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 > 1200, 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

BL8B for photoemission study of organic thin films was shut down in 2015 after operating for more than 30 years from the beginning of UVSOR (1983). Instead of BL8B, BL2B was reorganized for photoemission study of organic thin films in 2013, which has been conducted as one of the long-term project proposals for 2013–2015. As an endstation of BL2B, an experimental setup for angle-resolved photoelectron spectroscopy (ARPES) was brought from Chiba University. Commissioning and performance tests were started in September 2014. During commissioning, the vacuum pressure rises at the first mirror chamber were frequently observed due to a leak in the water-cooling system for the first mirror. We have decided to continue the operation of BL2B without the water-cooling system. Now it takes about 20 minutes to stabilize the beam position on the entrance slit but then the beam is stabilized in the top-up mode.

Reserch Highlight

Free University of Berlin and IMS have an international collaboration program in molecular science. One of the collaboration projects is application of our scanning transmission X-ray microscope (STXM) at the BL4U to the drug delivery from human skin. Advantages of this technique are not only high spatial resolution but also label-free approach. Dexamethasone is a widely used for the treatment of inflammatory skin diseases such as atopic dermatitis. It is aimed to study the depth profile of dexamethasone, so that specific information on the uptake process is derived. Dexamethasone was dissolved in ethanol and this 0.5% solution was applied onto the skin sample for 4 h. Subsequently, the sample was fixed and sliced into 350 nm thick sections. The skin samples were placed on silicon nitride membranes with thickness of 100 nm. Chemical selectivity is obtained from excitation at the O 1s-edge (525–560 eV). Figure 2 shows a comparison of the O 1s-absoption of fixed human skin and dexamethasone. Both spectra are similar in shape, showing an intense O 1s → π* resonance dominating the pre-edge regime. This resonance occurs at slightly lower energy in dexamethasone (E = 530.5 eV) than in skin (E = 532.2 eV), providing chemical selectivity for probing the drug uptake into skin.

Figure 3 shows a comparison of a skin sample exposed to dexamethasone probed by optical microscopy and soft X-ray microscopy. Figure 3(a) clearly shows the layered structure of the stratum corneum, the outermost skin layer, probed by optical microscopy. It is followed by the viable epidermis and the dermis. Figure 3(b) shows for the same section of the skin sample the spatial distribution of absorption, which is obtained from a difference image in X-ray absorption measured at 528 eV (pre-edge regime) and on the O 1s → π*-transition (530.5 eV) of dexamethasone (cf. Figure 2) providing chemical selectivity. The spatially resolved results indicate that highest absorption contrast is found in the stratum corneum, as indicated by red color. In contrast, lower concentration is observed in the viable epidermis and no change in absorption contrast occurs in the dermis. It is also evident that the cells nuclei in the viable epidermis (circular structures in Figure 3(a)) do not show any evidence for drug uptake.

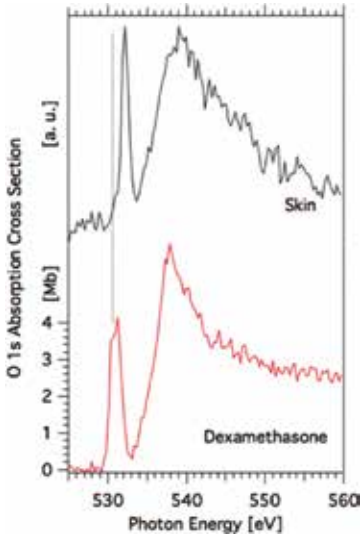

Figure 2. X-ray absorption cross section of human skin and dexamethasone at the O K-edge.

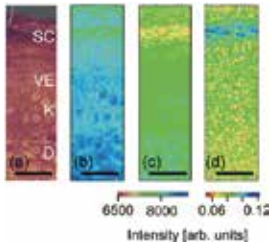

Figure 3. Uptake of dexamethasone into human skin (SC, stratum corneum; VE, viable epidermis; K, nuclei of keratinocytes; D, dermis): (a) optical micrograph of a vertical skin section, (b) absorption of the same skin section shown in (a) at 528.0 eV (pre-edge regime), (c) absorption of the same skin section shown in (a) at 530.6 eV (O 1s → π* resonance) and (d) optical density of taken up dexamethasone as a function of depth. The scale bar corresponds to 20 μm.

Reference

1) K. Yamamoto, *et al.*, *Anal. Chem.* **87**, 6173–6179 (2015).