Light Source Developments by Using Relativistic Electron Beams

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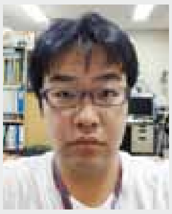

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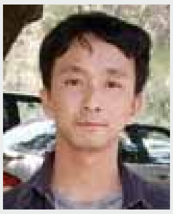

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This project involves researches and developments on synchrotron light source, free electron laser, beam physics and their related technologies, such as applications of the light sources. The most of the researches were carried out at the UVSOR facility.

1. Developments on UVSOR Accelerators

The magnetic lattice of UVSOR was modified in 2012. The new lattice gives small emittance of 15 nm-rad, which results in higher brightness of the synchrotron radiation. An in-vacuum undulator was successfully commissioned, which provides intense soft X-rays to a scanning transmission X-ray microscope (STXM). Although the storage ring was successfully commissioned in July, 2012,[1)] the machine tuning has been continued to achieve more stable operation. The beam injection efficiency has been gradually improved by the fine tuning of the injection system. Sudden beam losses frequently observed just after the commissioning have been gradually decreasing, as the vacuum conditioning via irradiation of synchrotron radiation was proceeding.

A new novel technique to inject the beam with a pulse sextupole magnet (Figure 1) was successfully demonstrated. By using this technique, the beam movement during the injection, which is inevitable with the traditional injection scheme with pulsed dipole magnets, can be avoided. As the result of the machine study just for two days, we could achieve the injection efficiency of about 20%. To introduce this scheme to the daily users operation, the efficiency should be higher than 50%. The study is going on.

Figure 1. Pulse sextupole magnet developed for UVSOR-III.

2. Improvements of STXM Beam-Line

After the successful commissioning of the STXM, the beamline BL4U (Figure 2), has been improved as an integrated system for upcoming user operation. For example, to bring out satisfactory performance of the STXM, 1) control software of the beamline with sophisticated GUI, which makes linkage between the undulator, the monochromator and the STXM, was updated. 2) Wider energy range of incident X-rays, from 150 to 880 eV, became available by tuning the monochromator and the gap width of the undulator. 3) An experimental hutch was built at the end station of the beamline to stabilize temperature, to avoid from acoustic noise and to keep the air clean around the STXM.

On the other hand, two sample cells were designed for new applications of in-situ and polarization dependent observations. These sample cells will open new region of molecular science of the STXM.

Figure 2. BL4U Beam-line for STXM.

3. Light Source Technology Developments

We have demonstrated that coherent synchrotron radiation of various properties could be generated in an electron storage ring by using an external laser source. This research is supported by the Quantum Beam Technology Program of JST/MEXT. Under this support, a new experimental station has been constructed. The generation of coherent synchrotron radiation at the new site was successfully demonstrated. Some basic researches on coherent synchrotron radiation have been conducted as shown in Figure 3.[2] An ultrafast terahertz detector was tested.[3] Applications using coherent synchrotron radiation are under preparation and will be demonstrated in near future.

Laser Compton scattering is a method to produce monochromatic and energy-tunable gannma-ray pulses. Laser pulses are injected to the storage ring and are scattered by the relativistic electrons circulating in the ring. We developed a method to produce ultra-short gamma-ray pulses and have demonstrated a photon-induced positron annihilation lifetime spectroscopy experiment.[4]

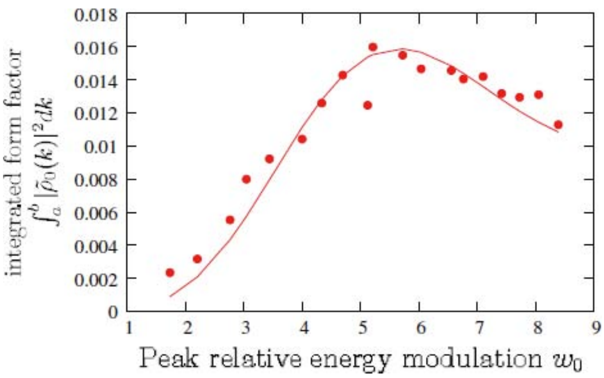

Figure 3. Observed saturation of coherent synchrotron radiation produced by the laser modulation method at UVSOR-II.

References

1) M. Adachi, H. Zen, T. Konomi, J. Yamazaki, K. Hayashi and M. Katoh, *J. Phys.: Conf. Ser.* **425**, 042013 (2013).
2) M. Hosaka, N. Yamamoto, Y. Takashima, C. Szwaj, M. Le Parquire, C. Evain, S. Bielawski, M. Adachi, T. Tanikawa, S. Kimura, M. Katoh, M. Shimada and T. Takahashi, *Phys. Rev. S. T. Accel. Beams* **16**, 020701 (2013).
3) P. Thoma, A. Scheuring, S. Wuensch, K. Il'In, A. Semenov, H-W Huebers, V. Judin, A-S. Mueller, N. Smale, M. Adachi, S. Tanaka, S. Kimura, M. Katoh, N. Yamamoto, M. Hosaka, E. Roussel, C. Szwaj, S. Bielawski and M. Siegel, *IEEE Trans. Terahertz Sci. Tech.* **3(1)**, 81–86 (2013).
4) Y. Taira, H. Toyokawa, R. Kuroda, N. Yamamoto, M. Adachi, S. Tanaka and M. Katoh, *Rev. Sci. Instrum.* **84**, 053305 (2013).

Awards

TAIRA, Yoshitaka; Young Scientist Award of the Physical Society of Japan.
TAIRA, Yoshitaka; 2012 Annual Meeting Award of the Particle Accelerator Society of Japan.
HIDA, Yohei; 2012 Annual Meeting Award of the Particle Accelerator Society of Japan.
NIWA, Takahiro; 2012 Annual Meeting Award of the Particle Accelerator Society of Japan.

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