Soft X-ray Photochemistry

Eiji ISHIGURO
Atsunari HIRAYA
Inosuke KOYANO

1. Introduction

The soft X-ray photochemistry beamline is one of the SPring-8 public beamlines whose construction have been approved this fiscal year. Beams of linearly polarized synchrotron radiation from the figure-8 undulator are utilized for very high resolution spectroscopy and other studies on dynamical processes of atoms and molecules, mainly in the gas phase. Studies of some surface processes are also in the scope. For these purposes, a very high resolution soft X-ray monochromator is essential. This year, our efforts have been concentrated on the design of this monochromator. In addition, we have completed the design of the experimental endstation, a part of which has subsequently been ordered by the RIKEN/JAERI Project Team after a competitive bidding. In the following, the outline of the monochromator and the endstation is given.

2. Monochromator

The requirements for the present soft X-ray monochromator are as follows:

1) Energy range: 0.5-2 keV
2) Resolution $E/\Delta E$: >10,000 at E=1 keV
3) Photon flux: ~10^{12} photons/s at $E/\Delta E$=10,000
4) Beam size at the sample: ~ 0.5 x 0.5 mm^2

To attain this high resolution, the following three types of monochromator mounts have been examined as a candidate. An important design concept to achieve high reliability is that the scanning mechanism should be as simple as possible.

1) Constant Deviation Angle-Plane Grating Monochromator (CDA-PGM)consisting of a plane grating and a parabolic focussing mirror. The grating to be used is a usual one with equi-distance grooves.
2) Varied Line Spacing-Grating Monochromator (VLS-PGM) consisting of a spherical mirror and a plane grating with varied line spacing.
3) Constant Angle of Diffraction-Spherical Grating Monochromator (CAD-SGM) consisting of a plane mirror and a spherical grating with varied line spacing.

SiC laminar gratings can now be fabricated by means of holographic exposure and ion beam etching. Scattered components involved in the diffracted light from the grating are found to be very small in the soft X-ray region. Moreover, the SiC gratings have a high resistance against heat load. Thus, the ion-beam etched holographic gratings are ready to be used in the monochromator.

3. Experimental Station

A schematic drawing of the experimental apparatus is shown in Fig. 1. It consists of three major parts: differential pumping /filter chamber section, a main chamber for all measurements, and a chamber for main pumping. Attached to the main chamber are a reflectron-type time-of-flight mass spectrometer (RTOF) and an ion energyanalyzer (IEMA). The main chamber houses a photoelectron energy analyzer (PEEA) and two total-ion monitors, both of which are mounted on a mechanism that is rotatable around the photon beam axis in the vacuum. The whole chamber along with the analyzers can also be rotated around the photon beam axis so that we can measure not only the angular distribution of photoions and photoelectrons but also the angular correlations between photoelectrons and photoions.

For this rotational purposes, the separation of the main chamber for measurements from that for pumping is necessary, and hence the above-mentioned additional chamber for main pumping. These chambers are connected via a rotation mechanism placed between them. Similarly, the main chamber is connected to the differential pumping/filter section via another mechanism that supports this rotation. All rotations are power-driven and performed without deteriorating the ultrahigh vacuum of the system.

4. Research Subjects

Main research subjects proposed for this beamline include (1) very high resolution molecular spectroscopy, (2) a "perfect" experiment on atomic and molecular photoionization, (3) complete determination of dissociation pathways and dynamics of inner-shell excited molecules, (4) formation, characterization, and decay dynamics of novel inner-shell excited states by SR-laser double resonance techniques, (5) dynamics of rearrangement reactions of multiple-charged molecular ions. All of them are new and the studies become only possible with the high quality radiation obtainable from the above-mentioned soft X-ray undulator, combined with the high resolution soft X-ray grating monochromator of our own design.

For the double-resonance and time-correlated experiments using the undulator and laser pulses, two Ti-sapphire tunable lasers will be used with active-mode-lock frequency at 1/6 of the RF frequency. The second and third harmonics will be generated. The additive mixing of the laser lights (fundamental and second and third harmonics) will provide visible and uv light for electronic excitation of molecules, while the subtractive mixing of them provides infrared light for vibrational excitation of molecules.