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Tests of the APS X-ray Transmitting Beam Position Monitors at ESRF

Deming Shu, Juan Barraza, Tuncer M. Kuzay, Advanced Photon Source, Argonne National Laboratory, 9700 S. Cass Av. Argonne, IL 60439, U.S.A. and
Graham Naylor, Pascal Elleaume, European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble, Cedek, France

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Abstract

Two different types of synthetic diamond-based X-ray transmitting beam position monitor (XBPM) prototypes have been studied with an undulator white beam at the European Synchrotron Radiation Facility (ESRF) ID-6 beamline. Of particular interest was the possibility of designing an integral window and filter/photon beam position monitor for the Advanced Photon Source (APS) high heat flux insertion device beamlines.

The photoelectron-emission type transmitting XBPM prototype uses a 25-mm-diameter, 175-micron-thick CVD-diamond disk with 0.2-micron-thick electrically isolated patterns of aluminum coating on one side of the diamond disk. The photoelectron emission signal was collected from the aluminum-coat surface to provide the beam position information.

A novel photoconductive-type transmitting XBPM prototype uses the same CVD-diamond disk, but patterns of aluminum coating were applied on both sides of the diamond disk. A DC bias voltage was used to generate the current signal, which is based on photoconductive properties of the CVD-diamond. Test results are presented in the paper.

1 INTRODUCTION

There are many challenging tasks in the design of insertion device (ID) beamline instrumentation that relate to high heat load and high heat flux problems. One such component is the X-ray beam position monitor (XBPM) for the ID beamlines.

Synthetic diamond has been proposed for use as an XBPM blade material for the ID front end of the APS project [1]. Synthetic diamond, such as CVD diamond, offers superior thermal-physical properties, such as high thermal conductivity, low thermal expansion coefficient, and good mechanical strength and stiffness under heat. In the classic photoelectron emission-type XBPM, the monitor blade is mounted parallel to the radiation beam direction to eliminate the total thermal power absorbed by the blade. To reduce the heat power density on the blade edge surface, inclined edge geometry is usually utilized.

A photoelectron emission-type X-ray transmitting beam position monitor (TBPM) has been proposed for combining filter/window and XBPM functions [2]. The basic concept of the TBPM is to mount the monitor blade perpendicular to the synchrotron radiation beam and to design the blade and its sensor coating in such a way that most of the x-ray beam will be transmitted through the blade. Thus, the total absorbed photon power cannot cause thermal damage to the blade. Earlier a sample monitor was tested at NSLS on the X-25 wiggler beamline for proof of the principle [3]. Based on the success of this preliminary test with a focused wiggler beam, a compact filter/mask/window assembly was designed for undulator beamline commissioning activity at the APS beamlines [4].

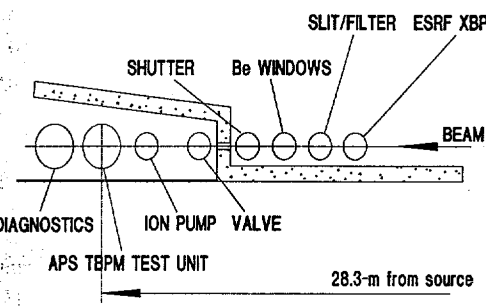

Fig. 1. Schematic layout of the ESRF ID-6 beamline.

Similar to the photoelectron emission-type TBPM, a novel photoconductive-type TBPM has also been proposed [5]. To test this design with a full power undulator beam, a prototype TBPM test base has been built. Two different types of synthetic-diamond-based TBPM test samples were prepared at the APS. The test plan at the ESRF beamline ID-6 was part of the Tripartite Joint Research Agreement Protocol among the APS, ESRF and SPring-8 synchrotron radiation facilities.

2 BEAMLINE TEST SETUP

The ID-6 beamline at the ESRF has a 46-mm-period, 1.66-meter-long undulator source. During the time we were doing our experiments, the ESRF storage ring was running in hybrid mode with a maximum of 140 mA current. The

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undulator was operating at a gap in the 21 mm to 41 mm range.

Fig. 1 shows a schematic of the ID-6 layout. During the test, an APS TBPM test unit was installed in the first optics enclosure (FOE). Upstream of the APS TBPM test-unit, a 500-micron-thick pyrolitic graphite filter and two 250-micron-thick Beryllium windows cut off most of the soft X-ray from the source. Downstream of the test unit, a fluorescent screen with a graduated aluminum filter and a CCD camera provides the capability to monitoring the beam profile and helps in the system alignment.

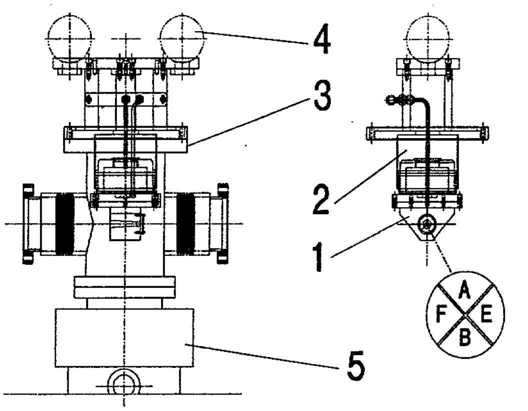

Fig. 2. The APS TBPM test-unit (1)sample mounting block ; (2) water-cooling base; (3) vacuum chamber; (4) survey-mark; (5) stepping-motor-driven stage.

The TBPM test unit was designed to be compatible with the ESRF XBPM vacuum chamber and its supporting stages. As shown in Fig. 2, the APS TBPM test unit consists of six components. The TBPM sample is assembled on a sample mounting block (1), which is cooled by a water-cooling base (2). The water-cooling base is mounted on the top of the ESRF XBPM vacuum
chamber (3). There are two survey marks (4) on the mounting flange for alignment purpose. The vacuum chamber is supported by a set of stepping-motor-driven stages (5), which provide precise horizontal and vertical motions for fine alignment and scan motion for the TBPM test. An optical encoder with 0.1 micron resolution was added to the stage to verify the motion accuracy.

3 TESTS OF THE PHOTOEMISSION-TYPE XBPM

The test sample for photoelectron emission-type TBPM uses a 25-mm-diameter, 175-micron-thick CVD-diamond disk with 0.2-micron-thick electrically isolated quadrant patterns of an aluminum coating on one side of the diamond disk. Fig. 4 shows the CVD-diamond disk and its clamping and cooling structure. The photoelectron emission signal was collected from the aluminum-coated surface to provide the beam position information.

Three different sample setups were arranged for the experiments as shown in Fig. 3. In configuration (a), we used same clamping and cooling structure as we did in the NSLS X-25 test. The aluminum-sensor coating was facing the X-ray beam, and an alumina insulator was applied to isolate the sensor from the cooling base electrically but retain reasonable thermal conduction for cooling.

Configuration (b) was designed to test whether we can use the CVD-diamond as an electric insulator for the aluminum sensor coating to improve the disk cooling efficiency. So that, in configuration (b), the aluminum coating on the CVD-diamond disk was mounted facing downstream to the beam direction and no insulator applied between the copper cooling base and the CVD-diamond disk.

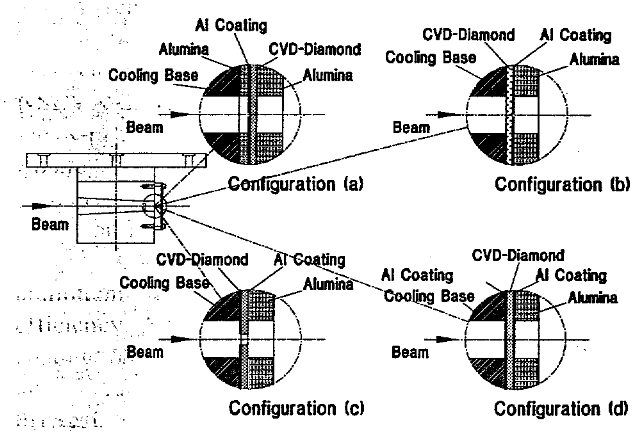

Fig. 3. Sample set-up configurations for the TBPM test.

The test configuration (c) was similar to (a), except a 1.5 mm through hole was made in the center of the CVD-diamond disk to allow a clear X-ray beam path.

The test results show that all of these three configurations provide good beam position sensitivity. Fig. 4 shows the output signal from the TBPM test sample in configuration (c) as a function of the stage vertical motion.

4 TESTS OF THE PHOTOCONDUCTIVE-TYPE XBPM

Since 1975, many researchers have explored the photoconductive properties of natural diamond with X-rays and gamma rays [6]. The photoconductive properties of CVD diamond have also been exploited [7]. A test sample for a novel photoconductive-type TBPM was designed and prepared at the APS as shown in Fig. 3 configuration (d). The sample was made from the same type of CVD-diamond disk as was used in the photoemission-type TBPM. But, the quadrant patterns of the aluminum coating were applied on both sides of the diamond disk. A DC bias voltage was used to generate the current signal, which is based on photoconductive properties of the CVD- diamond.

Fig. 5 shows the output signal from the photoconductive TBPM test sample in configuration (d) as a function of the stage vertical motion. During this test, the bias voltage applied to the CVD-diamond disk was 1.5-volts.

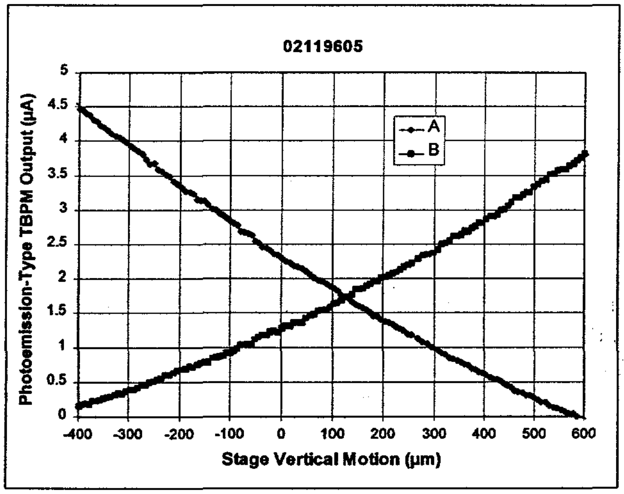

Fig. 4. Output signal from a photoemission-type TBPM test sample in configuration (c) as a function of the stage vertical motion. ID-6 undulator gap was 28.2-mm. ESRF storage ring current was 121-mA

5 DISCUSSION

According to the experiences obtained with the XBPMs in many synchrotron radiation laboratories, contamination signals caused by the bending-magnet (BM) emitted radiation become a major problem. Problems are exacerbated for the XBPM when the insertion devices (IDs) operate with different magnet gaps, because the percentage level of the contamination will be a variable.

From the test results, we have learned that, compared to a photoemmision-type TBPM, the beam position signal from a photoconductive-type TBPM has less ID gap dependence. This maybe caused by the higher sensitivity of the photoconductive type TBPM to the hard X-ray radiation.

6 ACKNOWLEDGEMENTS

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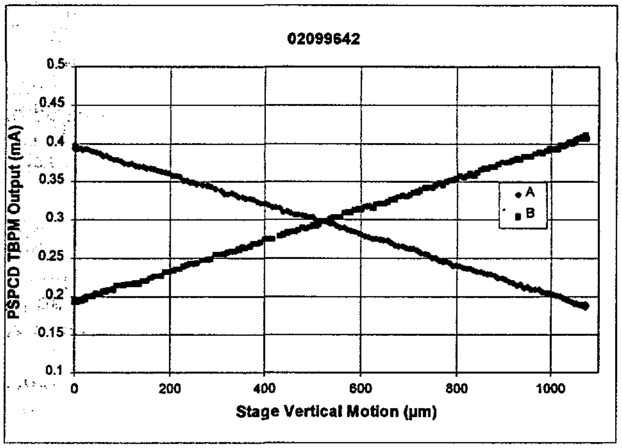

Fig. 5. Output signal from a photoconductive-type TBPM test sample in configuration (d) as a function of the stage vertical motion. ID-6 undulator gap was 29-mm. ESRF storage ring current was 110-mA.