

# UVSOR Facility

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## Outline of UVSOR

The UVSOR accelerator complex consists of a 15 MeV injector linac, a 600 MeV booster synchrotron, and a 750 MeV storage ring. The magnet lattice of the storage ring is the so-called double-bend achromat. The double RF system is routinely operated for the user beam time, and the lifetime of the electron beam has been improved to around 6 hours at 200 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. Initial beam currents stored under multi-bunch and single-bunch modes are 350 mA and 70 mA, respectively.

Eight bending magnets and three insertion devices are available for utilizing SR. The bending magnet with its radius of 2.2 m provides SR, whose critical energy is 425 eV. After completing the upgrade project, there are 14 beamlines available in total (13 operational, and 1 under construction) at UVSOR, which can be classified into two categories. 9 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 rest of the 5 beamlines 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, 8 EUV and SX stations (one of them is under construction) with a grazing incidence monochromator, 3 VUV stations with a normal incidence monochromator, 1 (far) infrared station equipped with FT interferometers, 1 station with a multi-layer monochromator.

## 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. In recent five years, the number of beamlines has been reduced from 22 to 14. 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) were planned in 2002–2003, has been accomplished on schedule. The upgraded storage ring is named UVSOR-II. The numbers of users and related publications have shown an upward tendency, since 2004.



**Figure 1.** Overview of the UVSOR storage ring room.

## Highlights of Users' Researches 2007

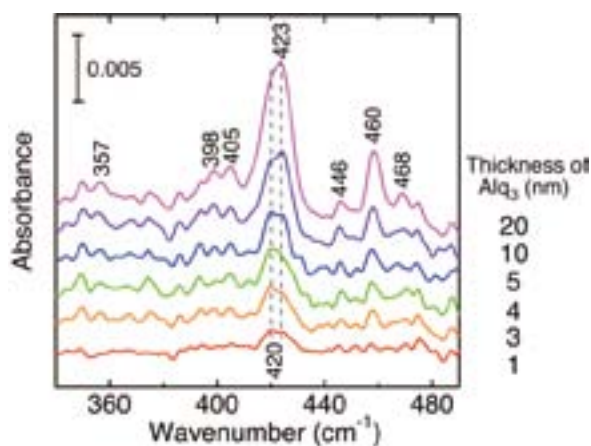
### 1) Infrared Reflection-Absorption Spectroscopy of Alq<sub>3</sub> Thin Film on Silver Surface Using Synchrotron Radiation

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Recently, organic semiconductors are attracting attention because of possible applications to electronic devices such as organic light emitting diodes (OLEDs). In OLEDs, tris(8-hydroxyquinoline) aluminum (Alq<sub>3</sub>) is most widely used as the electron transport/light emitting material. Alq<sub>3</sub> has two possible geometrical isomers of meridional (C<sub>1</sub> symmetry) and facial (C<sub>3</sub> symmetry) forms. It is important to find whether facial isomer exists at the interface between the metal and the Alq<sub>3</sub> film or not.

Vibrational spectroscopy such as infrared (IR) spectroscopy is suitable technique for distinguishing these isomers. We examined whether the facial isomer exists at the interface between the Ag and the Alq<sub>3</sub> film or not by infrared reflection-absorption spectroscopy (IRAS) using a synchrotron radiation (SR) light source. Use of highly brilliant infrared synchrotron radiation (IRSR) source enables us to obtain IRAS spectra in the low wavenumber region, which cannot be covered by conventional IRAS system using global light source because of its low brilliance.

Figure 2 indicates the thickness dependence of the IRAS spectra of an Alq<sub>3</sub> film deposited on an Ag surface. The observed IRAS spectra suggest that the Alq<sub>3</sub> film predominantly consists of meridional isomer including the first monolayer adsorbed on the Ag surface. In the spectrum of monolayer Alq<sub>3</sub>, Al–N stretching mode slightly shifts to the lower wavenumber side than that of multilayer Alq<sub>3</sub>, possibly due to the charge transfer between the Alq<sub>3</sub> and Ag surface.



**Figure 2.** The thickness dependence of the IRAS spectra of an Alq<sub>3</sub> film on Ag surface.

### 2) Electronic Structure at Highly Ordered Organic/Metal Interfaces

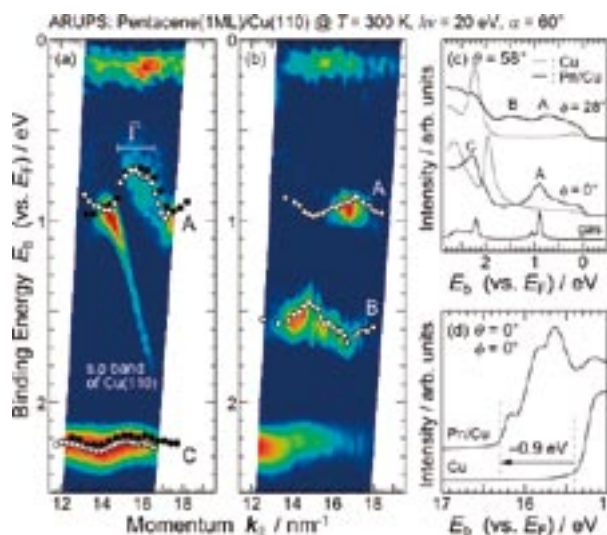
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The electronic structure at the interface formed between an organic semiconductor film and a metal electrode plays a crucial role in the performance of electronic devices using organic semiconductors such as electroluminescent displays, field-effect transistors, and photovoltaic cells.

We have studied the electronic structure of well-ordered thin films of pentacene (Pn) molecules prepared on Cu(110) in the monolayer regime, by using angle-resolved UV photoemission spectroscopy. The Pn molecules on Cu(110) in the monolayer regime form a highly ordered film structure with planar adsorption geometry, where the molecular long axis is parallel to the [1 $\bar{1}$ 0] substrate direction.

Figure 3(a) and (b) shows the observed energy versus momentum [ $E(k_{\parallel})$ ] relation for the flat-lying Pn monolayer film on Cu(110) along (a)  $\phi = 0^\circ$  (the [1 $\bar{1}$ 0] substrate direction) and (b)  $\phi = 28^\circ$ . The selected raw ARUPS spectra of the valence levels and the secondary-electron cutoff are shown in Figure 3(c) and (d), respectively.

We found that the change in the work function upon the adsorption of the flat-lying Pn monolayer film is  $\Delta = -0.9$  eV [Figure 3(d)] due to the formation of the interfacial dipole layer. We clearly observed the electronic structure characteristic of the interface with the following findings: (i) formation of the interface states with possible modification of the orbital symmetry and the energy position, and (ii) two-dimensional inter-molecular band dispersion of these interface states with the effective mass of the hole for the upper branch being  $0.24 m_0$  at 300 K.



**Figure 3.** (a,b)  $E(k_{\parallel})$  relation for the highly ordered flat-lying Pn monolayer film on Cu(110) at  $\phi =$  (a)  $0^\circ$  and (b)  $28^\circ$ . Open and filled circles indicate the position of the Pn-derived peaks measured at  $h\nu = 20$  and  $30$  eV, respectively. (c,d) Selected ARUPS spectra of the Pn monolayer film and the bare substrate for the regions of (c) valence levels and (d) secondary-electron cutoff.

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