Soft X-ray Spectroscopy of Solids

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1. Light Source and Optical System

A newly designed twin helical undulator with a potential of rapid helicity modulation is installed at BL25SU soft X-ray undulator beam line. Figures la-c show the beam line out of the shielding wall. The circularly polarized light passing through a water cooled aperture is first horizontally deflected by a variable focal length cylindrical mirror(Mh). The Mh could be retracted from the light pass when the light is to be guided to a crystal monochromator, which is not yet funded. Then the light deflected by Mh is guided to the Mv spherical mirror, which guides the light vertically to an entrance slit(Fig.1b) of a grating monochromator.

The monochromator(M) is a varied space plane grating type, which can cover from 100 to 1500 eV by in-situ selecting one of the three gratings mounted on a grating holder. The resolution at 1000 eV could be much better than 10^4 even considering typical slope errors of optical elemnts. In front of the grating, one of the two different mirrors(M1 and M2) can be put on the optical axis to focus the light behind the grating. The two mirrors cover different spectral regions. After passing through the exit slit(Fig.1c), the monochromatic light is focussed by a toroidal mirror(M3) onto the sample. For extremely small submillimeter focussing, we will use another mirror chamber with M4.

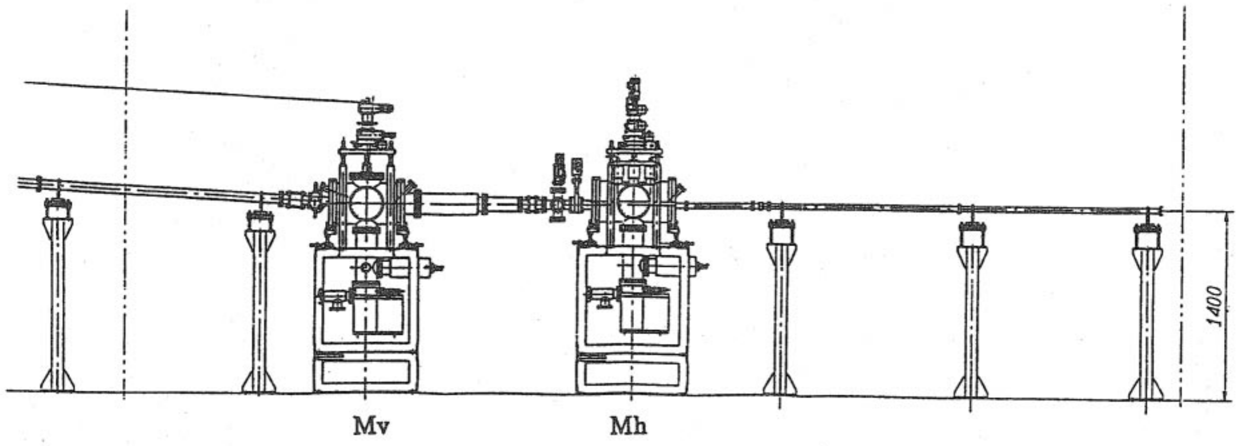

Fig.1a Mh and Mv from the right.

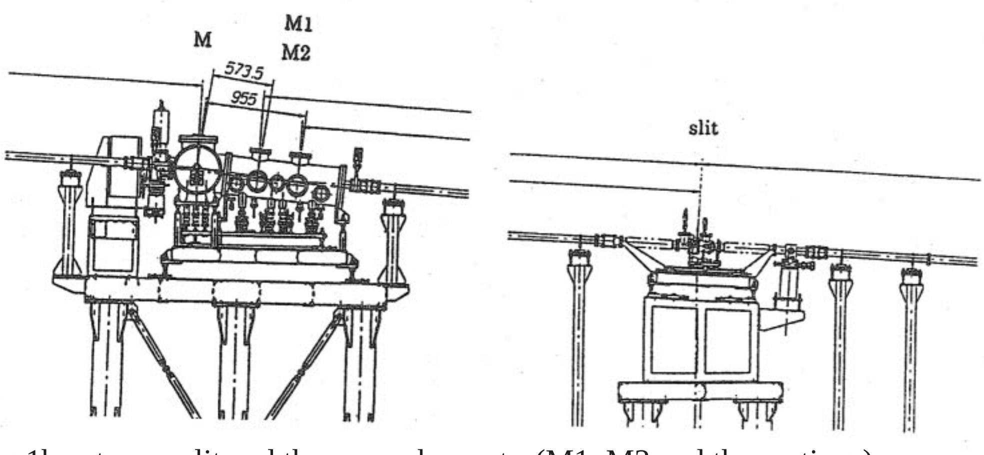

Fig.1b entrance slit and the monochromator(M1, M2 and the gratings)

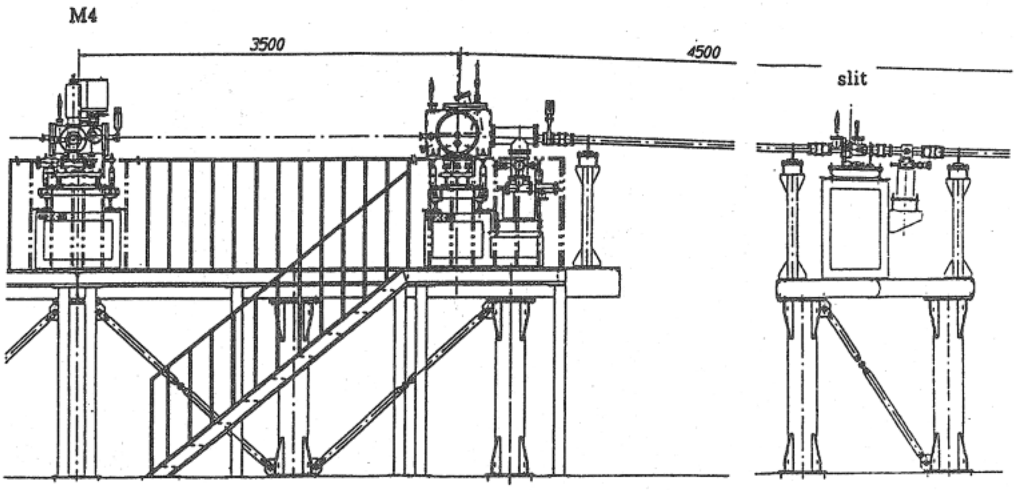

Fig.1c exit slit, and M3 and M4. The high resolution photoemission and MCD instruments are located between M3 and M4. 2D analyzer is placed behind M4.

2.End Station

Three stations are planned on this beam line. They are a)high resolution photoemission apparatus composed of a SCIENTA SES200 spherical mirror analyzer combined with a He cryostat. A schematic view of the experimental set up is shown in Fig.2.

The second is b)an apparatus for measurement of magnetic circular dichroism of core absorption spectroscopy. Here the sample is cooled by a He cryostat and the sample temperature is controlled. In the first stage, two permanet-magnet dipoles are used for changing the direction of the magnetization. In future, a superconducting magnet will be used in combination with the rapid helicity modulation of the undulator light. The third apparatus is c) 2-dimensional display-type photoelectron analyzer to be used for angle resolved photoemission and photoelectron diffraction experiments. A schematic view of the instrument is given in Fig.3. A two dimensional angular distribution pattern of photoelectron at one particular kinetic energy(E_K is recorded simultaneously by a CCD camera. In order to cover the photon energy range from 500 to 3000 eV in the second stage, the size of the analyzer is almost doubled than that described in Ref.1 to provide a resolution of 1/1000 for the electron pass energy of the analyzer.

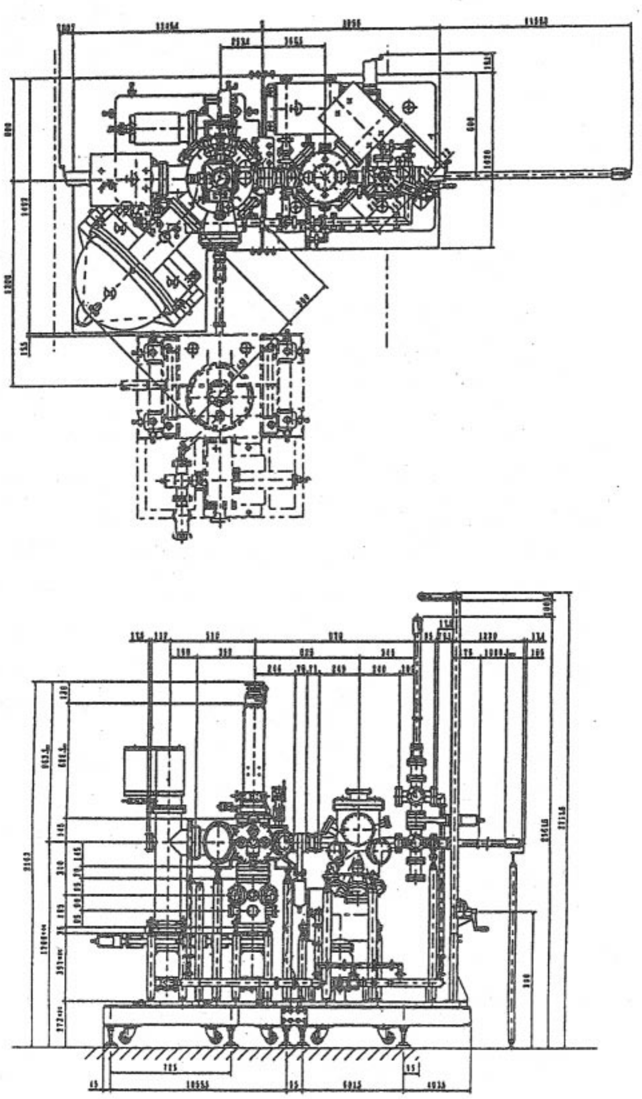

Fig.2 High resolution photoemission instrument.

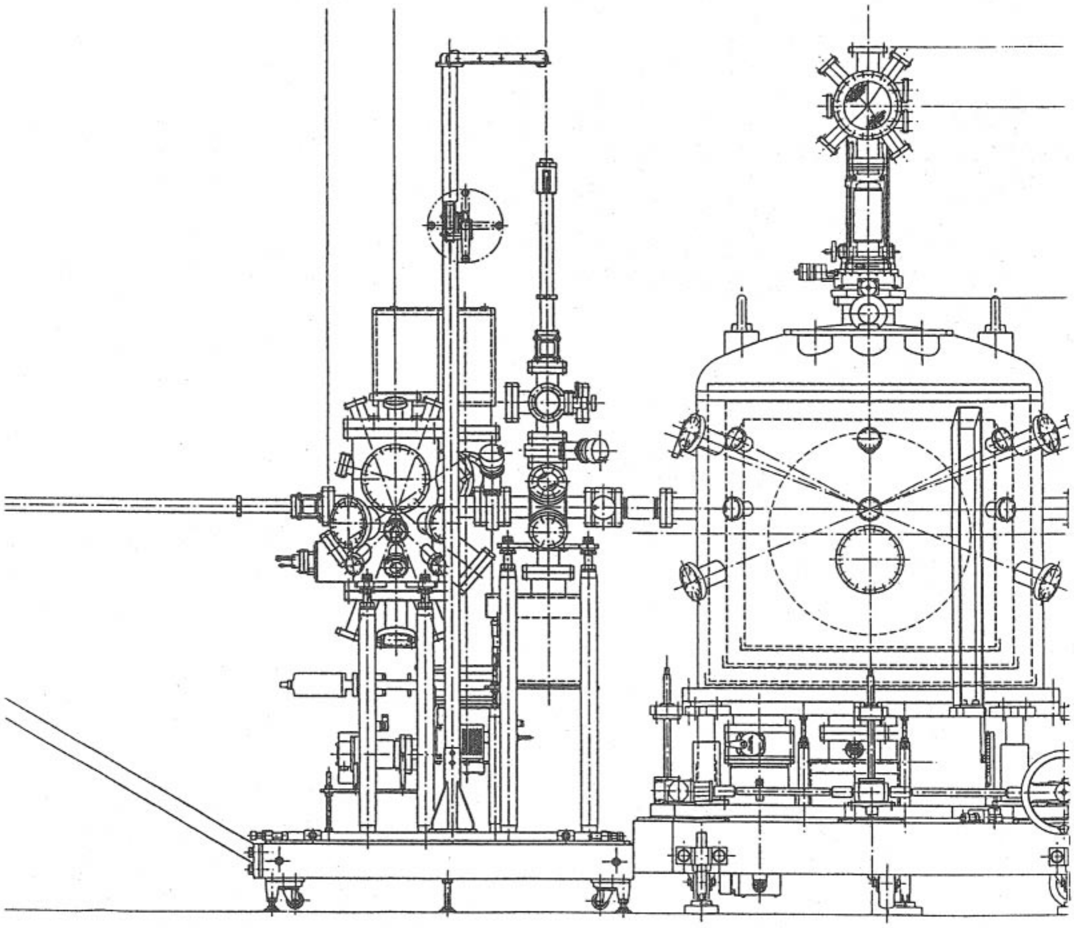

Fig.3 3D display type analyzer.

3. Research Subjects

3-1 High resolution photoemission

High resolution photoemission is very important to probe the electronic structures of correlated electron systems of such materials as high Tc oxide superconductors, heavy fermion materials and various materials which show phase transition with changing temperature. Since the low energy photoemission is strongly modified by the surface effect by the short mean free path of the photoelectrons,high energy photoemission with quite high resolution is required for many years. The apparatus installed at this beam line has a capability to perform such experiments.

3-2 Magnetic circular dichroism(MCD) of core absorption

The complete circular polarization of the light, easy handling of the helicity change and the parallel tuning of the undulator gap with hv enable us to do high precision MCD measurement. It is possible to measure the MCD of the core absorption of magnetic as well as non-magnetic atoms. So one can probe and know the spin polarization of the whole electronic states of complex magnetic materials . Dynamical behavior of the spin polarization and hybridization effects will be studied in detail on this beam line.

3-3 2D(two-dimensioned) photoelectron measurement

Both the surface geometrical structure and surface electron structures will be effectively probed by using the 2D display type photoelectron analyzer. For example, atomic structures of the surface adsorbed system can be well studied by means of the photoelectron diffraction (PED). Although PED can determine the 3D structure, it usually requires tedious trial and error cycles to determine the surface structure. The photoelectron holography (PEH) can be easily done by using many 2D PED patterns recorded at different kinetic energies . By this method we can obtain three-dimensional image of the surface structure by applying simple Fourier transformation to the observed 2-dimensional photoelectron diffraction patterns.

With use of the circularly polarized undulator radiation, the rotation of the photoelectron diffraction pattern from non-chiral and non-magnetic crystal is expected and really observed. This effect can be also utilized to develop a new method of 3-dimensional surface structure analysis without using even the Fourier transformation.

4.Schedule

4-1 design

	1997 Jan.	1998 Jan.	1999 Jan.	2000 Jan.	2001 Jan.
crystal monochromator		------------			

4-2 construction

	1997 Jan.	1998 Jan.	1999 Jan.	2000 Jan.	2001 Jan.
2-D detector	----				
experimental chamber	---				
grating monochromator	---				
crystal monochromator		--------			
optical system	-----				
undulator	-----				

4-3 commissioning

	1997 Jan.	1998 Jan.	1999 Jan.	2000 Jan.	2001 Jan.
undulator	----				
optical system	----				
grating monochromator	----				
crystal monochromator			--------		
experimental system		start of experiments			
		*(12 international proposal)			