Soft X-ray Scattering and Spectroscopy (SSS) beam line in PAL-XFEL

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The Soft X-ray Scattering and Spectroscopy (SSS) beam line provides the XFEL with an energy range of 0.25 ~ 1.2 keV, at a repetition rate of 60 Hz with pulse width as short as 90 fs. SSS experimental instruments are intended to be relevant to diverse scientific programs related to spectroscopy and scattering in a basic research area of solid state materials science. The beam line consists of offset mirrors, a varied line spaced grating monochromator, and Kirkpatrick-Baez (KB) refocusing optics, as shown in FIG1. The monochromator is designed to have fundamental resolving power of 10000. Using KB optics, photon beams with small divergence < 1 mrad, and small size < 5 μm can be provided all the entire range of photon energy.

SSS experimental instruments aim to provide diverse scientific programs related to spectroscopy and coherent scattering. Two different end stations will be constructed. End Station 1 (already setup now) will be used for Coherent X-ray diffraction imaging (CXDI), and resonant inelastic X-ray scattering (RIXS). End Station 2 (not completed yet) will be used for resonant soft X-ray scattering (RSXS).

XPS, RIXS, and CXDI experiments can be performed independently in one sample chamber (FIG.1). The experimental chamber (FIG. 1bottom) can provide three different photon sources and three different detectors; XFEL, optical laser, and EUV can be chosen as pump or probe beam. PI-MTE 2048B is used as the CXDI detector, and a Newton DO940P-BN is used as an RIXS detector.

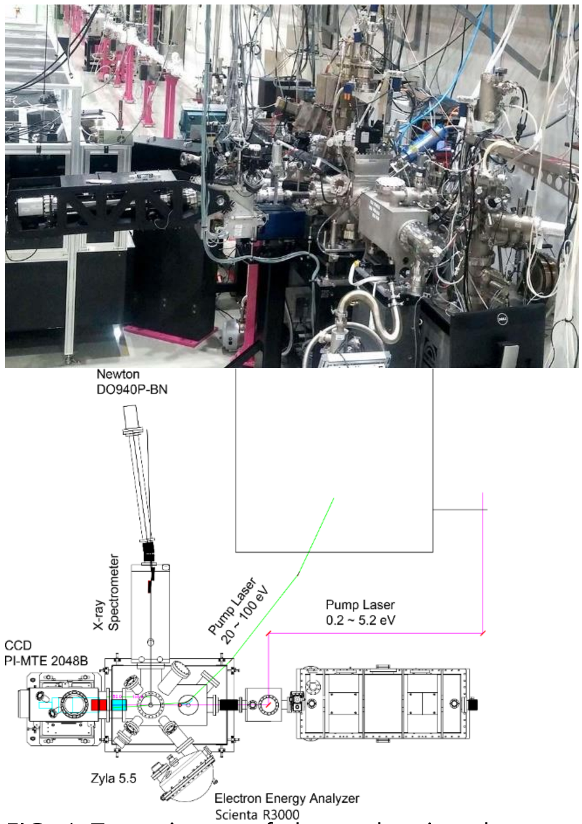

FIG. 1 Top: picture of the endstation, bottom: schematic diagram of the endstation.

The design of the RIXS spectrometer is based on that of Dr. Yi-de Chung at advanced light source (ALS). It is composed of three parts: a spherical pre mirror, a plane grating (2400 lines/mm), and an area CCD detector. This spectrometer is designed to diffract photons of 200 eV ≤ E ≤ 1200 eV with an expected energy resolving power of 1500 at 1000 eV. FIG. 2 top shows the results of test experiment using CeO_2. The typical charge transfer (CT), f-f excitation, and elastic emissions can be clearly seen. The elastic peak shows FWHM of 0.6 eV, which is the measure of resolving power of the spectrometer.

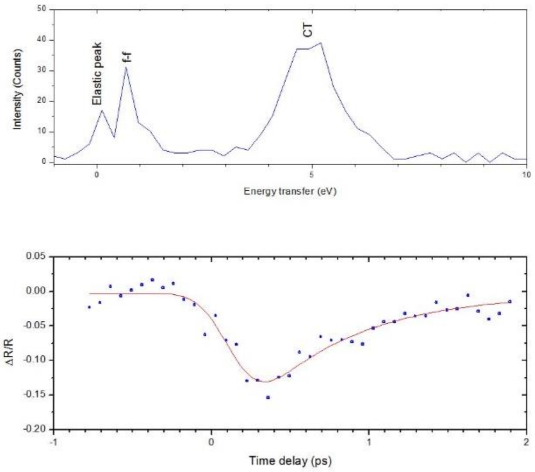

FIG. 2 Top: RIXS spectrum of CeO2 at incident photon energy of 884 eV. Bottom: X-ray pump-400 nm optical laser probe experiment showing total coincidence timing of the beamline.

Most of the XFEL experiments involve pump probe process, in which timing between pump and probe pulses is important. FIG. 2 bottom shows the typical pump-probe experiments, in which SiNx film was pumped by XFEL and the change of reflectivity of SiNx by 400 nm optical laser was recorded as a function of delay between the two pulses. The FWHM of modulated Gaussian peak is estimated to be around 320 fs. This value contains total timing coincidence including pulse widths of XFEL and Laser, timing jitter, XFEL pulse stretching by the grating, and time broadening by SiNx itself.

Even though the other end stations and experimental apparatus are still under development, this beamline has undertook three user experiments in 2017. And the 2018 beam time proposal is open to global users. (http://pal.postech.ac.kr/)

After obtaining Ph.D. from Dept. Physics of Yonsei Univ. in 2001, he elaborated on electronic properties of diversity of organic semiconductors both in industry and in university as a research professor. Since 2013, he has been developing x-ray optics and experimental instruments for soft X-ray beam line of PAL-XFEL. His main research interest is the investigation of the dynamics of electronic structure of nano-sized materials using photoemission spectroscopy and inelastic resonant x ray scattering (RIXS)