SCSS-XFEL Project

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Laser-like x-rays have long been a dream of scientists not only because a lot of techniques developed with lasers will be extended to explore the nano-world but the human history tells that creation of a new light has always led to creation of new scientific fields. Accelerator-based free electron lasers using SASE (self amplified spontaneous emission) principle are now paving the way to x-ray lasers. At this moment, there are three construction projects of SASE x-ray free electron laser (XFEL) around the world: LCLS in the US, the Euro-XFEL in Europe and Japanese XFEL in Asia. Japan launched the XFEL construction project in 2006 fiscal year (FY). The facility, co-located with SPring-8, will be completed in 2010 FY.

All the XFELs being planned are composed of a linear accelerator (linac) and a long undulator. A unique feature of the Japanese XFEL is its compactness. In-vacuum technology used for the standard undulators at SPring-8 can reduce the magnetic period of the undulator, thus reducing the energy of electron beams required for generating a certain short wavelength of x-rays. The lower required energy of the electron beams will reduce the length of the linac. In addition, C-band technology originally developed at KEK for a linear collider can further reduce the length of the linac. By the combination of in-vacuum undulator with C-band linac, total length of the facility is designed to be less than 800 m which is fully accommodated in the present SPring-8 site. Thus, we named the facility SPring-8 Compact SASE Source (SCSS).

The lower electron beam energy, however, imposes severe restriction on the electron beam quality. In order to overcome the restriction, we have designed a new type injector system starting from a themionic gun instead of a laser RF gun used for the US and European projects. The injector system was tested by using a 250 MeV prototype FEL which lased at 49 nm in June.

X-rays from SCSS has 10^9 times higher peak brilliance than the most brilliant x-rays at SPring-8, 10^{-2}-10^{-3} times narrower pulse width, and full transverse coherence. Applications of coherent x-rays have been explored by using both 1000 m beamline and 27 m undulator beamline of the SPring-8. One of the most promising techniques so far developed is ‘coherent scattering imaging’ where nano-structures of non-periodic materials are imaged by using forward scattered Fraunhofer diffraction pattern. Possibility of single molecule structural analysis is now discussed intensively all around the world. The short pulse in fs region will enable us to trace the structural change during chemical reaction.

Unlike other synchrotron radiation such as Energy Recovery Linac , XFEL emits non-chaotic light. Therefore, most phase control techniques developed in longer wavelength laser field could be in principle available.

We would like to report the status of the construction as well as the discussion of the scientific case.