2. Status of Beamline BL07LSU at SPring-8

The University-of-Tokyo high-brilliance synchrotron soft X-ray outstation beamline BL07LSU at SPring-8 has been maintained by the permanent staff members with an adjunct for user operations. A scientific aim of the beamline is to promote advanced spectroscopy for solid state and soft materials. There are currently three regular endstations: time-resolved soft X-ray spectroscopy (TR-SX spectroscopy), 3D-scanning photoelectron microscope (3D nano-ESCA) and ultrahigh resolution soft X-ray emission spectroscopy (HORNET), along with a free port station for users who bring their own experimental apparatus.

In 2013, several improvements and upgrading were made for the undulator. First, a compact photon absorber was installed in the ring. A high-heat-load problem at the bending magnet chamber was solved and almost all the restrictions on the minimum gaps of the undulator segments were lifted. Only one vertical undulator segment is restricted to close its gap below ~270 eV. The degree of the circular polarization using all the eight undulator segments was evaluated by the soft X-ray polarization analyzer to be as high as ~0.94, which is good agreement with the expected value from the calculation.

Second, updated electromagnetic phase shifters with redesigned thin-walled SUS ducts for the fast polarization switching were reinstalled to the ring in the summer. Before the reinstallation, the gaps of cut-core coils for the electromagnetic phase shifters have been narrowed from 40 mm to 25mm and pairs of the gaps of the coils have been mechanically optimized to suppress an integrated magnetic field which could disturb the trajectory of the electron beam (Fig. 1). In the second half of 2013, the electronic phase shifters were tested with the accelerator group of RIKEN SPring-8 center and found that the disturbance to the electron beam is small enough to be corrected by sterling magnets. By installing sterling magnets, the electromagnetic phase shifters will be available for user operation and the development of the fast polarization switching will be advanced.

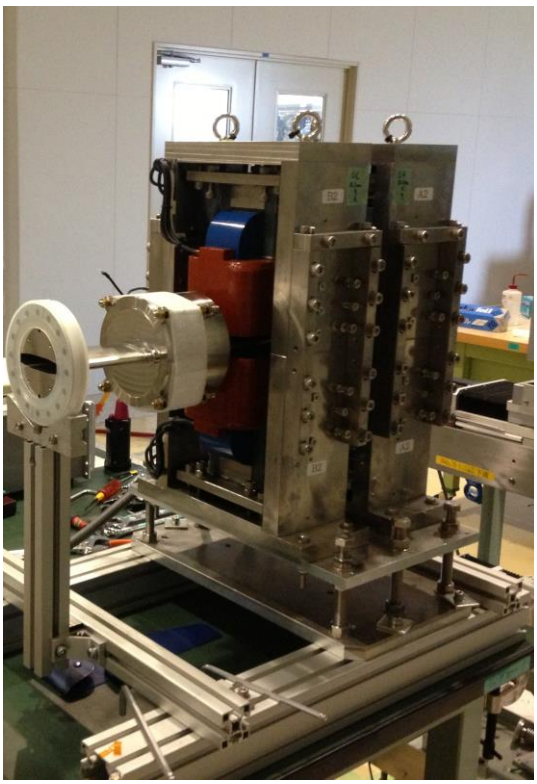

Figure 1. Adjustment of the electromagnetic phase shifter before the reinstallation in the SPring-8 storage ring.

At the beamline endstations, various scientific researches were carried out by both the laboratory staff and general users (G-type application). Below are brief introduction of recent activities at each station.

(1) Time-Resolved soft X-ray spectroscopy station (TR-SX spectroscopy)

The station is to perform time-resolved photoemission spectroscopy experiments by synchronizing the high-brilliant soft x-ray and the ultra-short laser pulses. A new type of the electron spectrometer, the two-dimensional angle-resolved time-of-flight (ARTOF) analyzer, is installed. In 2013, a low temperature manipulator, allowing sample cooling to 5 K, is combined with reflection high-energy electron diffraction (RHEED) to confirm structural phase transitions at low temperatures. In addition, sample transfer capability was added to the low temperature manipulator. Time-resolved photoemission measurements were performed to trace photo-induced phenomena on semiconductor surfaces, such as photo catalysts of $SrTiO_3$, ZnO, and TiO_2, in *real time*.

(2) 3D-scanning photoelectron microscope (3D nano-ESCA)

The endstation is for three-dimensional (3D) spatially resolved electron spectroscopy for chemical analysis (ESCA). With a zone-plate, a spot size of the beam on the sample is typically smaller than 100nm. The scanning photoelectron microscope is equipped with a depth profiling analysis capability. As a consequence, users carried out the 3D nano-ESCA measurements at the station. In 2013, bias application and semiconductor parametric analyzer systems were installed for *operando* spectroscopy of electronic devices. The system has been applied for the observation of charge-transferred region in graphene-FET, Li-insertion/extraction mechanism of $LiMnO_4$, thin film organic FET, VO_2 nanowire, N-doped graphene.

(3) Ultra high-resolution soft X-ray emission spectroscopy (HORNET)

The station is for soft X-ray emission spectroscopy measurements with ultra high-resolution ($E/\Delta E > 10^4$) and under various environmental conditions (gas, liquid and solid). In 2013, a silicon drift detector was installed for soft X-ray absorption spectroscopy by partial fluorescence detection, which enables low background collection of the XAS signal especially for insulating and wet materials. For liquid RIXS experiments a precise temperature control system which enables liquid flow-through experiments under 20^oC – 80^oC has been installed. The *operando* spectroscopy system for fuel cell catalysts and lithium ion-batteries has been modified and now enables irradiation-damage free/reduced experiments.

(4) Free-port station

The station is equipped with a focusing mirror chamber, and users can connect their own experimental chambers. In 2013, the station was used for measuring resonant magneto-optical Kerr effects (MOKE) from ferromagnetic thin films. Kerr rotation angle of about 2 degrees were observed from ferromagnetic and insulating BaFeO3 thin films at 100 K. This study will lead to systematic studies of MOKE from other ferromagnetic thin films, and to time-resolved MOKE measurements.

References:

[1]H. Niwa, M. Saito, M. Kobayashi, Y. Harada, M. Oshima, S. Moriya, K. Matsubayashi, Y. Nabae, S. Kuroki, T. Ikeda, K. Terakura, J.-i. Ozaki, S. Miyata, J. Power Sources, **223**, 30 (2013).

[2]S. Yamamoto and I. Matsuda, J. Phys. Soc. Jpn. **82**, 021003 (2013).

[3]R. Yukawa, S. Yamamoto, K. Ozawa, M. D'Angelo, M.G. Silly, F. Sirotti, I. Matsuda, Phys. Rev. B **87**, 115314 (2013).

[4] K. Horiba, K. Fujikawa, N. Nagamura, S. Toyoda, H. Kumigashira, M. Oshima, and H. Takagi, Appl. Phys. Lett. **103**, 193114 (2013).

[5] N. Nagamura, K. Horiba, S. Toyoda, S. Kurosumi, T. Shinohara, M. Oshima, H. Fukidome, M. Suemitsu, K. Nagashio, A. Toriumi, Appl. Phys. Lett. **102**, 241604 (2013).

[6] M. Ogawa, S. Yamamoto, R. Yukawa, R. Hobara, C.-H. Lin, R.-Y. Liu, S.-J. Tang, I. Matsuda, Phys. Rev. B **87**, 235308 (2013).

[7] M. Ogawa, S. Yamamoto, K. Fujikawa, R. Hobara, R. Yukawa, Sh. Yamamoto, S. Kitagawa, D. Pierucci, M.G. Silly, C.-H. Lin, R.-Y. Liu, H. Daimon, F. Sirotti, S.-J. Tang, I. Matsuda, Phys. Rev. B **88**, 165313 (2013).

[8]H. Niwa, H. Kiuchi, J. Miyawaki, Y. Harada, M. Oshima, Y. Nabae, T. Aoki, Electrochem. Commum. **35**, 57 (2013).

[9] Y. Harada, T. Tokushima, Y. Horikawa, O. Takahashi, H. Niwa, M. Kobayashi, M. Oshima, Y. Senba, H. Ohashi, K. T. Wikfeldt, A. Nilsson, L. G. M. Pettersson, S. Shin, Phys. Rev. Lett. **111**, 193001 (2013).

[10] M. Ogawa, R.-Y. Liu, C.-H. Lin, S. Yamamoto, R. Yukawa, R. Hobara, S.-J. Tang, I. Matsuda, Surf. Sci. **624**, 70-75 (2014).

[11] S. Yamamoto, Y. Senba, T. Tanaka, H. Ohashi, T. Hirono, H. Kimura, M. Fujisawa, J. Miyawaki, A. Harasawa, T. Seike, S. Takahashi, N. Nariyama, T. Matsushita, M. Takeuchi, T. Ohata, Y. Furukawa, K. Takeshita, S. Goto, Y. Harada, S. Shin, H. Kitamura, A. Kakizaki, M. Oshima, and I. Matsuda, J. Synchrotron Rad. **21**, 352 (2014).

[12] M. Kobayashi, H. Niwa, Y. Takeda, A. Fujimori, Y. Senba, H. Ohashi, A. Tanaka, S. Ohya, P. N. Hai, M. Tanaka, Y. Harada, and M. Oshima, Phys. Rev. Lett. **112**, 107203 (2014).

[13] K. Ozawa, M. Emori, S. Yamamoto, R. Yukawa, Sh. Yamamoto, R. Hobara, K. Fujikawa, H. Sakama, I. Matsuda, J. Phys. Chem. Lett. **5**. 1953-1957 (2014).

[14] Sh. Yamamoto, M. Taguchi, M. Fujisawa, R. Hobara, S.Yamamoto, K. Yaji, T. Nakamura, K. Fujikawa, R. Yukawa, T. Togashi, M. Yabashi, M. Tsunoda, S. Shin, and I. Matsuda, Phys. Rev. B **89**.064423 (2014).

[15] H. Fukidome, M. Kotsugi, K. Nagashio, R. Sato, T. Ohkochi, T. Itoh, A. Toriumi, M. Suemitsu and T. Kinoshita, Sci. Rep.4, 3713 (5 pages) (2014)

[16] H. Fukidome, K. Nagashio, N. Nagamura, K. Tashima, K. Funakubo, K. Horiba, M. Suemitsu, A. Toriumi and M. Oshima, Appl. Phys. Express 7, 065101 (2014).

[17] N. Nagamura et al., J. Phys.: Conf. Ser. 2014, accepted.

[18] I. Matsuda, A. Kuroda, J. Miyawaki, Y. Kosegawa, S. Yamamoto,T. Seike, T. Bizen, Y. Harada, T. Tanaka, and H. Kitamura, Nuclear Inst. and Methods in Physics Research A accepted..