Development of CZT Planar Detectors for High-Resolution Portable Radioisotope Identifier

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1. Introduction

Cadmium Zinc Telluride (CZT) is a proven material for high resolution gamma-ray spectroscopy at room temperature [1]. Since the bandgap of CZT is moderate, the CZT detector can be operated at room temperature without cooling system. The detection efficiency of the CZT detector is large comparing to other conventional detectors such as Si or Ge detector due to large atomic numbers of its composite material. The CZT planar type detector has been developed at Korea Atomic Energy Research Institute (KAERI) for a portable radioisotope identifier (PRI) [2]. The PRI can be used to identify the type and the activity of the nuclear material directly. It can be used at nuclear power plant, storage site of nuclear waste, and also environment radiation monitoring.

The progress of the CZT detector has been mainly plagued by the material problem. When one wants to use the CZT detector for radiation measurement, the CZT crystal should meet specific requirements. That is, the crystal should be thick enough to stop the incident radiation in the crystal, the resistivity of the crystal is high to reduce the leakage current of the detector, and the charge carriers, which are generated from the radiation, in the crystal transport easily without losing the signal information. Many methods have been applied to grow the CZT crystal for the radiation detector. Bridgman method is a common method for the crystal growing. However, the CZT crystal for radiation detector can not be obtained with the conventional Bridgman method. It is known that high pressure Bridgman method and modified Bridmgan method can be appropriate method for the CZT crystal growing.

We made planar type CZT detectors with various crystals, and the detector performance was measured and compared.

2. Methods and Results

Two types of CZT crystals were employed in the present work. One crystal was grown with High Pressure Bridgman method, and it was obtained from eV Products. The size of the crystal was 10 × 10 × 5 mm^3 and it was known as spectroscopy grade one. The other crystal was with Low Pressure Modified Bridgman method, and it was obtained from Yinnel Tech. The size of the crystal was also 10 × 10 × 5 mm^3.

The fabrication process of the CZT detector was as follows. Each face of the crystal was lapped and polished mechanically. The crystal was chemically etched with Bromine/Methanol solution. The gold metal electrode was deposited on large face (10 × 10 mm^2) of the crystal. Electroless deposition method was used for the metal deposition. The sides of the crystal was grinded to reduce the leakage current of the detector. Metal electrode was connected to the metal electrode to obtain the signal from the detector. Fig. 1 shows the fabricated detector in our work.

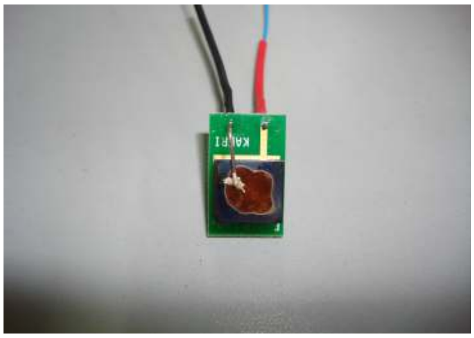

Fig. 1. The CZT detector fabricated in our work. The CZT crystal was grown with High Pressure Bridgman method.

The detector performances such as leakage current and spectroscopic response were measured. The signal electrodes of the detector were connected to Keithley 6517 A electrometer. High voltage was biased and the electric current from the detector was measured with the electrometer. Figure 2 shows the measured I-V curve of the detector.

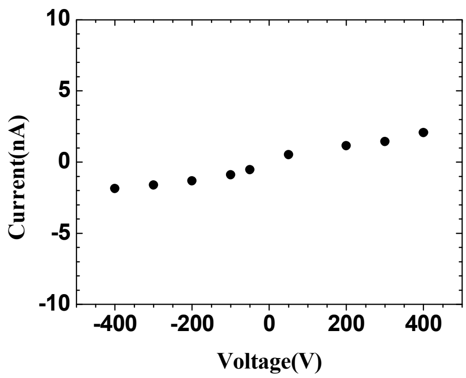

Fig. 2. I-V curve of the CZT detector.

The radiation energy spectrum of the detector was measured. The signal from the detector was passed through Pre-Amplifier (eV-550) and Amplifier (ORTEC 572 A), and the analog signal was digitized in the Multi Channel Analyzer (MCA). The data was stored in PC. Figure 3 shows the typical energy spectrum measured with the detector.

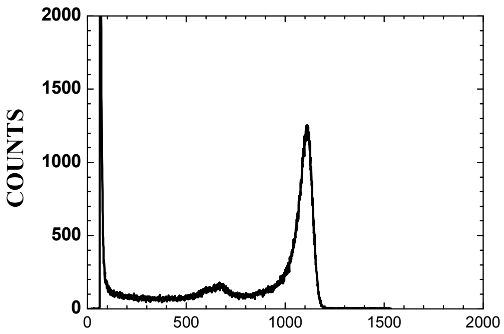

Fig. 3. Energy spectrum measured with the CZT detector.

The leakage current and energy spectrum of each detector were measured, and the data from two detectors were compared.

It can be seen that the leakage current of the detector made with Low Pressure Bridgman method was 2 -3 times higher than that of the detector made with High Pressure Bridgman method. Also, the energy resolution of the detector made with Low Pressure Bridgman method was slightly degraded comparing with the detector made with High Pressure Bridgman method. However, the performance of CZT crystal made with Low Pressure Bridgman method was tolerable to be used in PRI.

3. Conclusions

Two CZT crystals were used to make the radiation detector. One crystal was made with High Pressure Bridgman method, and the other crystal was made with Low Pressure Bridgman method. CZT detectors were made with the crystals, and the detector performances such as leakage current and the energy spectrum were measured and compared.

CZT detector can be used in various areas such as nuclear safety, homeland security, and industrial monitoring. The crystal quality is one of important factors to determine the detector performance. Our results would be helpful to determine the CZT detector when the CZT detector was used in specific application.

REFERENCES

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