Development of BGO scintillator as black detector for measuring absolute intensity of synchrotron radiation

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Introduction

The response of the Bismuth Germanate ($Bi_4Ge_3O_{12}$) scintillation detector was measured for X-ray energy range from 9 to 40keV. BGO scintillation crystals have been widely used for applications in medical diagnostics, high energy physics and high count rate experiments because of its large detection efficiency for high energy gamma rays and suitable scintillating properties (fast decay time of 300ns and emission peak at 480nm). However few measurements of the response of BGO scintillator were reported [1,2] for X-ray energy below hundreds keV.

In this energy region, particularly near X-ray absorption edges, the non-proportionality of the scintillation responses of alkali halide crystals are well known [3]. But the study on the BGO crystal is very rare [1,2]. Therefore the accurate measurements of the scintillation response of BGO crystal are indispensable to use it for measuring absolute intensity of X-ray beam of synchrotron radiation (SR).

Experimental

A cubical BGO crystal (12mm×12mm×12mm) was coupled to a Si photodiode (Hamamatsu S1227-1010BR) with polished face. Other sides of the crystal were not polished. The crystal and photodiode were settled in an aluminum case, which had a window of Be with thickness of 100 micron for shading. The photo-current of the scintillation light was measured by the electrometer (Keithley 6517A).

A free air ionization chamber was located upstream of the BGO scintillator, used for knowing the intensity of incident SR beam and calibrating the BGO scintillator.

Results and Discussion

The BGO scintillator was operated on the mode of current measurement, consequently the correction for escaped K, L X-rays was necessary. For this correction, the ratio of K, L X-rays and electrons escape from the BGO crystal surface were calculated by EGS4[4] photon electron Monte Carlo transport code.

Fig.1 shows the light output of the BGO crystal for unit absorbed energy. The considerable non-proportionality was observed near L absorption edge of Bi (16.4keV) and a slight bit near K absorption edge of Ge (11.1keV). The relative light output of the BGO crystal around 15keV is about 20% less than that of 40keV. The present result is in good agreement with ref [2] in the whole energy region. But below 10keV, the present result and that in ref [2] differs from that in ref [1].

It is noted that there are other two L absorption peaks of Bi (15.7, 13.4 keV), and presence of more fine structure of response was expected in the energy near below L absorption edge of Bi.

We intend to use this BGO scintillator for measuring very high intensity X-ray beam in 3rd-generation SR facility SPring-8, consequently the measurement of characteristic of the saturation in such high intensity X-ray beam is planed.

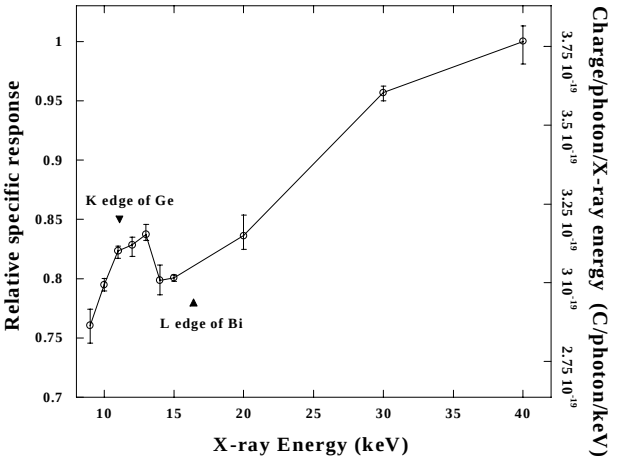

Fig.1 : Measured photon response of the BGO scintillator per unit energy deposited in the scintillator. Data are normalized to unity at 40keV.

References

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