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High-resistivity CZT Crystal Growth by an LP-Bridgman Furnace at KAERI

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1. Introduction

Room-temperature semiconductor radiation detectors such as CdZnTe (CZT) and CdTe are being developed and grown in the world-wide due to their high performance as a gamma-ray detector. Although a germanium semiconductor radiation detector has superior gamma-ray detection efficiency and high energy resolution to a CdZnTe radiation detector, it has a drawback such as a huge cooling system.

High-resistivity CZT crystal growth is very important to make a high resolution CZT radiation detector. Because the leakage currents is one of the noise-sources of the detectors. And bulk leakage currents, which are the leakage current from material itself, cannot be controlled by any other methods such as surface passivation or guard electrode structure. [1~5)]

In this conference, a high-resistivity CZT crystal grown by a 6-zone low-pressure (LP) Bridgman furnace at Korea Atomic Energy Research Institute (KAERI) is introduced and its characteristics are addressed.

2. Methods and Results

2.1 CZT crystal grown by a LP Bridgman furnace

A CZT crystal ingot, which was doped with 7 ppm In and grown by a 6-zone Low Pressure (LP) Bridgman, was etched to reveal the grain boundary and to cut (1,1,1) crystalline face. The etched CZT crystal ingot and the cut crystal are shown in Fig. 1. The grown ingot had 12 cm long and 1” diameter. Grain boundary are definitely shown and a large domain of single crystal was obtained.

Fig. 1. The etched CZT ingot and the cut crystal, which were grown by 6-zone LP Bridgman furnace at KAERI.

2.2 Fabrication of a CZT radiation detector

The etched CZT crystal was cut along with the (1,1,1) crystalline face. The cut crystal was lapped with various SiC paper and polished with 3 μm ceramic powder. The mechanically polished CZT crystal was also chemically polished with 5% Br-methanol solution.[6-8)] Br-methanol solution makes Te-rich faces on CZT and this Te-rich layer react to oxide. So, we leave the CZT in the clean room during one day to make natural oxide layer.[7)]

Gold electrodes to make ohmic-ohmic contacts were deposited onto both sides of the crystal, where the electroless deposition technique with gold chloride was used. The fabricated CZT detector is shown in fig. 1. The dimension of the CZT detector was 10 mm X 12 mm X 10 mm (thickness).

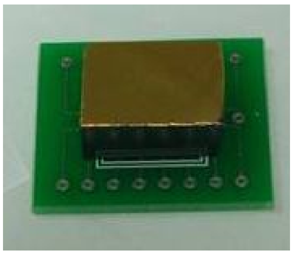

Fig. 2. A fabricated CZT radiation detector.

2.3 I-V Characteristics of the fabricated CZT detector

We measured the operating property of the detector: I-V. The detector was placed in a shielding box to reduce the electronic noise, and the high voltage was biased between the metal electrodes of the detector. The electrometer, Keithley 6517 A, was used to bias the high voltage on the detector and read the leakage current. We measured the current up to ± 500 V. The measured I-V curve is shown in fig. 3.

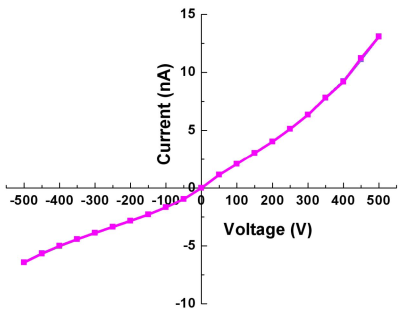

Fig. 3. I-V curve measured with the fabricated CZT detector. Ohmic-ohmic contact characteristics was shown.

Routinely, above 10^9 Ω·cm resistivity of CZT crystal can be used to make CZT radiation detector due to high voltage application.[1] A resistivity of the fabricated CZT radiation detector, which didn't apply any passivation, was 7.8 X 10^9 Ω·cm. Figure 4 shows the pulse shape measured with an oscilloscope for 660 keV gamma-ray when biased at -1000V. We can observe the clear pulse shape for 660 keV gamma-ray.

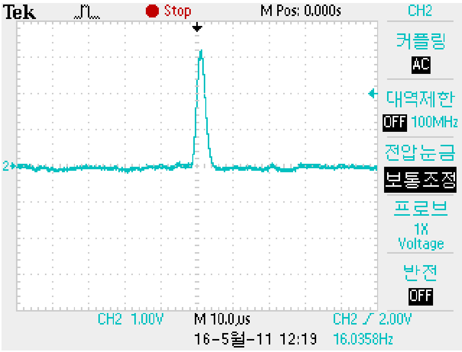

Fig. 4. Pulse shape measured with an oscilloscope for 660 keV gamma-ray by using the fabricated CZT detector.

3. Conclusions

CZT crystal was grown by 6-zone LP Bridgman furnace at KAERI. A grown ingot was etched and cut along with (1,1,1) crystalline face. To evaluate characteristics of the grown bulk-crystal, only routine crystal processes were applied and also the detector was fabricated in a planar-type. A resistivity of 7.8 X 10^9 Ω·cm and a clear pulse shape for 660 keV gamma-ray were observed. In future work, various processes, such as passivation of the bulk crystal and forming guard-electrode of the detector, will be adapted and their characteristics will be also addressed.

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