Instrumentation and Technique

14C1/2009G191

Tritium measurement by using a photo-stimulable phosphor BaFBr(I):Eu^{2+} plate

Hiroko OHUCHI*[1], Yuji HATANO[2]
[1]Tohoku Univ., 6-3 Aoba, Aramaki, Aoba-ku, Sendai 980-8578, Japan
[2]Toyama Univ., 3190 Gofuku, Toyama, Toyama 930-8555, Japan

Introduction

Tritium measurement is indispensable for fuel processing systems of DT-fusion facilities. Recently, the tritium imaging plate (IP) technique detecting the beta particles by using an IP sheet has been applied to determine the surface tritium distribution on plasma facing tiles [1]. An IP made of europium-doped BaFBr(I), a photostimulated luminescence (PSL) material, is a two-dimensional radiation sensor with a high sensitivity. This technique, however, is unsuitable for use in deeper regions than the escape depth of beta-rays from tritium.

We have been developing a new approach to detect tritium utilizing bremsstrahlung induced by tritium beta-rays with the IP [2]. The measurement principle of this approach of tritium detection is observing the bremsstrahlung X-rays generated by the interaction between beta particles from tritium and matter, on the basis of X-rays penetrating materials much more easily than weak beta-rays of tritium with the maximum energy of 18.6 keV. In the present work, the energy response of the IP was examined.

Experimental

The experiments using X ray beam sources were performed on a beam line at BL-14C1 in the KEK-PF. The energy response of BAS-MS type IP was measured by using monoenergetic X-ray beam sources of 8.0, 10.0, 13.5, 16.0, and 18.6 keV. BAS-MS type IP, manufactured by FUJIFILM Co., Ltd., consists of a 9-µm-thick polyethyleneterephthalate protective film and a 115-µm-thick photostimulable phosphor layer affixed to a 12-µm-thick plastic back layer and a 190-µm-thick polyethyleneterephthalate base layer. The PSL sensitivities of the IP covered with aluminum filter of three different thicknesses of 0.1, 0.3, and 0.5 mm, were measured in order to investigate the variation of the energy response with filters. To read out the IP samples, an imaging plate reader, Model FLA-3000 fabricated by FUJIFILM Co., Ltd was used.

Results and discussion

The measured IP sensitivity (PSL per arbitrary unit) with and without the aluminum filters of different thicknesses is plotted against X-ray energies (keV) in Fig.1. The result shows that IP's sensitivity greatly depends on the X-ray energy. PSL intensity even without the aluminum filter is quite low at 8 keV, indicating that most X-rays below 8 keV are attenuated by the thick protective film of the IP. It was also found that all of PSL intensities with and without filters increase as the X-ray energy becomes higher.

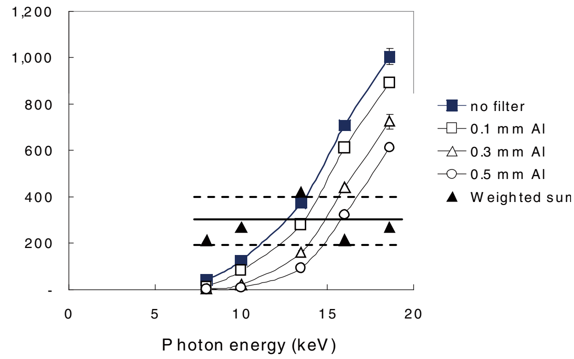

Fig.1 PSL sensitivities measured with and without aluminium filters of different thicknesses. The ▲ symbols show the weighted sum of PSL sensitivities measured with and without different filters.

By combining the sensitivities data measured using 0.1-, 0.3-mm-thick and 0.5-mm-thick aluminum, and those without filters, a constant PSL sensitivity of an IP per arbitrary unit independent of the X-ray energy can be obtained. By taking the weighted sum, Res_{sum} shown in Eq. (1), a response having flat energy dependence can be obtained as shown in Fig. 1,

$$Res_{sum} = 8.00 \cdot Res_{no\ filter} - 8.76 \cdot Res_{Al0.1mm} - 2.00 \cdot Res_{Al0.3mm} + 2.45 \cdot Res_{Al0.5mm} \quad (1)$$

where $Res_{no\ filter}$, $Res_{Al0.1mm}$, $Res_{Al0.3mm}$, and $Res_{Al0.5mm}$ are, respectively, the IP sensitivities measured without filters, with 0.1--mm-thick aluminum, 0.3-mm-thick aluminum, and 0.5-mm-thick aluminum filters. The IP sensitivity so obtained was constant to within ±14% deviation for X-rays with energies from 8.0 to 18.6 keV except at 13.5 keV, where Res_{sum} shows ±25% deviation.

By using Eq. (3), we can correct energy dependence on PSL sensitivities. By combining the energy spectrum information (depth profiles), the amount of tritium in deeper regions by this technique can be quantified.

References

[1] T. Tanabe et al., J.Nucl. Mater. 313-316, 478 (2003).
[2] H. Ohuchi et al., Proceedings of The Fifth iTRS International Symposium On Radiation Safety and Detection Technology, 199 (2009).

* hiroko@mail.pharm.tohoku.ac.jp