Development of a Position Sensitive Ionization Chamber with Backgammon Electrodes as a Beam Position Monitor for SR Experiments

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1. Introduction

Real time information on the beam position during an user experiments under way is extremely important to make the fine beam strike the small sample at third generation synchrotron radiation facilities. Though it is a forecast that synchrotron radiation beams will be finer and finer as its natural trend and we will be able to use smaller and smaller samples, there is one big problem. The problem is how such a fine beam on the order of tens of micrometers can be stabilized on to an equally small size of the sample or a small part of the large sample. A synchrotron radiation beam is pre-shaped with slits and the wave length is selected with double crystal monochromators in a standard beamline of SPring-8. It is known that the behavior of those devices is changed due to the influence of the heat generated by the synchrotron radiation beam within the time scale of a few minutes up to several hours. Moreover, in those experiments changing X-ray energies with the rotated inclined double crystal monochromators, which are commonly installed on the hard X-ray undulator beamlines at SPring-8, it is known that the X-ray beam positions in horizontal directions can move about one mm at their sample positions while being adjusted $d\theta_1$ axis, needed after changing X-ray energy. After analytical work of the experiment data it is sometimes realized that the data have been deteriorated due to some unknown experimental factors. This situation could give potentially a serious influence on the quality of the experiment data here at SPring-8, the third generation synchrotron radiation facility in our country.

Based upon the argument above, it is clear that the absence of beam position monitors at the downstream sample position prevents us from the quantitative analysis and discussion concerning the beam position stabilization. In this respect the penetration type beam position monitors, which are able to observe the beam position without destructing the beam exposure onto the sample, are extremely important. Once such beam position monitors are developed, SR experimenters can expect the following merits concretely:

(1) When an extremely fine collimator is used such as in the crystal diffraction experiments, the stabilization of the beam position in front of the collimator, should result in stabilizing the incident beam intensity at the sample downstream position as well.

(2) When the wide beam is used as in the XAFS measurements, the center position of a incident beam can be stabilized at the sample center.

(3) Highly accurate adjustment of fixed-position emission of the monochromator will be possible by person in charge of the beamline.

(4) Real-time monitoring of the beam position in the whole experiment become possible.

2. Position Sensitive Ionization Chamber (PSIC) with Backgammon Electrodes

Ionization chambers have been widely in use as X-ray beam intensity monitors in synchrotron radiation experiments. It makes full use of its variable X-ray absorption efficiency of gas materials as transmitting X-ray beam monitor. The spatial structure of ionization volume filled with gas material by an incident X-ray beam is deeply dependent on the beam position as shown in our previous research on its recombination problem in high brilliant X-ray beam [1]. If the collecting electrode is segmented into two parts along the incident beam, the amount of collected charge in the two segments will vary depending on the X-ray beam position. And we will detect not only the intensity but also the position of the X-ray beam with an ionization chamber as indicated in the research work of split anode ionization chambers [2].

One of the most characteristic nature of synchrotron radiation is its very broad energy spectrum owing to the generation process and we can change monochromatized X-ray energy in a very wide range with monochromators. When the so-called “triangular electrodes” are used, however, the amount of charge collected on the both electrodes can be changed, even if the incident location of the beam is fixed, with changing the X-ray energy, because the absorption length varies as an exponential function of the energy. We attempted to solve this problem with backgammon electrode structure which is shown in Fig. 1 together with it photograph in Fig. 2. The segmented electrodes are cut into zigzag-shaped pieces and the difference of signal from both electrodes could provide information of the X-ray beam position. The position output can be obtained in the unit of μm using a signal operation of Differential Over Summation [3], by diverting the technology developed for XBPM at SPring-8.

With these prospects, we are currently developing a prototype of position sensitive ionization chamber and have already tested it on SPring-8 R&D Beamline I BL47XU.

3. Experimentals

The prototype model of the position sensitive ionization chamber was constructed on the basis of the commonly used ionization chamber of Ohyo Koken Kogyo S-1194B1 with a printed circuit board of backgammon electrodes, which has backgammon stroke (L_{stroke}) of 15 mm as shown in Fig. 2.

The ionization chamber was mounted on a stage rotating around the beam axis on an xz stage. Fig. 3 shows the measured linearity of the position output to the detector position in the vertical direction by a step of 50 µm. At this time, the X-ray energy was set to be 7.79 keV, FE slit 1 mm × 1 mm, and the filling gas pure nitrogen. Measurement was performed with an XBPM four channel current amplifier module and a GPIB controlled ADC board ADM488Z of the MCI Electronics Co. without any signal averaging. Therefore, the wide range position linearity was sufficinetly confirmed in spite of the fact that the S/N of the signal was very poor. Figure 4 shows the measured sensitivity of the PSIC with the same step yet with Moving Average of 100RDGS using Keithley2000/J DMM instead of the ADC board. It can be seen that the system was responding to a movement of 50µm or less.

4. Summary and Future Plan

We have confirmed that the position of an X-ray beam can be measured by using the backgammon electrode experimentally. The electrode structure should be well isolated from the microphonic vibration noise for S/N to improve the performances of the production model more than the prototype model.

There are some researches about X-ray beam stabilization with ionization chambers in literature [4]. Position sensitive ionization chamber may provide us with more detail information for systematic research of X-ray beam stabilization.

Production model will become available in spring 1999 as Ohyo Koken Kogyo S-2403 series at almost the same size and cost as commonly used type of S-1329A.

References

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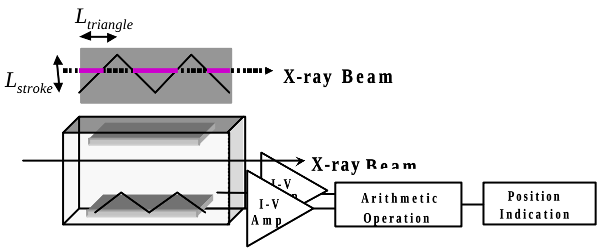

Fig. 1. Schematic Diagram of PSIC.

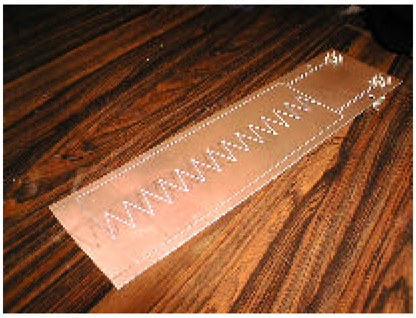

Fig. 2. Tested Backgammon Electrode.

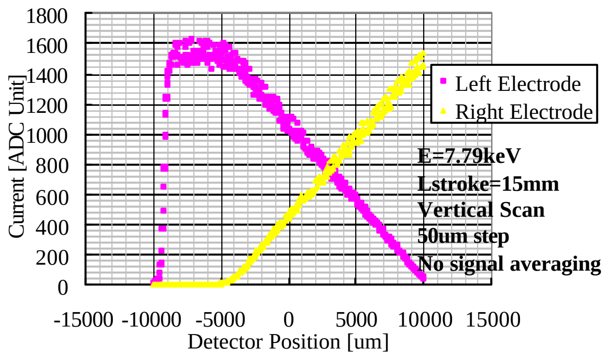

Fig. 3. Position Linearity.

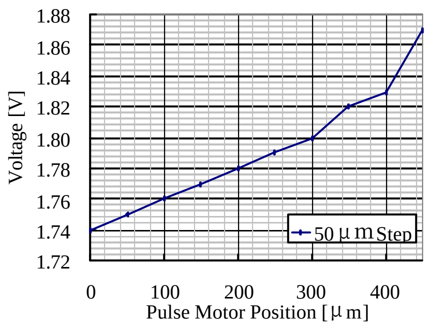

Fig. 4. Position Response Test with Signal Averaging.