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Study on response function of CdTe detector

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ABSTRACT

So far the origin of the mechanism of light emission in the sonoluminescence has not elucidated whether it is due to blackbody radiation or bremsstrahlung. The final goal of our study is measuring X-ray energy spectrum using high-sensitivity cadmium telluride (CdTe) detector in order to obtain information for understanding sonoluminescence phenomena. However, the scope of this report is the measurement of X-ray spectrum using a high-resolution CdTe detector and determination of CdTe detector response function to obtain the corrected spectrum from measured soft X-ray source spectrum. In general, the measured spectrum was distorted by the characteristics of CdTe detector. Monte Carlo simulation code, MCNP, was used to obtain the reference response function of the CdTe detector. The X-ray spectra of ^{57}Co, ^{133}Ba, and ^{241}Am were obtained by a $4 \times 4 \times 1.0(t)\,mm^3$ CdTe detector at room temperature.

1. Introduction

In the X-ray and gamma-ray measurement, semiconductor and scintillator combined detector are widely used. However, the detector selection is made by considering various required detector characteristics such as fast raising time, detection efficiency, energy resolution, etc. NaI(Tl) and HPGe detectors are useful tools for hard X-ray and gamma-ray radiation measurement because NaI(Tl) and HPGe have good efficiency compared to any commercial detectors and provide high resolution. However, they are not suitable for soft X-ray measurement. Recently, many researchers developed a detector that has good detection efficiency and high resolution in soft X-ray spectral range, the so-called soft X-ray detector. Especially, cadmium telluride (CdTe) is a promising material for X-ray and gamma-ray detectors that can operate at room temperature with a high detection efficiency comparable to NaI(Tl) and good energy resolution comparable to an HPGe detector. The prior application fields of the CdTe detector are medical engineering and astrophysics.

To date, many researchers have developed and tested various types of detectors that are used in the X-ray range for obtaining an accurate knowledge of energy spectra as well as for astrophysical and medical applications [1–8]. Among those X-ray detectors, cadmium telluride detector is gaining interest recently in many applications because its large band-gap reduces leakage current, and makes room-temperature operation feasible. High-energy resolution, good mobility lifetime product and large stopping power are attracting many users. It also has a compactness and portability that are outstanding advantages in many applications.In our research, we selected CdTe for the study on sonoluminescence phenomena [9,10]. So far the origin of light emission mechanism in sonoluminescence has not elucidated whether it is due to blackbody radiation or bremsstrahlung. X-ray spectrum analysis might be the interesting measurement that could provide the key information to find unrevealed sonoluminescence mechanism. We investigated the nonlinear behavior of heat transfer within and through the shell of a microbubble by ultrasound

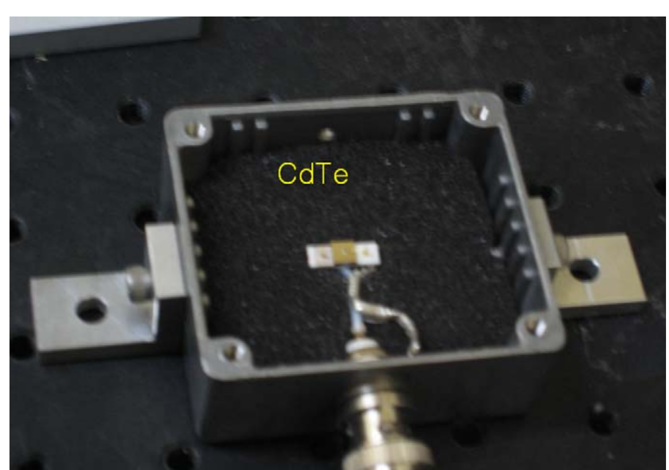

Fig. 1. Schottky-type CdTe shielded inside aluminum dark box.

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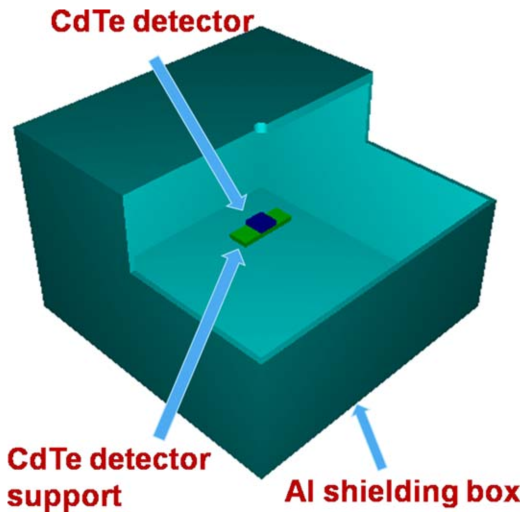

Fig. 2. Input geometry for MCNPX simulation.

injection. We are trying to infer the microbubble temperature using a high-sensitivity CdTe X-ray spectrometer by measuring X-ray spectrum from a sonoluminary microbubble. Recently, we tested a $4 \times 4 \times 1\,\text{mm}^3$ high-resolution Schottky CdTe detector to study its response to low-energy gamma-ray source at room temperature. The measured spectrum was generally distorted by the characteristics of CdTe detectors such as hole tailing and pile-up effect. Computer simulation was also performed using MCNP to obtain response function of CdTe detectors.

2. Experiment and simulation

In the experiment, a CdTe detector of 1 mm thickness and $4 \times 4\,\text{mm}^2$ surface area was employed. The detector was a Schottky contact-type CdTe detector made at ACRORAD, which helps the CdTe operating with higher electric field than the one with Ohmic contacts type. It was shielded by $5.5 \times 6 \times 2.7\,\text{cm}^3$ of aluminum box as shown in Fig. 1.

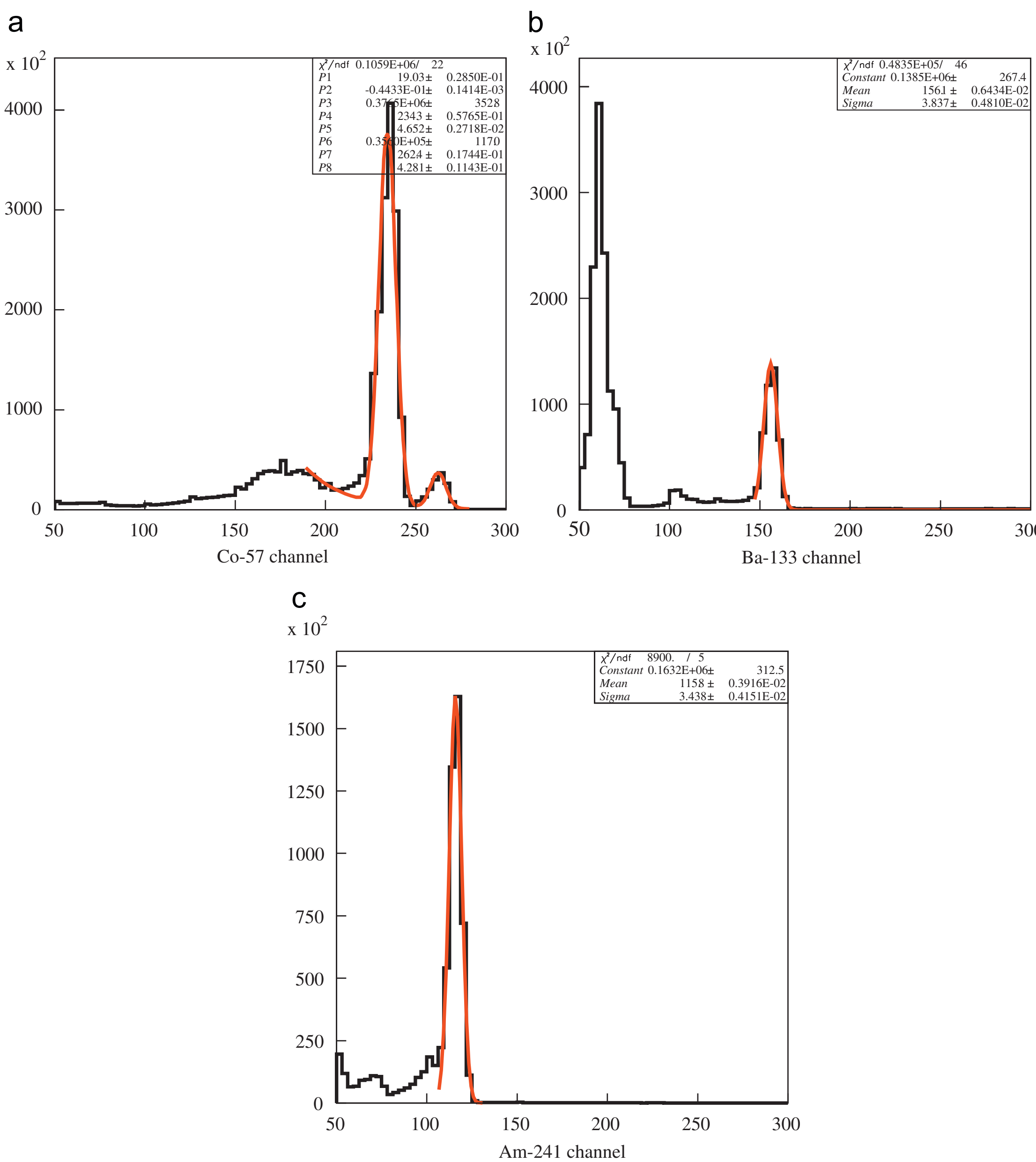

Fig. 3. The pulse height spectra were measured by CdTe at room temperature. ^{57}Co spectrum was shown in (a). Two ^{57}Co gamma-ray peaks of 122 and 136 keV were found at 230 and 260 channel of MCA, respectively. Two Gaussian peaks of ^{133}Ba appeared at about 60 and 150 channels as shown in (b). ^{241}Am spectrum is shown in (c). Gaussian peak of 59 keV gamma ray appears at the 120 channel.