Soft X-ray Spectroscopy of Solids

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1.Light Source and Optical System

Our light source is "Twin Helical Undulator" consisting of two helical undulators (left and right-handed) installed in tandem in a 4.5m straight section. This device covers the energy range from 0.5 to 3 keV with the fundamental radiation. Each helicity light can come out on the same optical axis(0-direction in Fig.1) and the helicity can be alternatively reversed by five kicker magnets. The circularly polarized light with unwanted helicity comes out into off-axis direction (1-direction with θ_k of 300 rad) and can be absorbed by a water cooled mask x-y slit set in the down stream. Quick helicity modulation up to 10 Hz or more with a switching time within 50 msec is the target.

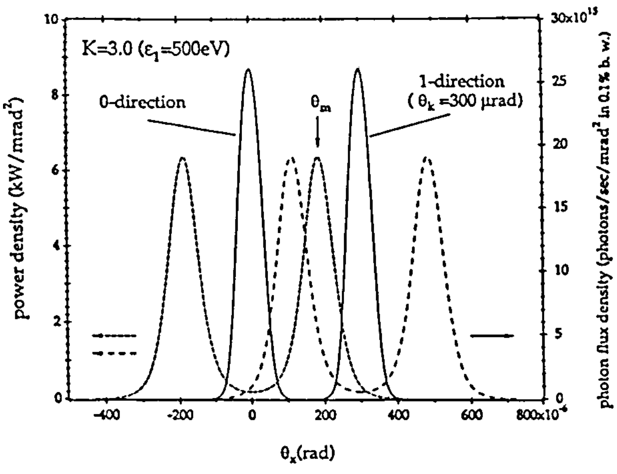

Fig.1 Power density and photon flux density from the twin-helical undulator for 100mA stored current.

The exclusive use of the circularly polarized light from the helical undulator of a high energy storage ring has characteristic advantages. First, the on-axis power density from the helical undulator is very low, especially for high K values, compared to that of the planar undulator, because most of the higher harmonics radiation is emitted off the axis of the helical undulator. The power density and photon flux density are shown by dashed and solid curves (The horizontal arrows indicate the corresponding ordinates). The left dashed curve(LCP) has two maxima at $\theta_x = \pm\theta_m$ and a minimum at $\theta_x = 0$. The right dashed curve shifted by 300μrad corresponds to the RCP radiation[1]. The on-axis power density of each undulator at K=3.0 (corresponding to the fundamental energy of ε_1 =500 eV) for the stored current of 100 mA is about 0.2 kW/mrad^2 for the total radiation power of 0.8 kW and θ_m is about 190 μrad. The photon flux density for 0.1% band width at ε_1 =500 eV is still as high as 2.6 × 10^{16} photons/sec/mrad^2 on the axis as shown by the solid curve.

When the helicity is changed, the undesirable radiation pass through the optical axis (0-direction) depending on the angle,θ_k, between the radiation directions of 0 and 1. The θ_m decreases with decreasing K value as approximated by $K/\gamma \sim$ 64μrad·K.

The θ_k between the two directions (0 and 1) is so determined that the power from the unused undulator is sufficiently suppressed in using a particular helicity. Restriction of the power supply for the kickers is also taken into account. As a result, the θ_k is set to 300 μrad.

The energy range from 0.5 to 1.5 keV is covered with a grating monochromator. The L and M edges of most transition metal and rare-earth materials are covered by this energy range.

Major optical elements of the BL25SU are as follows: (1)the pre-focusing mirrors, M_h and M_v in a hutch, (2)the varied-space plane-grating monochromator with the entrance and exit slits S_1 and S_2, and (3)the post focusing mirrors, M_3 and M_4. A variably bendable cylindrical mirror, Mh, horizontally deflects the undulator radiation by 3° and horizontally converges the light onto the sample positions. The spherical mirror, M_v, vertically focuses the beam onto the entrance slit. Water cooled Si substrates are used for these optical components to minimize possible effect of thermal instability. The water cooled entrance slit is continuously variable from 2 μm to 1 mm. In the present design of the monochromator, two deviation angles of 176˚ and 174˚ are employed to cover a wide photon energy range from 200 to 1500 eV, by in-situ selecting one of the spherical mirrors, M_1 and M_2, and one of the three gratings, G_1, G_2 and G_3. For the 174˚ deviation angle, the M_1 mirror is retracted from the beam path. One of the gratings is selected by a linear translation mechanism. The gratings are mechanically-ruled in the Au thin film deposited on SiC substrate to avoid the heat load problem. In the present monochromator, the wavelength scanning only requires a rotation of the grating. The performance of the monochromator is evaluated by the ray tracing. Very high resolution beyond 104($h\nu/\Delta h\nu$) is expected in the whole energy region even after considering possible slope errors.[1)]

2.End Stations

Three experimental stations are set up on this beam line. They are a)a high resolution photoemission apparatus composed of a SES200 spherical mirror analyzer combined with a closed cycle liquid He cryostat. The second is b)an apparatus for spectroscopy of magnetic circular dichroism of core absorption(MCD) as shown in Fig.2. Here the sample temperature can be also controlled by a liquid He cryostat. Two permanent-magnet dipoles with light guide hole are alternatively set on the optical axis by using a linear feed through. Then the direction of the magnetization can be changed. The sample surfaces are cleaned by in situ filing. In order to bake the analyzer chamber for getting ultrahigh vacuum, the internal cylinder of the He closed cycle cryostat should be removed. For facilitating that, working decks are set above the SES200 analyzer chamber and the MCD chamber. The third apparatus is c)a 2-dimensional display-type photoelectron analyzer to be used for angle resolved photoemission and photoelectron diffraction experiments. A two dimensional photoelectron angular distribution pattern at one particular kinetic energy is recorded simultaneously by a CCD camera. In order to realize a resolution of 1000 for the electron pass energy of the analyzer, the radius of the outer hemisphere of this analyzer is set to 300 mm. For baking these vacuum chambers, we employ thermal insulation clothes in the form of oven. In all three systems, samples are introduced from the entry air-lock system and cleaned in the sample preparation chamber separated from the analyzer chamber by gate valves. UHV test is over for these instruments and the users are now waiting for the circularly polarized light from the twin helical undulator.

References

[1] Y.Saitoh, T.Nakatani, T.Matsushita, T.Miyahara, M.Fujisawa, K.Soda, T.Muro, Ueda, H.Harada, A.Sekiyama, S.Imada, H.Daimon and S.Suga, J.Synchrotron Rad.(1998), in press.

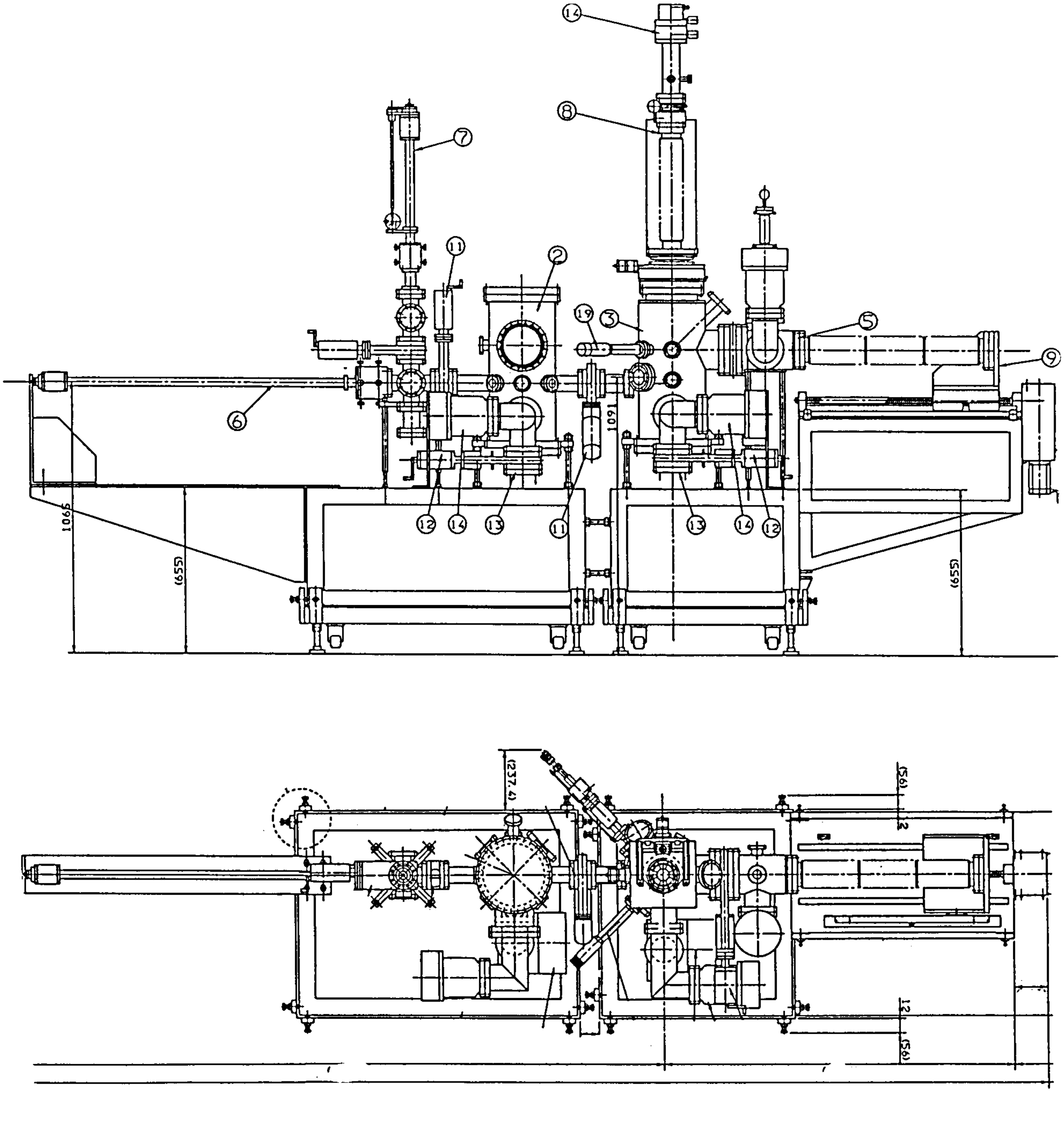

Fig.2 MCD instrument installed at BL25SU.
Side view(top) and top view(lower).