

A New Undulator for Polarization Control at SPring-8 BL07LSU: Present Status

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A new soft X-ray beamline, BL07LSU, has been constructed at SPring-8 in order to perform advanced X-ray spectroscopies for materials science. The beamline is designed to achieve high energy resolution ($E/\Delta E > 10,000$) and high photon flux ($> 10^{12}$ photons/s/0.01% BW) in the photon energy range of 250-2000 eV with controllable polarization [1]. To realize the state-of-the-art performance above, a novel insertion device (ID) has been developed and adopted as a light source at SPring-8 BL07LSU. In this report, we present the basic characteristics of the new undulator at SPring-8 BL07LSU and the current status of commissioning.

The ID at SPring-8 BL07LSU, segmented figure-8 undulator, is the 27 m-long undulator, which consists of eight segments of figure-8 undulator and seven phase shifters. (Figure 1) Four ID segments generate horizontally-polarized radiation as the first harmonic, and the other four segments generate vertically-polarized radiation. The horizontal and vertical segments are placed alternately. The helicity of the circular polarization and the linear (horizontal or vertical) polarization can be controlled by the phase shifters located between the segments, which adjust the relative phase of light emitted from each segment by changing the electron orbital between the segments. Figure-8 undulator, proposed and developed at SPring-8 [2], generates linearly polarized radiation with low on-axis power density. The novelty of the ID at SPring-8 BL07LSU lies in the invention of the vertically-polarized figure-8 undulator and its combination with the horizontally-polarized figure-8 undulator in the segmented cross undulator [3,4] configuration. The circularly polarized radiation can be obtained by the superposition of horizontally and vertically-polarized lights. Furthermore, the fast switching of the helicity of the circular polarization is possible by using electromagnets as phase shifters. It should be noted that the source point of ID is not displaced as the helicity of the circular polarization is changed.



Figure 1 Schematic of a new undulator at SPring-8 BL07LSU

The construction of beamline is divided into two phases. In 2009, as Phase I of the beamline construction, four segments of horizontally-polarized figure-8 undulator and three permanent magnet phase shifters (PM-PSs) were installed. In 2010, as Phase II, the remaining four segments of vertically-polarized figure-8 undulator and four PM-PSs have been installed; seven electromagnet phase shifters (EM-PSs) have been also installed for the fast switching of helicity.

Next we will report the achievements and challenges in the commissioning of the new undulator at SPring-8 BL07LSU. We have confirmed the successful operation of PM-PSs. The phase shifter has two important roles: (i) the optimization of photon flux by the phase matching of the undulators with the same polarization, (ii) the control of polarization by the phase shift between the undulators with the different polarization. Figure 2 shows the proof

of operation for the phase shifter to optimize the photon flux; the photon flux intensity from two horizontally-polarized ID segments shows a sinusoidal variation as a function of phase shifter gap. The ID spectrum when the phase of each ID segments matches exhibits a higher photon flux at the center energy with a narrower spectrum width. Regarding the polarization control, a high (>98 %) degree of linear polarization has been confirmed for both horizontal and vertical figure-8 undulators using soft x-ray polarimeters based on multilayer optics. In addition, the change of polarization from linear to circular has been observed by the phase shifter. Details of polarization measurements will be described elsewhere [5].

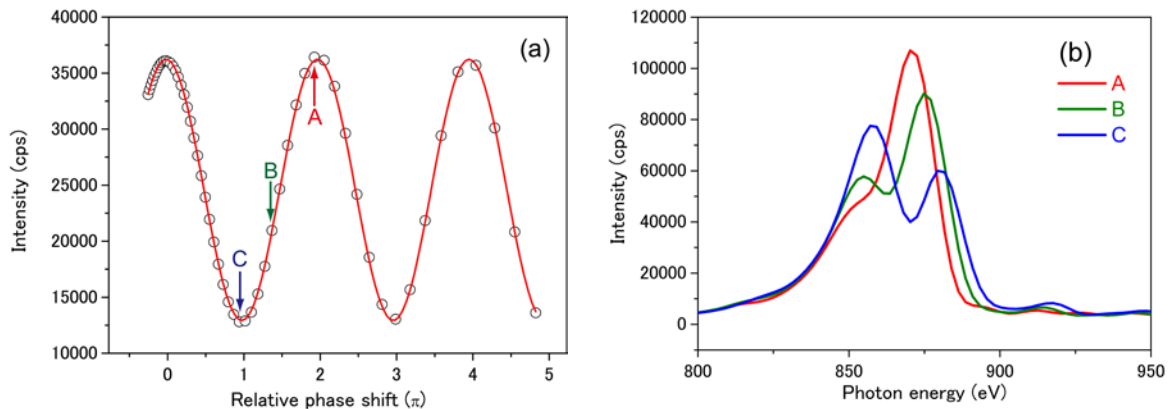


Figure 2 (a) The photon flux intensity at 870 eV from two horizontally-polarized undulators as a function of phase shifter gap. The horizontal axis is converted from the phase shifter gap to relative phase shift in the unit of π . (b) ID spectra at the representative relative phase shift points as indicated in (a).

Regarding the challenges we faced during the commissioning of the novel segmented figure-8 undulator, there is a current limitation in the usage of the vertically-polarized figure-8 undulator below a photon energy of 500 eV. This is because the radiation of the vertically-polarized figure-8 undulator has a large angular divergence in the vertical direction, which results in the heating of a bending magnet chamber located downstream of the 27-m undulator at BL07LSU. The redesign of the bending magnet chamber is now under consideration to allow for the full ID operation at all the photon energies of 250-2000 eV.

In summary, the new type of ID with controllable polarization, segmented figure-8 undulator, has been developed and adopted as a light source at SPring-8 BL07LSU. All the components of ID, eight segments of horizontally/vertically-polarized figure-8 undulators, seven PM-PSs, and seven EM-PSs, are now installed. The successful operation of PM-PSs for both the optimization of photon flux and the control of polarization has been confirmed.

References

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