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EPU-PBPM WITH CVD-DIAMOND BLADE AT PLS-II

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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 [1]. 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 [2].

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) [3]. 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

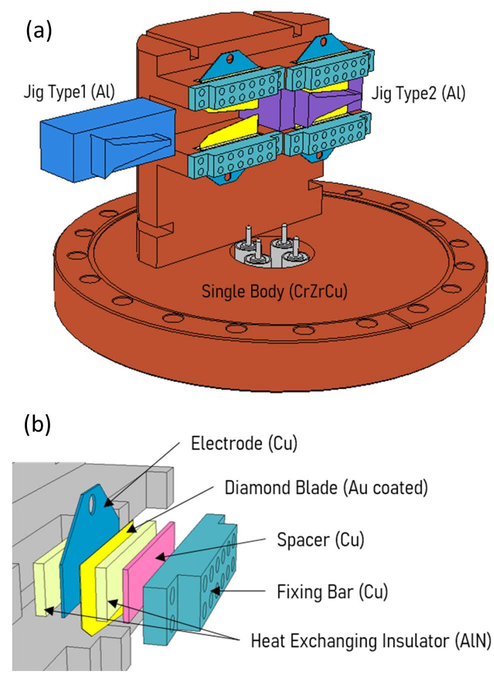

Figure 1: (a) A schematic diagram of the structure of the pick-up of EPU-PBPM. (b) Layered construction of blades.

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 [4]. Angular power density can evaluate the thermal

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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 Fig. 2 (bottom).

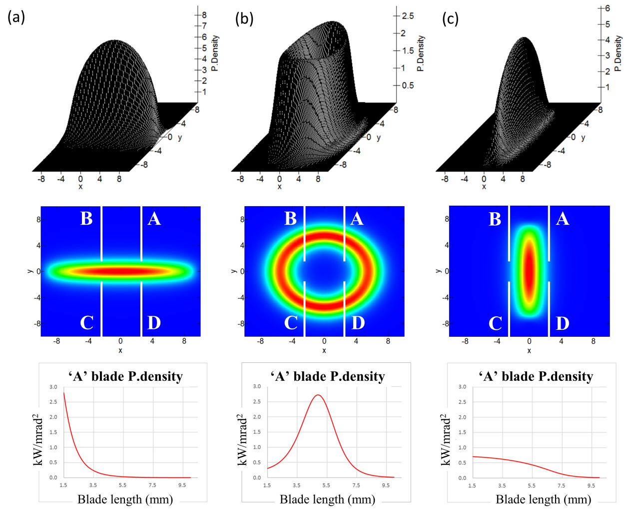

Figure 2: The power density according to the light polarization. (Top) 3D wire-frame. (Middle) 2D contour plot. (Bottom) Power density for 'A' balde. (a) is for horizontal linear mode, (b) is for circular mode, and (c) is for vertical linear mode.

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. 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.

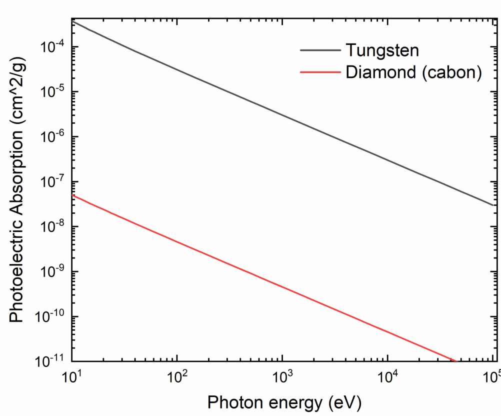

Figure 3: Comparison of photoelectric absorption of tungsten and diamond.

The diamond blade is more effective at thermal loads than the tungsten blade because it has a lower X-ray cross section. The energy domain of the synchrotron radiation we use mainly is 100 to 10000 eV. And in this region, the interaction between photons and materials is the photoelectric effect. Therefore the absorbed photons by the photoelectric effect are converted to heat, so if the photoelectric absorption cross section for X-ray [5] is small, the thermal load of the material is small. Figure 3 shows photoelectric absorption for tungsten and diamond. We can see that the photon absorption of diamond is 1/10,000 than that of tungsten. Therefore, CVD-diamond was adopted as a blade for EPU-PBPM.

Flux Density

The flux density for the three modes is shown in Fig. 4. It is also calculated using SPECTRA.

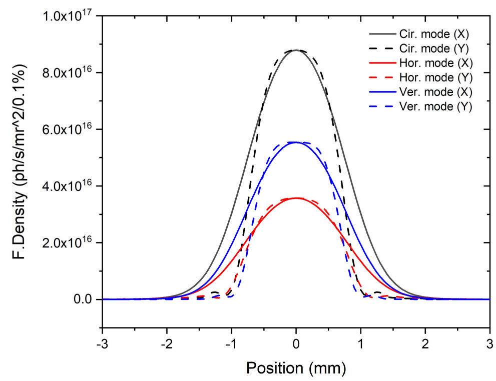

Figure 4: Flux density by polarization mode of EPU72.

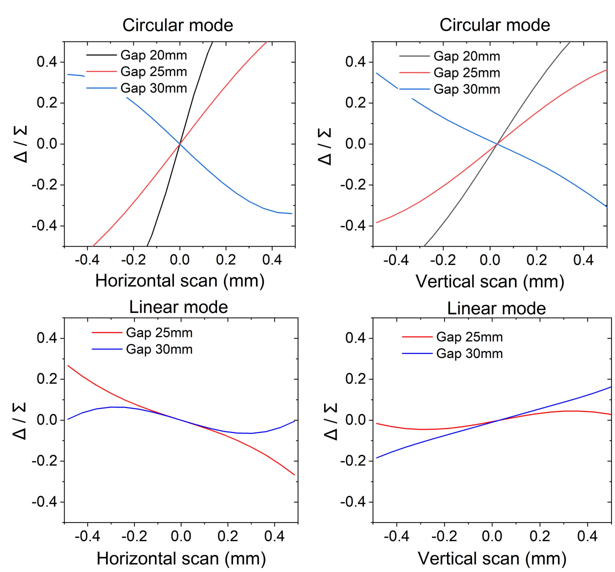

Figure 5: The position changes according to circular/linear polarization mode and undulator gap.

Flux density is used to evaluate whether EPU-PBPM can cover the positional changes of the three modes with fixed blade gap. Figure 5 and Table 2 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

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range of hundreds of micrometers and the slope is adjusted to 1 by adjusting the calibration factor K in the signal processor.

Table 2: The slope of linearity according to circular/linear polarization mode and undulator gap. Horizontal linear mode is used above 25 mm gap.

	Circular Mode		Hor. Linear Mode	
	X	Y	X	Y
Gap 20 mm	3.67	1.33	-	-
Gap 25 mm	1.45	0.70	0.37	0.16
Gap 30 mm	1.05	0.40	0.32	0.24

So, a CVD-diamond blade with a spacing of 5 (H)x3 (V) mm is considered suitable for thermal load and position measurement of the photon beam from the EPU72.

ASSEMBLY AND INSTALLATION

Figure 6 shows the assembly process of EPU-PBPM. A CVD-diamond is a commercial product of Applied Diamond, Inc. Four gold-plated CVD-diamond blades are inserted between insulators and mounted on copper blocks. During the assembly process, the electrical short and vacuum leakage tests are performed.

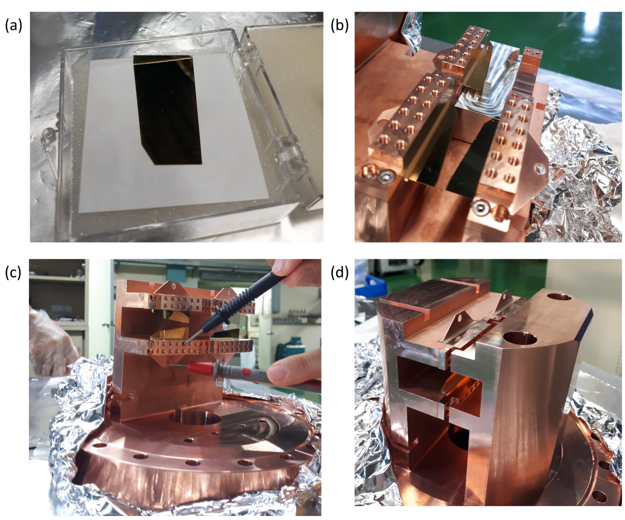

Figure 6: Assembly process for the EPU-PBPM. (a) A piece of CVD-diamond blade, (b) Utilizing jig, (c) Short test, (d) Complete basic configuration.

EPU-PBPM was installed at the front-end of BL10A during this summer maintenance (Figure 7) . Signal processing connection and calibration are the next steps, and will be applied to beam operation later this year.

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 verifies 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.

Figure 7: EPU-PBPM installation at the front-end of BL10A.

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