UVSOR Facility

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Outline of UVSOR

After the major upgrade in 2003, UVSOR was renamed to UVSOR-II and became one of the world brightest low energy synchrotron light source. The UVSOR accelerator complex consists of a 15 MeV injector linac, a 750 MeV booster synchrotron, and a 750 MeV storage ring. The magnet lattice of the storage ring is the extended double-bend cell with distributed dispersion function. Since July, 2010, the storage ring has been operated for users fully in so-called top-up mode, in which the electron beam intensity is kept almost constant at 300 mA. The storage ring is normally operated under multi-bunch mode with partial filling. The single bunch operation is also conducted about two weeks per year, which provides pulsed synchrotron radiation (SR) for time-resolved experiments.

Eight bending magnets and four undulators are available for utilizing SR. The bending magnet with its radius of 2.2 m provides SR, whose critical energy is 425 eV. There are 12 beam-lines operational at UVSOR, which can be classified into two categories. 8 of them are the 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 other 4 beam-lines are the so-called “In-house beamlines,” which are dedicated to the use of the research groups within IMS. We have 1 soft X-rays (SX) station equipped with a double-crystal monochromator, 7 EUV and SX stations with a grazing incidence monochromator, 3 VUV stations with a normal incidence monochromator, 1 (far) infrared station equipped with FT interferometers.

Collaborations at UVSOR

Variety of investigations related to molecular/material science is carried out at UVSOR by IMS researchers. In addition, many researchers outside IMS visit UVSOR to conduct their own research work. The number of visiting researchers per year tops about 800, whose affiliations extend to 60 different institutes. International collaboration is also pursued actively and the number of visiting foreign researchers reaches over 80, across 10 countries. UVSOR invites new/continuing proposals for research conducted at the open beamlines twice a year. The proposals from academic and public research organizations (charge-free) and from enterprises (charged) are acceptable. The fruit of the research activities using SR at UVSOR is published as a UVSOR ACTIVITY REPORT annually. The refereed publications per year count more than 60 since 1996.

Figure 1. Overview of the UVSOR storage ring room.

Highlights of Users' Researches 2009

1) Temperature-Dependent Angle-Resolved Photoemission Spectra of EuO Ultrathin Films

H. Miyazaki, H. Mitani, T. Hajiri, T. Ito, S. Kimura *(UVSOR)*

Europium monoxide (EuO) is a ferromagnetic semiconductor with the Curie temperature (T_C) at around 70 K. The magnetic moment originates from the half-filled 4*f* shell of the Eu^{2+} ion with a spin-only magnetic moment of $S = 7/2$. Recently, we reported that the origin of the magnetic properties of EuO is caused by the hybridizations of the Eu 4*f*–O 2*p* and Eu 4*f*–5*d*. Next step is to investigate the electronic and magnetic structure of thin films of a few nanometers, which is the thickness of spin filter tunnel barriers. Three dimensional angle-resolved photoemission spectroscopy (3D-ARPES) using synchrotron radiation is the most powerful technique to directly determine the electronic band structure. Using this technique we observed the change of the electronic structure across T_C.

Single-crystalline EuO ultrathin films were fabricated by a molecular beam epitaxy (MBE) method. The Curie temperature T_C was about 40 K that is lower temperature than that of the bulk material. The magnetic properties and 3D-ARPES measurements were performed at the beam line 5U of UVSOR-II combined with the MBE system.

Figure 2 (a) and (b) show the energy distribution curves (EDCs) of Eu 4*f* states for EuO (100) thin films with a thickness of 100 nm and 2 nm near the Γ and X points, respectively. The band width of Eu 4*f* states of the 2 nm thickness sample become narrower compare to those of the 100 nm sample. Across the ferromagnetic phase transition, the EDC with 2 nm thickness shifts to the lower binding energy side only at the X point. The energy shifts of Eu 4*f* states with 100 and 2 nm thickness samples are 0.3 and 0.16 eV, respectively. This result indicates that the hybridization intensity between the Eu 4*f* and other states become weaker with decreasing thickness. This is consistent with the decreasing T_C.

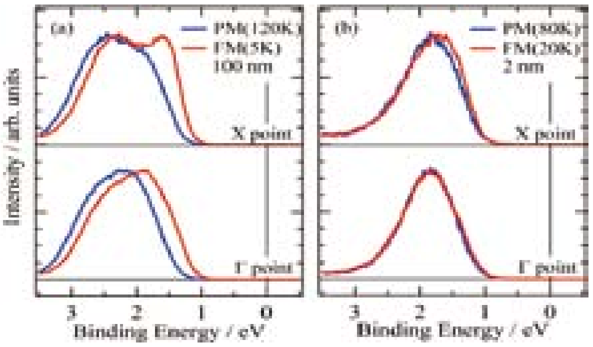

Figure 2. Temperature-dependent energy distribution curves (EDCs) of Eu 4*f* states with a thickness of 100 nm (a) and 2 nm (b) at the Γ and X point.

2) Local Environment Analysis of P Atoms in Proton-Conducting Amorphous Zirconium Phosphate Thin Films

Y. Aoki, H. Habazaki *(Hokkaido Univ.)*

Inorganic phosphate compounds are attractive as an unhydrated proton conductor due to the presence of large number of native acid sites. Thin film of such materials has potential as an electrolyte membrane of next-generation intermediate temperature fuel cell. Previously, we reported that amorphous zirconium phosphate thin films exhibit the enhanced proton conductivity in nonfumidified atmosphere in the intermediate temperature range. In addition, the films hydrated by heating in moisture at 400 °C exhibit the increment of conductivity by two orders of magnitude. This superior conductivity is speculated to be related to the structure of phosphate groups.

P K-edge XANES spectroscopy was carried out with *a*-$ZrP_{2.5}O_x$ films of 40 nm, 100 nm and 300 nm-thickness (Figure 3). It is reported that P K-edge spectra of inorganic phosphate salts is very sensitive to the counter metal cation. *a*-$ZrP_{2.5}O_x$ films show a clear peak at 2154 eV and a lower-energy, pre-edge peak at around 2151 eV in agreement with the spectral features of various phosphate salts. These peaks correspond to the transition from P 1s P 3p-dominant unoccupied states which satisfy the dipole selection rule. The *a*-$ZrP_{2.5}O_x$ films possess the same features of XANES in every thickness. Furthermore, the apparent change in spectra was not observed between the as-prepared and hydrated films. These results indicate the possibility that the polymerization degree, *n*, of phosphate group P_nO_{3n+1} does not change through the hydration.

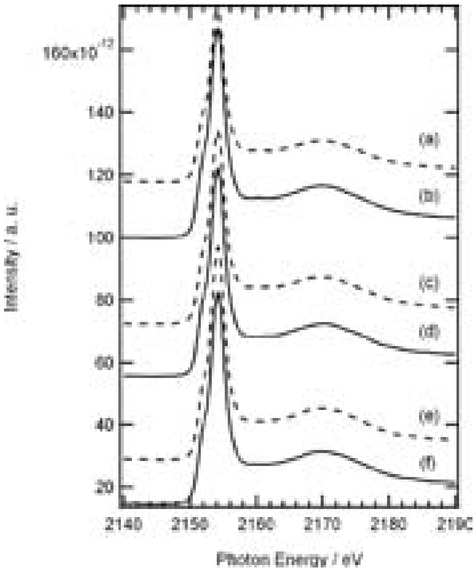

Figure 3. (a) P K-edge XANES spectra of amorphous $ZrP_{2.5}O_x$ film with thickness of (a) and (b) 40 nm, (c) and (d) 100 nm and (e) and (f) 300 nm. Solid line indicates as-prepared film and dashed line hydrated film.