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Response of GafChromic MD-55 film to synchrotron radiation

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Introduction

Recently, owing to the increase of synchrotron radiation facilities such as SPring-8, dose measurements of high-intense low-energy photons are increasingly needed for radiation protection and medical researches. For the dose measurement, tissue equivalence of dosimeter material becomes important.

A radiochromic film that has sensitivity in the dose region of several Gy to 100 Gy has been used in medical applications [1]. The film is thin and mainly composed of polyester. The purpose of this study is to measure responses of the double-layer GafChromic film for synchrotron radiation.

Materials and method

The experiment was carried out at BL-14C beamline. The exposure was monitored with a parallel plate free-air ionization chamber within 2.8% accuracy. The beam shape was collimated into a rectangle of about 10-mm long and 10-, 4- and 3-mm wide for 10, 30 and 40 keV photons, respectively. The doses of 2-150 Gy were given by changing the exposure time.

To be irradiated in free air, radiochromic films were set on the Scotch tape extended between acrylic poles and scanned horizontally during exposure to avoid beam strength inhomogeneity. The accuracy of the dose estimation depends not only on the accuracy of the ionization chamber but also on that of the readings of the beam cross-section length and the scanning speed. The former accuracy is considered to be 2-3% and the latter is below 1%.

The dosimeter film used was double-layer GafChromic MD-55 (ISP Technologies Inc.). The optical density was measured by 670-nm wavelength using FWT-100 radiachromic reader of Far West Technology two days later after the exposure.

The film sensitivity depends on the temperature and humidity during and after the exposure, which shows 5% fluctuation at most between 10 ℃ and 40 ℃ for 40 Gy [1]. The temperature in the experimental hutch was constant at 22 ℃, while the temperature at the ^{60}Co calibration was 10 ℃. In the case, the absorbance for synchrotron radiation possibly decreased by 3% owing to the temperature difference.

Results

Figure 1 shows the measured energy response of MD-55, which is normalized at ^{60}Co gamma rays: 0.592, 0.592, 0.581, 0.662 and 0.724 at 10, 15, 20, 30 and 40 keV. Chiu-Tsao et al have obtained 0.56 value for ^{125}I [2] and McLaughlin et al 0.63-0.66 at 20-40 keV and 0.61 at 15 keV [3]. Between 30 and 40 keV, the values appear to be smaller than those in Fig. 1, while the experiments of the other authors were made using broad energy spectrum source. The response of MD-55 having one active layer measured at BL-14C was also smaller at 30 keV, while the responses at 10 and 15 keV were larger than those in Fig. 1 [4].

The energy response was calculated using a photon-electron Monte Carlo transport code EGS4 [5]. The result is shown in Fig. 1, which is smaller than the measurements by about 10%. Considering the measurement errors of 4% for ^{60}Co calibration, 3% for reading of MD-55, 2% for the ionization chamber, 3% for the scanning method and 3% due to the temperature dependence, the discrepancy is considered to be within the errors.

References

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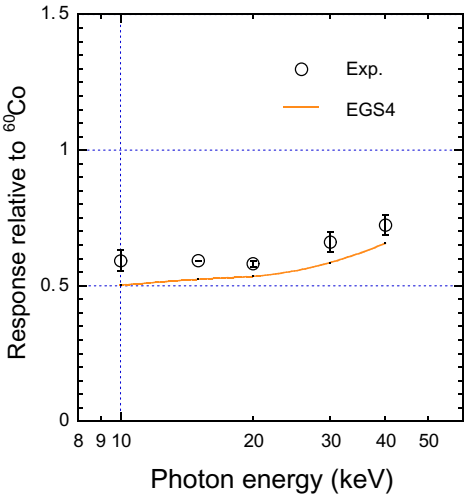

Fig. 1 Energy response of MD-55

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