Soft X-ray Photochemistry (BL27SU)

1. Introduction

BL27SU is designed for the study on the photochemical processes of atoms, molecules, and surfaces in the inner-shell excitation region, from both the scientific and the industrial point of view [1]. The beamline consists of two experimental stations, (a) soft X-ray CVD and (b) soft X-ray photochemistry. (Fig. 1.)

2. Figure-8 Undulator

A novel insertion device called the Figure-8 undulator is installed as a light source [2]. The Figure-8 undulator provides linearly polarized soft X-rays in the energy range from 0.1 to 5 keV (at first order light). In addition, it provides both horizontally and vertically polarized soft X-ray beams by choice of an appropriate undulator gap.

3. (a) Soft X-ray CVD

In the soft X-ray CVD experimental station, soft X-rays from the above-mentioned undulator are used without further dispersion. Irradiating gaseous or solid samples with these soft X-rays in the range of 0.2~3 keV aims at the creation, synthesis, or processing of a variety of new materials.

3.1. Experimental Station

The experimental station consists of a differential pumping system, two reaction chambers with preparation chamber and analysis instruments. The reaction chamber allows for the irradiation of solid samples under ultra-high vacuum conditions, as well as under heated or cooled conditions in the presence of an added gas, such as rare gases, nitrogen, oxygen and hydrogen. The differential pumping system can maintain the ultra-high vacuum upstream, even when the reaction gases are introduced into the reaction chamber at pressures up to 1×10^{2} Pa.

4. (b) Soft X-ray Photochemistry

The soft X-ray photochemistry experimental station is designed for the study on the photoionization, and electronic relaxation dynamics of core excited atoms and molecules, as well as following ion fragmentation processes of molecules using a high resolution monochromator.

4.1. Monochromator

The monochromator is a Hettrick type, which is equipped with varied line space plane gratings and spherical focusing mirrors. Three gratings and two spherical mirrors cover the photon energy range from 0.2 to 3 keV [3]. The first commissioning of the monochromator has already been done. By measuring the photoabsorption spectrum of N_2 and Ne in the K-shell excitation region, the resolving power ($E/\Delta E$) is tentatively estimated to be better than 10000.

4.2. Experimental Station

The experimental station is equipped with a reflectron type time-of-flight mass analyzer (R-TOF), a cylindrical mirror type electron energy analyzer (CMA) and two retarding field ion detectors. These units are positioned around the incident photon beam axis. The chamber which houses these analysis instruments can rotate around the photon beam axis in the range from -20° to +110°.

Two retarding field ion detectors are set at right angles (fixed) and positioned in front of the CMA. In addition, they are mounted on a turntable, which allows for the rotation of the detectors independently around the photon beam axis, so that angle between the ion and electron analyzer can be continuously varied. In this way, the apparatus allows for the

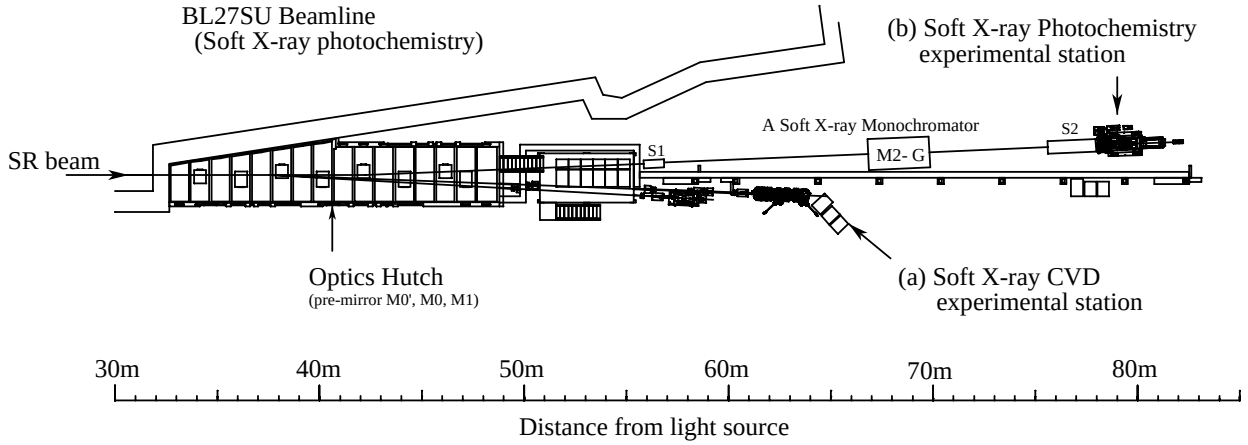

Fig. 1. Schematic view of BL27SU.

measurements of not only the angular distribution of photoelectrons and photoions but also for the angular correlation between them.

References

[1] I. Koyano *et al.*, J. Synchrotron Rad. **5** (1998) 545.

[2] T. Tanaka *et al.*, Rev. Sci. Instrum. **70** (1999) 4153.

[3] E. Ishiguro *et al.*, J. Electron Spectrosc. Related. Phenomena. **101-103** (1999) 979.

Light Source	
Type	Figure-8 undulator
Undulator period, λ_u	100 mm
Number of Periods, N_{period}	44
Tunable range	0.1 ~ 5k eV
Peak brilliance	1.1×10^{19} ph/s/mrad^2/mm^2/ 0.1%b.w. (at 1st harmonic=500 eV)
Total power	2.7kW (at 1st harmonic=500 eV)
Power density	1.7kW/mrad^2 (at 1st harmonic=500 eV)

X-rays at Sample	
Soft X-ray CVD	
Energy range	0.2 ~ 3 keV
Beam size	0.5×0.5 mm^2
Soft X-ray photochemistry	
Energy range	0.2 ~ 3 keV
Linearly polarized	
Photon Flux	>10^{11} photon/s
Energy resolution	E/ΔE >10^4

Facilities in Experimental Station

Soft X-ray CVD

• Reaction chamber

Ultimate pressure	5×10^{-8} Pa
Sample support	x, y, z, 15 mm square
Temperature range	-140 ~1000 ºC

500L/sec-TMP vacuum pump with load lock mechanism

• Gas supply system

Cylinder stokers (10 L×4, 47 L×3)

Soft X-ray photochemistry

• Reflectron Time-of-Flight Mass spectrometer

Wiley-McLaren type

Rotation angle	-20º~ +110º
Mass resolution	800 (thermal ions)
	80 (energetic ions ; 5 eV of E_{kE})

• Cylindrical Mirror type Electron Energy Analyzer

Acceptance solid angle	10% of 2πsr.
Energy resolution	0.1eV

• Retard Field Ion Detector

Two detectors are set at right angle on the rotating table.