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The Siam Photon Laboratory

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A synchrotron radiation research project, the Siam Photon Project, is underway in Thailand. The light source used in the project is the modified SORTEC storage ring. The project and simple aspects of the light source are described. The detailed design of the building to accommodate the experimental hall and the light source has been accomplished and the construction will start soon. The engineering design work of the machine components necessary for the modifications to reduce the beam emittance and to make the installation of insertion devices possible is underway.

Keywords: Siam Photon Project; NSRC.

1. Introduction

The Siam Photon Laboratory is the facility that will realize the Siam Photon Project promoted by the National Synchrotron Research Center of Thailand (NSRC). The Siam Photon Project is the first synchrotron radiation research plan not only in Thailand but also in the ASEAN countries (Pairsuwan & Ishii, 1997). When an advanced and large-scale science project of this type is proposed in a society where the background technology for implementing it is not well developed, there must be arguments regarding the way in which the project should be realized. A simple and obvious way is to start with basic studies that allow technical experience to be acquired and enhance experimental skills in related research fields. Another extreme is to import a completed machine and use it for research as well as for the training of scientists and engineers with no experience in synchrotron radiation research. The scientists in Thailand selected the second option as it appears to be quite effective for training research workers in this novel interdisciplinary science and for catching up with world standards.

The National Synchrotron Research Center was established in March 1997. The Center proposed the Siam Photon Project and decided to receive the shutdown SORTEC storage ring, modify it and reassemble it at Nakhon Ratchasima, 250 km to the northeast of Bangkok. The transfer of the SORTEC ring to NSRC was agreed between the SORTEC Corporation of Japan and NSRC in late August 1996. The components of the dismantled SORTEC ring and its injector system were shipped to Thailand in December 1996, and arrived at NSRC in January 1997. Building construction will start in October 1997.

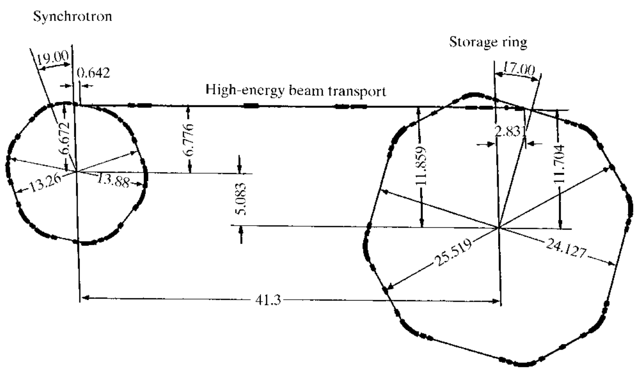

Figure 1
Plan view of the layout of the synchrotron, the high-energy beam-transport line and the storage ring. Note that the beam-transport line is not straight in practice (see text). The illustrated sizes (m, °) are not accurate.

2. The Siam Photon Project

The Siam Photon Project can be summarized as follows:

(1) The SORTEC storage ring will be modified and rebuilt. The new ring, referred to as the *Siam Photon Source*, will have an ultimate beam energy of 1.2 GeV with an energy of 1.0 GeV at the initial stage. Insertion devices are to be installed.

(2) The major scientific research will be spectroscopic studies on solid and gaseous materials, surfaces and interfaces, and biological materials. Studies of the radiation effects on biological materials and basic research on microlithography and micromachining will also be carried out.

(3) Throughout the construction of the Siam Photon Source and the associated beamlines, young scientists, engineers and technicians shall be trained in this field of advanced technology. Experiments carried out with the newly built experimental stations will be used to train young scientists in state-of-the-art science, particularly in the fields of physics, chemistry and materials science.

Table 1
Design parameters of the synchrotron.

Injection energy	40 MeV
Maximum energy	1 GeV
Circumference	43.19 m
Bending radius	3.03 m
Lattice structure	FODO
Beam current	30 mA
Repetition rate	1.25 Hz
Betatron tune, ν_x /ν_y	2.25/1.25
Maximum dipole field	1.1 T
Maximum gradient of quadrupole field	4.8 T m^{-1}
RF frequency	118 MHz
Maximum RF voltage	60 kV
Chamber pressure (with beam)	$<1 \times 10^{-6}$ Torr

A beam-dynamics calculation of the modified storage ring has been carried out (Kengkan *et al.*, 1998). The results show that the dynamic aperture is wide enough for the electron beam to be stored in the ring easily. For meeting the objectives of the Siam Photon Project, the beamlines will be equipped with advanced experimental stations for angle- and spin-resolved photoemission, soft X-ray fluorescence, magnetic circular dichroism, photoelectron microscopy, photo electron–photo ion coincidence (PEPICO), two-color measurements with laser and synchrotron radiation, and high-resolution spectroscopy of gaseous atoms and molecules. XAFS measurements are also planned. Concerning the practical applications of synchrotron radiation, beamlines for basic research on metrology, microlithography and micromachining will be built in the later stages of the project. With regard to biophysics, the electronic properties of some biological materials will be investigated using solid-state experiment beamlines. In addition, a beamline for radiation effects on biological materials will be commissioned.

3. The Siam Photon Laboratory

The Siam Photon Laboratory is located on the campus of the Suranaree University of Technology (SUT). It is managed by NSRC affiliated to SUT. The address is as follows: The Siam Photon Laboratory of the National Synchrotron Research Center, Suranaree University of Technology, 111 University Avenue, Muang District, Nakhon Ratchasima 30000, Thailand (telephone: +66 44 216191 8 ext. 2377; fax: +66 44 216311; e-mail: siampl@nsrc.sut.ac.th).

4. The Siam Photon Source

The injector linac, the booster synchrotron and the low-energy beam-transport line are those of the SORTEC facility used in the form described by Nakamura & Okada (1990) and Kishimoto *et al.*, 1994). In contrast to the SORTEC facility, they are installed in an underground room. Electrons accelerated to 1.0 GeV by the booster synchrotron are transported through the high-energy beam-transport line to the storage ring and injected into it from the inside of the ring. The electron beam is deflected up and down by 17.5° in the vertical plane. In the horizontal plane, the electron beam is deflected twice: first by 4° at a point about 5.1 m away from the inflector of the synchrotron and second by 2° at a point about 1.7 m from the injection point, where the electron beam is deflected by 15°. Because of the small deflection angle of the electron beam in the high-energy beam-transport line, the line appears to be almost straight. The relative locations of the storage ring and the synchrotron are shown in horizontal view in Fig. 1.

Table 2
Important parameters of the storage ring.

Electron energy, E	1.0 GeV
Circumference, C	81.3 m
Magnetic lattice	DBA
Superperiodicity	4
Betatron wavenumbers, ν_x /ν_z	4.71/2.78
Momentum compaction factor, α	0.0214
Natural chromaticities, ξ_x/ξ_z	−7.96/−6.45
Natural emittance (nm rad)	72π
RF voltage, $V_{\rm RF}$	120 keV
RF frequency, $f_{\rm RF}$	118 MHz
Harmonic number, h	32
Synchrotron oscillation frequency, f_s	13.5 kHz
Critical energy of synchrotron radiation, ε_c	958 eV
Beam sizes, σ_x/σ_z	0.94/0.15 mm

The injector linac is about 9.5 m long. The electron beam is accelerated to 40 MeV in this linac. A pair of acceleration tubes is used in the linac. The length of one accelerator tube is 2.3 m. A klystron, PV-3035, supplies a maximum output power of 35 MW to both of the acceleration tubes. The microwave power is also allocated to two prebunchers and a buncher. An electron beam of large current, 60–80 mA, with a low emittance and a low-energy dispersion, can be obtained with this system. The width of the electron-beam pulse is 1.7 µs, the beam emittance is 700 nm πrad and the energy width $|\Delta\varepsilon|/\varepsilon$ is 0.7%

The yokes of the bending and quadruple magnets of the synchrotron are made of laminated silicon steel. The thickness of an element plate is 0.5 mm. Instead of describing the details of the synchrotron, we summarize important design parameters in Table 1. For more details, readers are referred to the report by Nakamura & Okada (1990).

Contemporary synchrotron radiation sources are equipped with insertion devices. Since the structure of the SORTEC storage ring was optimized for microlithography studies, it was not necessary for the original ring to have an insertion device and the ring was actually designed in this way. This was one motivation for changing the magnet-lattice structure. The SORTEC storage ring was also not required to have a small beam size. It had a beam emittance of about 500 nm πrad. This was a second motivation for modification of the ring. The details of the modified storage ring are described elsewhere (Pairsuwan & Ishii, 1997; Kengkan *et al.*, 1997) and important parameters of the modified ring are summarized in Table 2. The data are

Table 3
Monochromators and experimental subjects considered in the five-year plan of the Siam Photon Project.

Subject	Monochromator	Spectral range	Experiment
1. Photemission I	Harada–Koike type	10 eV–1 keV	Surface and interface research
2. Soft X-ray fluorescence	Harada–Koike type	10 eV–1 keV	Solid-state spectroscopy; photo-induced correlation effects
3. VUV absorption–reflection	Seya–Namioka type	5–30 eV	Characterization of matter; radiation effects
4. Photoemission II	CDM	30 eV–1 keV	Use of circularly polarized light
5. XANES	CDM	30 eV–1 keV	Characterization of matter; spectroscopy of gaseous samples

for the case where the machine is operated at a beam energy of 1.0 GeV. In the near future, the beam energy shall be increased to 1.2 GeV.

The storage ring has four long-straight sections where insertion devices will be installed. Two insertion devices out of four are planar undulators of the revolver type. The third is a helical undulator. The installation of a superconducting magnet wiggler is also to be considered. In the first five-year plan of the Siam Photon Project, however, construction of only one planar undulator is planned.

The energy spread of the electron beam, σ_E/E, in the storage ring is 5.02×10^{-4}. The energy loss per turn is estimated at 31.8 keV, which is not small, and the first optical element must be water-cooled. The duration of light pulse evaluated from the calculated bunch length is 135 ps, which enables us to carry out measurements of time-dependent or transient phenomena.

The detailed design work of the building to accommodate the Siam Photon Source has been completed. Contractors are currently being asked to put in tenders for the building work. Building construction is expected to start in October 1997.

5. Scientific program

Because of budgetary constraints, not all of the scientific research subjects originally included in the Siam Photon Project can be implemented in the first five-year plan. In particular, the inclusion of the construction of advanced and sophisticated beamlines does not appear to be practical. Thus, the construction of ordinary well established beamlines (Table 3) is planned. For more details, readers are referred to the report of Pairsuwan & Ishii (1997). With the experimental stations to be built here, advanced up-to-date scientific information will be obtainable.

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