Passivation effect of CdZnTe crystal grown at KAERI

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1. Introduction

The wide band gap, high effective Z-number and high resistivity of CdZnTe make it a good candidate for use as a room temperature operated detector with good absorption efficiency [1]. In radiation detector, leakage currents are one of main noise sources and must be minimized to achieve good energy resolution. Leakage currents are from CdZnTe crystal itself, thus, this cannot be controlled after crystal growth. But surface leakage currents can be controlled by such as passivation [2,3]. There are some methods to passivate CdZnTe Such as dielectric substance deposition [4], II-VI isomer growth on surface [5] and native oxide film coating [6].

In this study, Passivation was performed with NH_4F contained solution. And passivation effects were studied by comparison with leakage currents before and after passivation. Gamma-ray response is also addressed.

2. Methods and Results

2.1 CdZnTe sample preparation

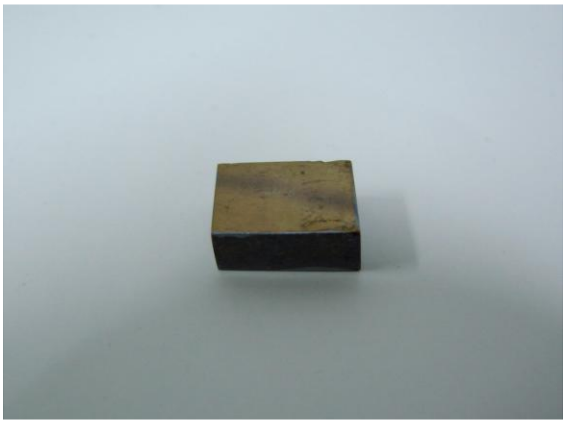

Fig. 1. CdZnTe detector with gold chloride solution electrode (10mm(W) x 12mm(L) x 5mm (T))

CdZnTe single crystal doped with 5 ppm of Indium was grown by Low Pressure Bridgman(LPB) method at KAERI. CdZnTe crystal was cut by diamond wire saw and grinded with various SiC papers. And then, CdZnTe crystal was mechanically polished and gold was contacted by using $AuCl_3$ solution. Figure 1 shows an ohmic-ohmic contacted CdZnTe detector. The dimensions were 10mm (W) x 12mm (L) x 5mm (T).

Passivation solution was consisted of $NH_4F + H_2O_2$ + DI water. Before passivation of CdZnTe crystal, I-V curve was measured.

2.2 Comparison of I-V Characteristics

In order to measure I-V curve of CdZnTe detector, a Keithley® 6517A high-precision electrometer was used.

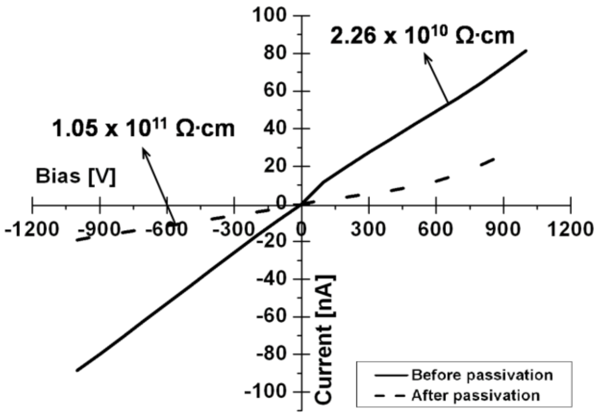

Fig. 2. I-V characteristics of CdZnTe. The dimension of CdZnTe crystals is 10mm(W) x 12mm(L) x 5mm (T).

Figure 2 shows I-V characteristics of the CdZnTe detector. The characteristic before passivation tends toward typical Ohm's law. Calculated resistivities from I-V characteristics are 2.26×10^{10} Ω·cm before passivation and 1.05×10^{11} Ω·cm after passivation. As a result of passivation, 1 order of magnitude of resistivity was increased after passivation compared with before passivation.

2.3 Gamma ray response

To measure gamma-ray response, Cremat® CR-110 charge sensitive amplifier, ORTEC® shaping amplifier, ORTEC® high voltage supplier, and ORTEC® spectrum master Multi-Channel Analyzer (MCA) were used. Biasing voltage was -450V and shaping time was 5 µs.

Since the CdZnTe detector cannot be biased with high voltage in non-passivated case, spectrum after passivation is only described. This figure shows 662 keV peak of photon energy of Cs-137.

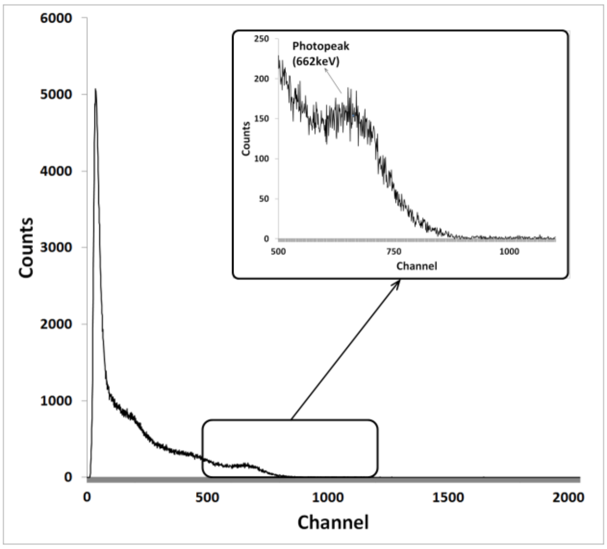

Fig. 3. Gamma-ray response of CdZnTe detector with Cs-137 source

3. Conclusions

In this experimental, surface leakage can be reduced CdZnTe material after growing through passivation. The CdZnTe detector is less influenced by other factors such as air or water after passivation. This result came from passivation which made oxidation layer on surface of CdZnTe detector. Since leakage current is reduced after passivation, much higher voltage can be biased. Consequentially, photon energy can be collected quickly. Therefore, more effective CdZnTe detector can be produced and this detector can be applied for such as astrophysics, cosmology, and medical science.

ACKNOWLEDGMENT

This work has been carried out under the R&D program of the MEST (Ministry of Education and Science Technology)

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