Compact synchrotron light source HiSOR - Present status and future prospects -

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The light source accelerator system at the Hiroshima Synchrotron Radiation Center (HSRC) consists of a 150 MeV injector microtron, a beam transport line, and a racetrack type storage ring. This system is called HiSOR (Hiroshima Synchrotron Orbital Radiation). The circumference of this ring is 22 m, and the bending radius is 0.87 m in the normal conducting bending magnet with high magnetic field of 2.7 T. Stored electron beam energy is 700 MeV, and synchrotron radiation having the critical energy of 873 eV from two 180-degree bending magnets can be extracted through 14 photon beam ports. There are two straight sections in the ring and two undulators are installed there. One is a linear undulator (2.4 m long, 57 mm period. Another is the variable polarization undulator (1.8 m long, 78 mm period). They provide high brightness VUV radiation to the photoelectron spectroscopy beam-lines.

HiSOR has been successfully operated since 1996. Operation hours exceed 2,000 hours in each year, and users' operation hours are about 1,600 hours. The machine is running 11 hours a day (with 2 injections) and 4 days a week. Monday is reserved for machine tunings, machine studies and maintenances. The machine startup in the morning takes 30 minutes. It is almost possible to make a turn-key operation for normal use. The beam is about 300mA just after the energy ramping and about almost a half just before the re-injection. Although the 24-hour operation has been requested from users, it is difficult to realize it due to the lack of manpower.

In the early 2010s, we had a significant issue regarding the leakage of cooling water from the synchrotron radiation absorbers into the ultra-high vacuum chamber in the dipole magnets. Unfortunately, this issue has recurred this year, approximately 10 years later. The absorber was temporally repaired to recover the accelerator as soon as possible. It should be replaced with new one, whose mechanical design would be reconsidered, in the nearest future.

We evaluated the necessity and urgency of the aging-related issues of the accelerator components, and have been replacing those one by one. We are currently promoting the replacement of the pulsed electromagnet power supply for beam injection, which would utilize semiconductor devises instead of a thyratron for the switching element. The replacement would be in the summer of 2025.

The control systems of the undulators are being upgraded. In FY2023, it was improved within the existing accelerator control system framework, so that they can be controlled from the beam-line control system. However, the response speed is not sufficiently high as requested from the users. In addition, the accuracy of the closed orbit correction is not sufficiently high and the experiments in the other beam-lines are perturbed by the undulator gap changes. To address these, we are going to install a totally new control system which is equivalent to that used in UVSOR.

Since the upgrade of the present HiSOR storage ring is not realistic because it is designed so compact and has no redundancy to introduce new ideas or apparatus. Therefore, for the future plan, a new storage ring HiSOR-2 has been designed. We are preparing several plans to flexibly adapt to the situations of the synchrotron radiation science in our country and also of Hiroshima university. The beam energy of HiSOR-2 would be 500 MeV, which is appropriate to produce high brightness VUV radiation with a compact ring. We have designed a ring with a circumference of approximately 50m but also are designing a more compact one with a circumference below 40m. Although construction of a full energy injector is included in the plan, we are also considering usage of the current HiSOR storage ring as a full-energy injector for HiSOR-2.

To prepare for future plans, we are conducting researches on new accelerator technologies, such as new injection scheme using pulse multipole magnets, accelerator control by machine learning and permanent-

electric hybrid magnets. These development researches are being conducted in the collaboration with KEK-PF, UVSOR, and Nagoya University. This year, the accelerator groups of KEK-PF, UVSOR, Nagoya University and HiSOR have initiated regular monthly information exchange meetings. The collaboration aims not only to advance joint developments of new technologies but also standardization of accelerator components and maintenance parts, all of which would be effective in the reductions of the cost and the manpower for operating and maintaining the present machine and for developing the future accelerators. HiSOR-2 would be almost diffraction-limited VUV source. We continue researches on developing new light source technologies in collaboration with UVSOR. The graduate and undergraduate students join these researches. Some of them are conducted under the support of KEK's Accelerator Science International Education Program (IINAS-NX).

REFERENCES

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