A. ferrooxidans* produces polysaccharide-abundant extracellular polymeric substances (EPS) at the cell-pyrite interface. Figure 2 shows the STXM-based merged Fe/C image and Fe 4p NEXAFS of bacteria cells attached to pyrite particles in 2 weeks incubation. The image in Figure 2a shows that Fe was localized around the surface of the bacteria cells. Considering that C NEXAFS demonstrated the appearance of a polysaccharide-rich EPS layer at the cell-pyrite interface, this suggests that Fe had accumulated in this polysaccharide layer. In the Fe NEXAFS spectra, both the spectra of whole cell and cell-pyrite interface (interface 1 and 2 in Figure 1b) consist of Fe(II) and Fe(III) peaks. Thus, the Fe species in both cell and cell-pyrite interface were Fe(II) addition to Fe(III). The Fe(II) detected by direct STXM based NEXAFS analyses in this study is a first direct evidence supporting the oxidative attack by the Fe(III) in EPS.

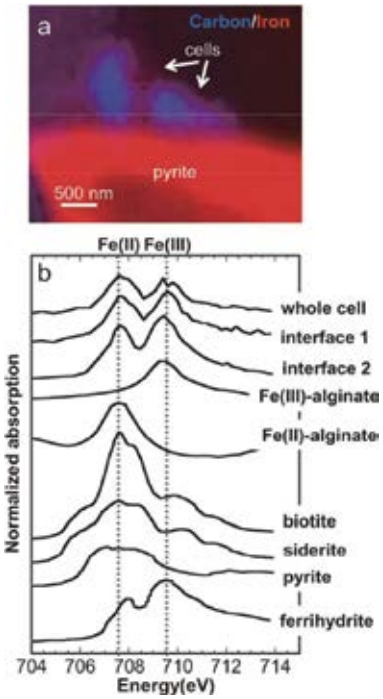

Figure 2. STXM-based C and Fe images (a) and Fe 4p NEXAFS spectra (b).

Reference

1) S. Mitsunobu, M. Zhu, Y. Takeichi, T. Ohigashi, H. Suga, M. Jinno, H. Makita, M. Sakata, K. Ono, K. Mase and Y. Takahashi, *Microbes Environ.* **31**, 63–69 (2016).