PERFORMANCE TEST OF DIAMOND DETECTOR FOR X-RAY BEAM POSITION MONITOR

Diamond is promising as a base material for the detector head of X-ray beam position monitors (XBPM) because of its high thermal conductivity, high electric resistivity and low absorption coefficient for X-rays. We have been developing an area-type XBPM that is operating in photo-conduction mode [1]. In this monitor, a bias voltage is applied to produce an electric field inside the diamond plate. When photons are absorbed inside, electron-hole pairs are created. These carriers drift along the electric field and generate a current in the circuit. The number of carriers is proportional to the energy of the absorbed photon, and thus the amount of signal current is proportional to the absorbed beam power. On the other hand, hard X-rays are nearly transparent. Therefore, the detection efficiency is expected to be greater at the energy of several keV. Moreover, the peak energy is expected to be higher by up to a few tens of keV, with the effective thickness of the plate. This property is suitable for detecting photon beams from undulators because this detector is less sensitive to low energy photons, which are dominant in background from the fringing field of bending magnets.

We designed and fabricated a test sample of the detector head for test measurements at the beamline **BL01B1**. Figure 1 shows the metalization pattern on the diamond plate. The dimensions of this CVD diamond sample is 20 mm X 40 mm X 0.24 mm. A pair of aluminum electrodes was formed by an evaporation technique on both sides of the plate. One electrode is for reading signals and the other is for applying bias voltage. The top part of the sample is for heat contact. This sample was set on a translation stage in two ways. One was to set it in parallel with the beam to evaluate the performance as a blade photo-conduction type. There are five spots of various effective thicknesses: 0.5, 1, 2, 4 and 8 mm. The other was to set it perpendicular to the monochromatic beam to evaluate the performance as an area photo-conduction type. The typical pressure of this chamber was about 10^{-5} Pa.

The response time observed upon opening and closing the shutter was relatively slow because of the low quality of the base material. Since high electric resistivity is desirable for use in photo-conduction mode, it is important to obtain a high-grade CVD diamond at a reasonable price.

The dependence of signal current on bias voltage and thickness was observed (Figure 2). The sample was set in parallel with a monochromatic beam of 20 keV. The signal current is proportional to bias voltage at each effective thickness. The current signal increased with the effective thickness along the beam path. Therefore, the blade photo-conduction type is a promising candidate for future XBPMs. The dependence of the detection efficiency on photon energy was also observed with the

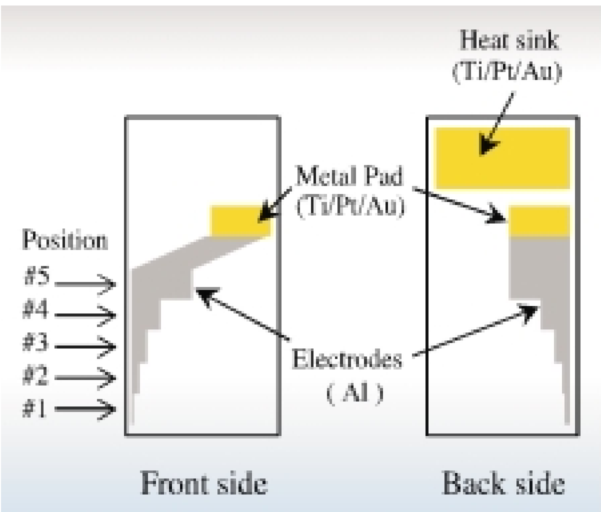

Fig. 1: Metalization pattern on diamond plate.

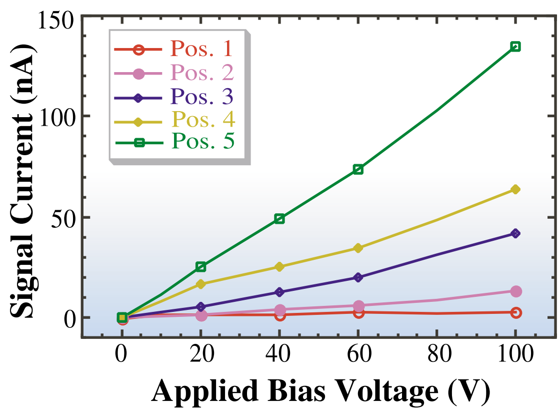

Fig.2: Bias voltage and thickness dependence of signal current.

range of the photon energy was from 4.5 keV to 70 keV. A preliminary analysis showed that the detection efficiency decreased in the photon energy range from 4.5 keV to 30 keV and increased over 30 keV. The latter increase seems to be due to Compton scattering. We are planning to measure the efficiency in the range below 4.5 keV to clarify the peak structure at the energy of several keV.

Hideki Aoyagi
SPring-8 / JASRI

E-mail: aoyagi@spring8.or.jp

References

[1] H. Sakae *et al., J. Synchrotron Rad.* **4** (1997) 204.

EVALUATION OF X-RAY REFRACTIVE LENS MADE OF LIQUID MATERIAL

In spite of the extremely small X-ray refractive index decrement, an X-ray refractive lens was first achieved in an array of pinholes on an aluminum alloy plate (compound refractive lens, [1]). A two-dimensional lens was also developed by crossing two linear arrays in perpendicular directions [2]. This was also discussed in a case of parabolic lenses [3]. When liquids and gases are used as the lens material, the surface tension seems to form spherical and parabolic shapes much more naturally. Lenses were manufactured in the following way. First, the so-called "bubble lens" was manufactured by forming bubbles in a liquid adhesive (Figure 1). A mixture containing glycerol was used as the liquid and an acrylic container was designed so that 168 bubbles with diameter of about 2.8 mm each could be aligned in a straight line in the liquid. Pure helium gas from a gas cylinder was injected into the liquid through a needle valve and a syringe needle with an outer diameter of 0.5 mm

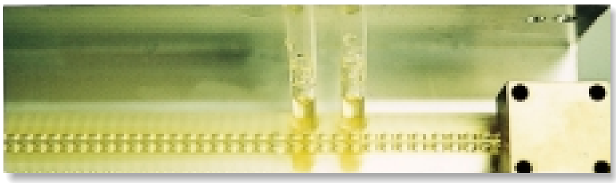

Fig. 1: Liquid container for X-ray "bubble lens" made from acrylic resin and Kapton films. Two pipes worked as inlet and outlet of the bubbles and a triangular ceiling kept the bubbles in a straight line. *Courtesy of SPIE [4].*

We further evaluated the so-called "micro-capillary lens". This lens was made by the Belarusian State University [5,6,7]. Bubbles were formed in a glue in thin glass capillaries and then solidified to obtain a solid X-ray refractive lens. The surface tension of the glue gives the surface of the bubbles an approximately spherical shape. So far, lenses with small apertures of around 0.2 mm in diameter have been developed (Figure 2). A similar lens with a diameter of 0.8 mm was also made with glycerol [7].

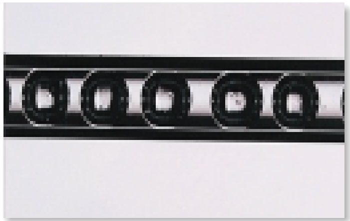

Fig. 2: Image of a micro-capillary lens taken with an optical microscope. The inner diameter of the glass capillary is 0.8 mm.

These two types of lenses were probably the first two-dimensional X-ray refractive lens systems using spherical lenses [4, 5].
An evaluation of the lenses was made at the beamline **BL47XU**. The demagnified image of the undulator source was taken, and the image size and gain at the focal plane were measured. The experimental conditions (ID gap and X-ray energy) were **(a)** 27 mm, 19 keV for the "bubble lens" and **(b)** 26 mm, 18.3 keV for the "micro-capillary lens". The observed focal lengths were **(a)** 5.4 m and **(b)** 0.8 m.