EPU-PBPM with CVD-Diamond Blade at PLS-II

J. Ko[1*] , D-T. Kim[1] , G. Hahn[1] , S. Shin[1] and T. Ha[1]

[1]Pohang Accelerator Laboratory, POSTECH, Pohang, Gyungbuk 37673, KOREA

ABSTRACT

All 18 photon beam position monitors (PBPM) installed on the PLS-II are tungsten blade types. The elliptical polarized undulator (EPU) has the characteristic that the spatial profile of the beam varies depending on the polarization mode. This is related to the thermal load of the blade and therefore changes in blade material are inevitable on fixed blades. In this paper, we analyze power density and flux density according to EPU mode and describe the process of installing new PBPM with CVD-diamond blades on the PLS-II EPU beamline for the first time.

INTRODUCTION

- The Pohang Light Source II (PLS-II), a third-generation synchrotron-radiation source, has been operational since 2013, with electron-beam energy of 3 GeV and natural emittance of 5.8 nm-rad [S. Shin et al., J. Instrum. 8, P01019 (2013)]. The maximum average beam current stored in the storage ring is 400 mA and operates in top-up mode to achieve stable electron-beam orbit as well as synchrotron-radiation flux. Currently, a total of 35 beamlines including 19 insertion-device beamlines are in operation for user service.
- One of the major operational issues in electron-storage ring as a light source is the stability in the transverse position for the photon beam as well as the electron beam. To monitor the transverse position of the photon-beam the PLS-II installs 18 photon-beam position monitors (PBPM) at the font-end of the beamline. 13 of these operate on the planar undulator beamline and 5 on the bending magnet beamline. A pick-up usually has two or four blades. For beamlines using BM as a light source, it has two blades. For the blades, 0.5 mm-thick tungsten plates are used, which are installed on the top and bottom of the detector head [C. Kim et al., J. Korean Phys. Soc. 66, 167 (2015)].
- For beamlines using an elliptically polarized undulator (EPU) as a light source a new type of PBPM is required. Because the spatial profile of the beam varies with the polarization of light, the blade can cut a large part of the photon beam from EPU. Thus, structural changes of the blades due to thermal loads could cause a problem because the existing blades are optimized for photon beams from bending magnets and planar undulators. Thus we built the new type of PBPM for EPU beamline (EPU-PBPM) invented by the Taiwan Light Source (TPS) [J.-Y. Chuang et al., Nucl. Instrum. Methods Phys. Res. A 953, 163174 (2020)]. In this paper, an analysis is described to verify that this EPU-PBPM satisfies the characteristics of the PLS-II EPU source

DESIGN OF EPU-PBPM

- Table 1 shows the parameters according to the polarization of EPU72 which is the light source of 10A1-Soft X-ray Nanoscopy beamline (BL10A) at PLS-II.
- EPU72 with a length of 2.6 m was divided into 72 mm intervals.
- Figure 1 shows a schematic diagram of the pick-up of EPU-PBPM, which is installed at the front-end 10 m away from EPU72. The blade spacing is 5 mm horizontally and 3 mm vertically.
- And the blades of EPU-PBPM were decoupled horizontally, this structure may be useful to suppress the cross-talk effect of scattered beams affecting the opposite blade.

Table 1: PLS-II BL10A EPU72 parameters.

	Hor. mode	Cir. mode	Ver. mode
$B_x(T)$	0	0.48	0.6
$B_y(T)$	0.79	0.48	0
K_x	0	3.24	4.09
K_y	5.33	3.24	0
Total power (kW)	3.30	2.44	1.94

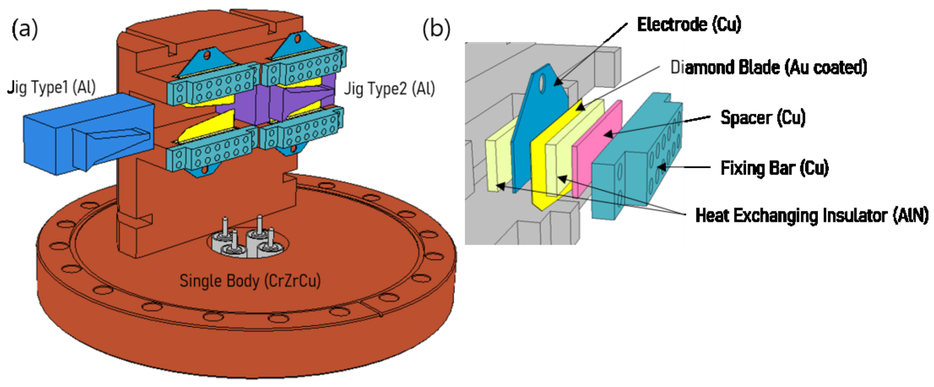


Figure 1: (a) A schematic diagram of the structure of the pick-up of EPU-PBPM. (b) Layered construction of blades.

ANALYSIS OF EPU-PBPM

- Power density
  - The power density according to the mode is shown in Figure 2. These properties were calculated using SPECTRA code [T. Tanaka et al., J. Synchrotron Rad. 8, 1221 (2001)]. Angular power density can evaluate the thermal load on the blades of the PBPM. Assuming that the beam passes through the center of the PBPM, the thermal load on the blades can be evaluated from the integral value in Figure 2 (bottom).
  - The The integral values are 2.3 for horizontal linear mode, 8.4 for circular mode, 3.1 for vertical linear mode, and we can see that the thermal load in circular mode is three times great than linear modes.

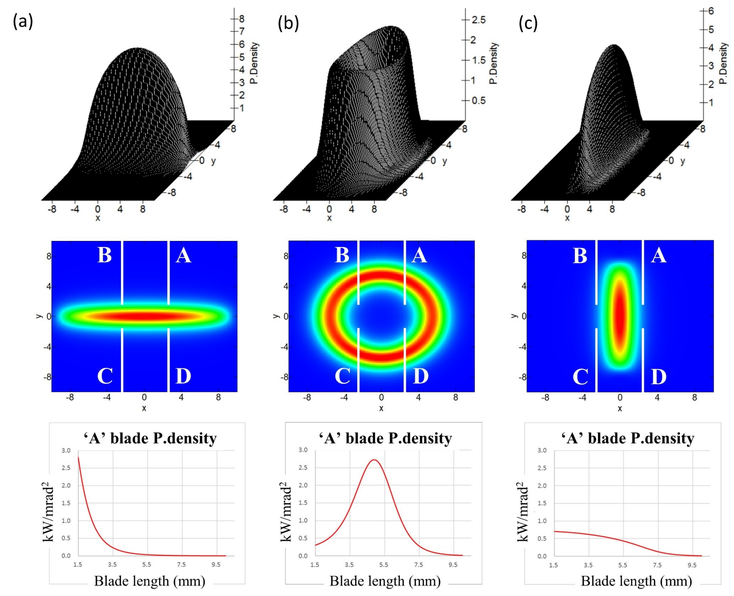


Figure 2: The power density according to the light polarization. (Top) 3D wire-frame. (Middle) 2D contour plot. (Bottom) Power density for 'A' balde. (a) is for horizontal linear mode, (b) is for circular mode, and (c) is for vertical linear mode.

  - Therefore, to cover these three modes with a fixed blade spacing of 5(H) x 3(V) mm, the blade material had to be changed to be effective for thermal loads.
  - The diamond blade is more effective at thermal loads than the tungsten blade because it has a lower X-ray cross section [XCOM: Photon Cross Sections Database]. The photon absorption of diamond is $1/10^4$ than that of tungsten. Therefore, CVD-diamond was adopted as a blade for EPU-PBPM.loads.
- Flux density
  - The flux density for the three modes is shown in Figure 4. Flux density is used to evaluate whether EPU-PBPM can cover the positional changes of the three modes with fixed blade gap.
  - Figure 5 show the rate of change in the position of the photon beam according to the pick-up stage and EPU gap. In all cases, linearity is obtained in the range of hundreds of micrometers and the slope is adjusted to 1 by adjusting the calibration factor K in the signal processor.

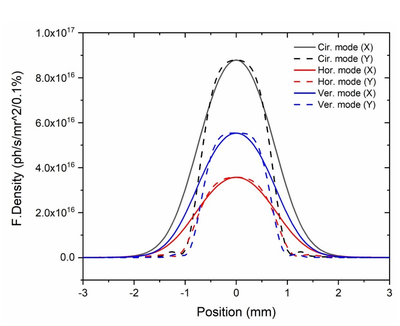
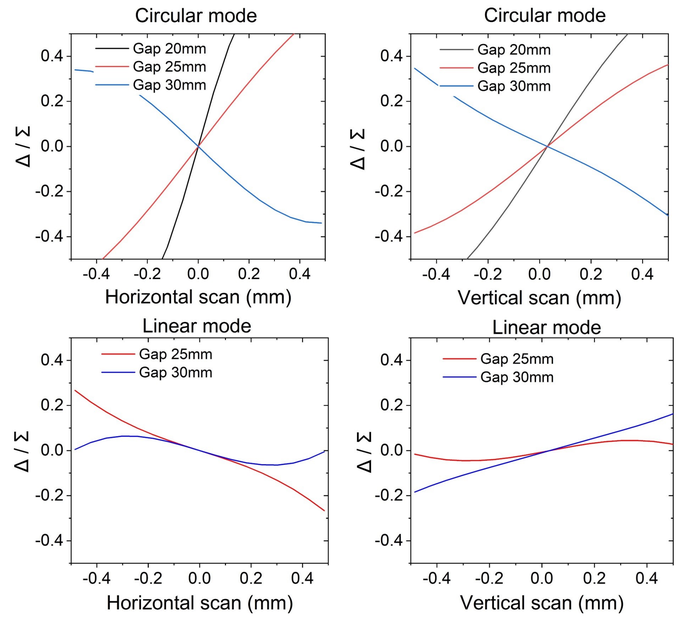


Figure 4: Flux density by polarization mode of EPU72.

Figure 5: The position changes according to circular/linear polarization mode and undulator gap.



ASSEMBLY AND INSTALLATION

EPU-PBPM was assembled and installed at the front-end of BL10A during this summer maintenance. Signal processing connection and calibration are the next steps, and will be applied to beam operation later this year.

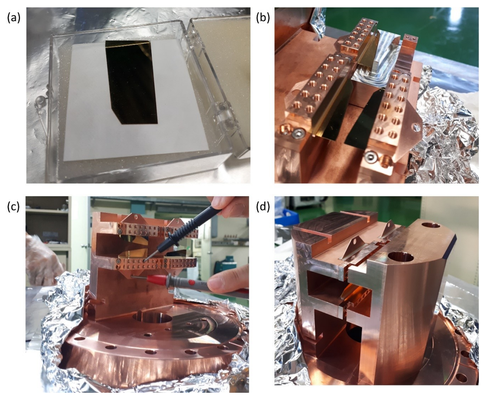


Figure 6: Assembly process for the EPU-PBPM.

Figure 7: Installation at the front-end of BL10A

CONCLUSION

A new type of EPU-PBPM has been installed on PLS-II for the first time. Although TPS XBPM was referenced for the pick-up design, an analysis of power density and flux density reveals that it is a photon beam position monitor that meets the characteristics of PLS-II EPU72. Furthermore, the horizontally decoupled blade structure is considered to be effective in suppressing the cross-talk effect shown in PBPM, which is currently operating on 18 beamlines. It will be used after thorough calibration and inspection, but particularly careful observation is required for the thermal load on diamond blades.