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Performance Evaluation of CdZnTe Crystal grown at KAERI

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1. Introduction

Cadmium zinc telluride (CdZnTe) and Cadmium telluride (CdTe) wide band gap semiconductors have attracted increasing interest as X-ray and gamma ray detectors due to the high atomic number, the high density and the wide band gap [1, 2]. Among these, critical issues of CdTe detector are their time instability under bias, so-called polarization effect and its relatively high bulk leakage currents [3-4], Thus, CdTe cannot be made thick and needs to minimize the polarization effects by using high bias voltages and low temperature operation. But resistivity of CdZnTe are typically between one and two orders of magnitude greater than that of CdTe and thus leakage currents are correspondingly low due to increased band gap by addition of Zn. Moreover, the main advantage of CdZnTe is the absence of the polarization effect and this make CdZnTe exploitable.

In this study, the electrical and radiation response characteristics of the grown CdZnTe crystal were evaluated

2. Methods and Results

2.1 Fabrication of CdZnTe radiation detector

CdZnTe crystal was grown by using a 6-zone Low Pressure Bridgman furnace (LPB). CdZnTe crystal was cut from the grown ingot to reveal the grain boundary and to cut the (1,1,1) crystalline face. The cut CdZnTe crystal was lapped with various SiC paper and polished with 1 μm ~ 0.05 μm ceramic powder. After mechanical polishing, CdZnTe chemically polished with 5% Br-methanol solution [5-7]. Br-methanol solution makes Te-rich faces on the CdZnTe crystal. The chemically polished CdZnTe crystal was stores in the clean room for a day to make a natural oxide layer on Te-rich faces.

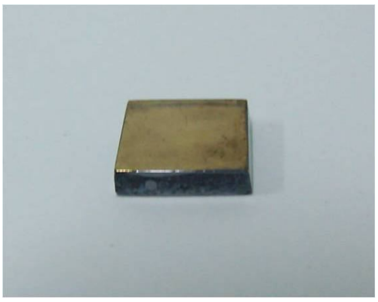

Fig. 1. The fabricated CdZnTe nuclear radiation detector by using the 6-zone LPB at KAERI.

CdZnTe crystal was not passivated. Gold chloride solution was used to make ohmic-ohmic contacts. The fabricated CdZnTe is shown in Fig. 1. The dimension of the CdZnTe detector is 10 mm (w) x 12 mm (L) x 3 mm (t).

2.2 I-V characteristics

Current-voltage (I-V) Characteristic was investigated to measure the resistivity of the grown CdZnTe crystal. The CdZnTe detector was placed in a shielding box to prevent the external electromagnetic wave and electronic noises. A Keithley® 6517A electrometer was used to bias and to read the leakage currents on the CdZnTe detector. We measured the current up to ± 1,000 V. The measured I-V curve is shown in Fig. 2. Ohmic-ohmic characteristic was clearly observed.

The calculated resistivity of CdZnTe was 1.96 x 10^{13} Ω·cm. Higher than 10^9 Ω·cm resistivity of CdZnTe crystal can be used to fabricated a CdZnTe nuclear radiation detector for high applied bias application [8] and most of commercialized CdZnTe crystals show 10^9 ~ 10^{13} Ω·cm resistivity. Thus, the grown CdZnTe crystals can be used as a nuclear radiation detector.

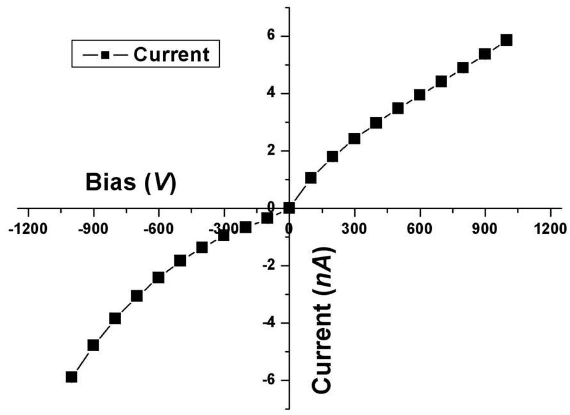

Fig. 2. I-V characteristic of the fabricated CdZnTe nuclear radiation detector. The CdZnTe radiation detector was non-passivated ohmic-ohmic contacts. The dimension of CdZnTe crystals is 10 mm (w) x 12 mm (L) x 3 mm (t).

2.3 Gamma ray response

Gamma ray response for the fabricated CdZnTe was observed to ensure availability as a nuclear radiation detector. A Cremat® CR-110 charge sensitive amplifier, ORTEC® shaping amplifier, ORTEC® high voltage supplier, and ORTEC® Spectrum Master Multi-channel analyzer were used in pulse height spectrum measurement. Biasing voltage and shaping time were set at -1,000V and 5 μs, respectively. The measured background and 662 keV gamma ray pulse height spectra were shown in Fig. 3. Energy resolution for 662 keV gamma ray was 2.4%. Characteristic X-ray, which is about 10% emission rate from Cs-137 decay chains, was also clearly observed.

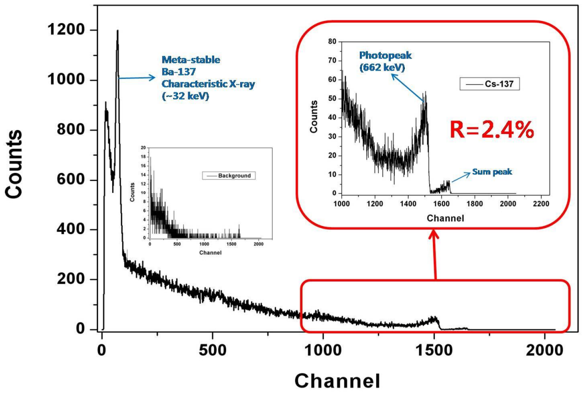

Fig. 3. The measured pulse height spectra for background ground and 662 keV gamma ray. Energy resolution for 662 keV photopeak was 2.4%. Characteristic X-ray from meta-stabled Ba-137 (~ 32 keV) was also clearly observed.

3. Conclusions

CdZnTe crystal was grown by using a 6-zone LPB furnace at KAERI. The grown ingot was prepared several procedures such as grinding, lapping and polishing. For electric contact to CdZnTe crystal, gold was deposited by using gold chloride solution. The fabricated CdZnTe nuclear detector was characterized by I-V curve and 662 keV gamma ray pulse height spectra. 1.96×10^{13} Ω·cm high resistivity was obtained in spite of non-passivated. 2.4% energy resolution for 662 keV gamma ray was achieved. And characteristic X-ray (~32 keV) was also clearly observed. From the results, the fabricated CdZnTe can be used as X- and gamma ray nuclear detectors. In future work, to obtain better energy resolution for gamma ray, single charge carrier measurement detector, such as a Frisch collar or pixellated type, will be fabricated and their characteristics will be also addressed.

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