Measurement of Glass Dosimeter Response for Low Energy Photon using Synchrotron Radiations

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1.Introduction

Radiophotoluminescent glass dosimeters made of silver activated metaphosphate glass are widely used for dosimetry of gamma-ray fields because of the unique characteristics such as repeatability, integrity during intermittent monitoring and reading, and extremely low fading. In addition, by utilizing a pulsed N_2-gas laser in readout system, the performance of the glass dosimeter has been improved on reproducibility of low-dose measurement[1] and expected to be widely used for personnel dosimeter.

The characteristics of the dosimeter, including the energy response for photons up to about 20 keV, had reported. However, few experimental data were presented for monochromatized low energy photons. Recently, high intensity photons with low energy has been widely used in synchrotron radiation facilities and the dosimetries including the personnel one is one of the serious safety problems for the low energy photons. Therefore, the responses of glass dosimeter badge, made by Toshiba Glass Corp., have been measured for low energy photons by using monochromatized synchrotron radiation and compared with the results by using X-ray tube. In order to get the knowledge of characteristics of the detector response, radiation transport phenomena have been simulated and compared with the experimental results.

2. Experiment

The GD-403 type glass dosimeter[2] consists of 4 elements with respective different filters (Al of 1mmt,Sn of 1mmt, polyester films of 35 μ mt and 250 μ mt), as illustrated in Fig.1. The response of glass dosimeter for low energy photon ranging from 7 keV to 37keV have been

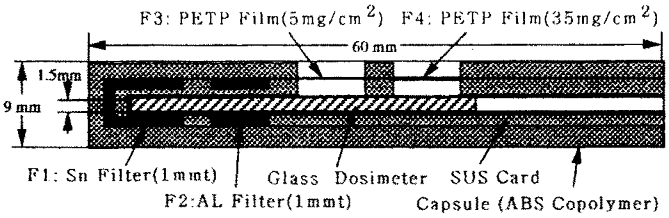

Fig.1 Cross-sectional view of GD403 type glass dosimeter badge

measured by using monochromatized synchrotron radiations at a vertically polarized wiggler beamline, BL-14C, at Photon Factory in KEK. Synchrotron radiation from the wiggler was monochromized to $\Delta E/E \sim 10^{-3} - 10^{-4}$ band width. Absolute photon intensities were monitored with a free air ion chamber calibrated with a new type calorimeter[3]. The dosimeters were scanned horizontally in order to uniformly irradiated. The higher harmonic components of monochromatized photons reduced to less than 0.3% by detuning the double crystal monochromater, which components were monitored by a HP-Ge detector.

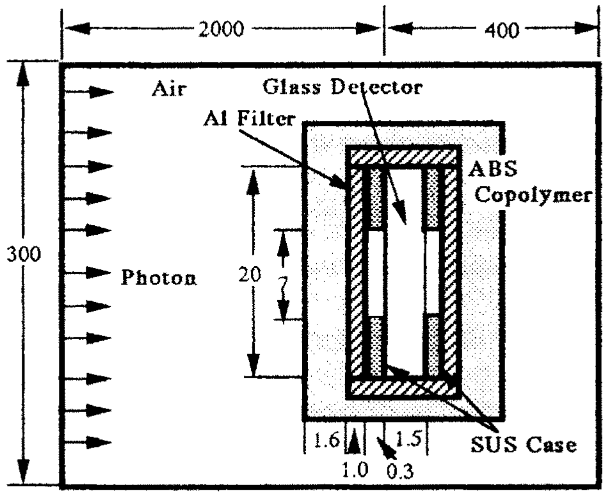

Fig.2 Calculational configuration of glass dosimeter with Al filter

Gamma-ray of ^{137}Cs (662keV) was also used for normalization.

In readout operation, the FDG-60 automatic system[4] was used. On the system, the N_2-gas laser incidents with slightly inclined on the side of glass dosimeter and the radiophotoluminescences were detected outside the front of the dosimeter.

3. Model Calculation

CYLTRANP was used in ITS3.0 and 4 models were employed for the 4 filters. For example, figure 2 shows the calculated configuration of slab-cylinder model of glass dosimeter with Al filter.

To obtain an effective radius and thickness, calculations were made under the following conditions; (a)deposited energy is independent of the depth of detector for 37keV and 662keV photons, (b)deposited energy is reduced by shadow effect of SUS case , and (c) deposited energy is dependent upon the readout thickness of the detector for 7keV photons.

The effective radius of the detector can be expressed as a function of the ratio of the energy deposition with 37keV photons to 662keV photons and determined by the interpolation using the function. After knowing the effective radius, the effective thickness can be estimated from the ratio of the energy deposition with 7keV photons to 37keV photons. Energy responses of the glass dosimeter were calculated by using the effective radius and the thickness.

4. Results

On the calculation of the energy deposition as a function of the depth of detector, it is confirmed to be depth independent of the photon energies above 30keV, that is, the ratio of the energy deposition for 37keV photon to that for 662keV photon is independent of the depth of the detector. From the model calculations mentioned above, 5.1±0.3mm was obtained for the effective radius of the detector and 0.53±0.01mm for the effective thickness of the detector.

The energy responses of the detector with each filters are shown in Fig.3, the comparison between the experimental results and calculations with the effective radius and the thickness. As shown in Fig.4, fairly good agreements are obtained between the experiments and calculations, except the response of the detector with tin filter because of the insufficient accuracy in the calculation.

5. Concluding Remarks

The energy responses of the glass dosimeter badge for monochromatized low energy photons ranging from 7 to 37 keV have been measured by using synchrotron radiation and the sensitivities have been investigated accurately. The comparison between the experimental results of synchrotron radiation and the Monte Carlo calculations, showed close agreements as to the energy response.

We found that sensitivity of detector is estimated highly in the results for low energy photons, especially below 24keV in conventinal method of X-rays, and that the response functions depend on the readout system, especially readout radius and thickness.

Dose estimation for the personnel within fields of low energy photons mixed with β-rays is currently underway for future studies.

References

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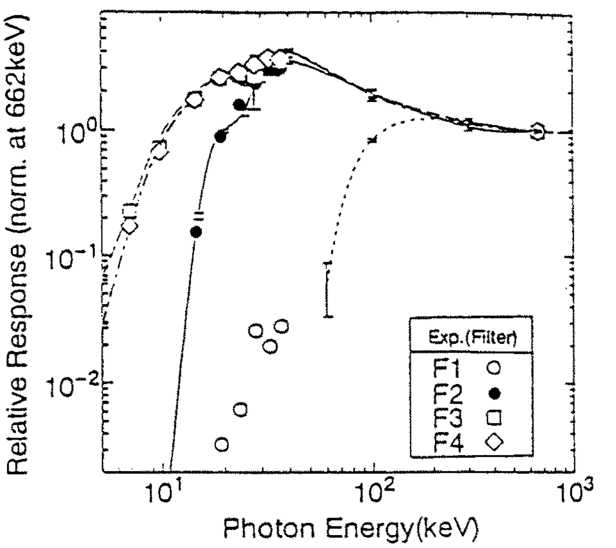

Fig.3 Energy response of glass dosimeter badge within free air .(○, ●, □ and ◇ are experimental data with each filters and lines are calculated data by ITS3.0)