CZT Crystal Growing for Room Temperature Radiation Detector

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1. Introduction

Cadmium Zinc Telluride (CZT) is a proven material for high resolution radiation detector, which could be operative at room temperature. CZT could be used in applications including nuclear safety, composition analysis of spent nuclear fuel, astronomy, nuclear medicine, national security, and non destructive analysis. Tremendous efforts have been made in the development of CZT detector [1]. Wider applications of CZT detector were mainly hindered by the difficulty to obtain the high quality CZT crystal. Material of high resistivity, low structural and microscopic defect concentrations should be supplied to make the application of CZT detector wider [2]. Especially, the CZT crystal with high resistivity is required to measure the radiation with high energy resolution, and this requirement is only strongly required for radiation detector application.

Bridgman growing method is generally used to grow the CZT crystal. We have developed the growing method of CZT material. In this paper, we will discuss the development of CZT crystal growing, and the recent result of our work.

2. Crystal Growth

2.1 Bridgman Furnace

The CZT crystals were grown by means of the Bridgman method. A 3-zone Bridgman crystal growth furnace was designed and fabricated. A heater of each zone was made with carbon. Upper zone was set to 1100 ^{o}C to melt the CZT, the middle zone was set to 1020 ^{o}C to remain the solid state of CZT, and the lower zone was to apply the Cd over pressure inside the ampule. The ampule was slowly moved from the upper zone to middle zone. The ampule could be transported with 2 speed mode: one mode was slow moving one, generally 1 mm/h, and the other mode was fast moving one to load the ampule in the furnace and to remove the ampule from the furnace. The temperature of each zone could be controlled with a remote controller. The heaters were in the vacuum box. Therefore the growing could be performed in the vacuum condition or in the high pressure condition, up to 10 atm.

2.2 Carbon coating system

The CZT crystal was grown in the vacuum sealed ampule. The ampule was made with semiconductor-grade quartz. The inside surface of the ampule was coated with carbon to prevent the adhesion of the material into the ampule wall and to hinder the intrusion of silicon into the CZT crystal.

Fig. 1 Bridgman Furnace

A furnace was set to coat the carbon on the inside wall of ampule. The carbon coating process was as follows; The quartz ampule was cleaned with chemical way. The quartz was set in the furnace and it was heated to 1100 ^{o}C to remove the impurities in the ampule. The temperature of the ampule was lowered to 650 ^{o}C, and Hexane was flown in the ampule to coat the carbon inside the ampule. The temperature of the ampule was raised to 1100 ^{o}C and remained for 4 hours in the vacuum condition to anneal the carbon coated ampule.

The high purity Cd, Zn, and Te was loaded into the ampule. The ampule was connected to a vacuum sealing system. The vacuum inside the ampule was 10 $^{-6}$ Torr, and the ampule was sealed.

2.3 Crystal Growing

The ampule was loaded in the furnace. The ampule was in the upper zone. The temperature was raised into 1100 ^{o}C. The ampule was lowered into the middle zone with the speed of 1 mm/h. After the ampule was stopped in the middle zone, the temperature was lowered slowly to prevent the thermal shock on the crystal.

Fig. 2 CZT Crystal grown with the Bridgman method

3. Analysis and Radiation Response

The crystal was cut with diamond wire saw. The surface was polished with SiC paper, and alumina. The crystal was analyzed with XRD (X-Ray Diffraction), EPMA (Electron Micro Probe Analyzer), FT-IR, PL (Photoluminescence), and AES. The grown substrate was single crystal from the XRD analysis.

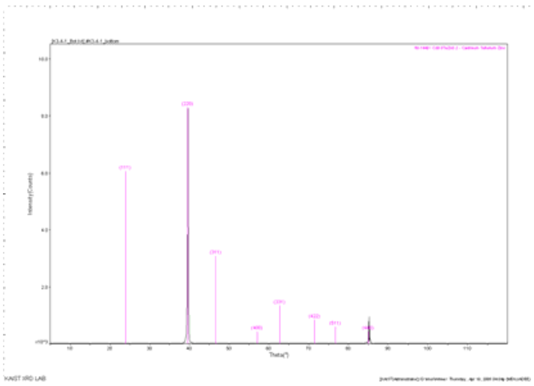

Fig. 3 XRD of grown CZT crystal

Indium was deposited on one face of the crystal and gold was evaporated the other face of the crystal. The radiation energy spectrum from ^{241}Am source could be successfully measured with CZT detector. Figure 4 shows the measured energy spectrum.

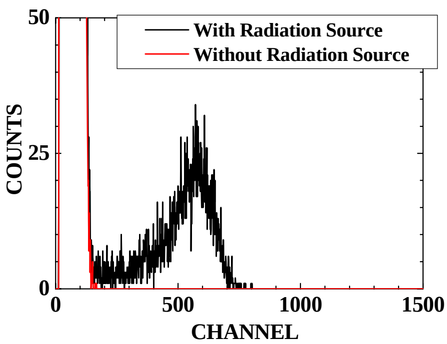

Fig. 4 Energy spectrum measured with CZT

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REFERENCES

[1] O. Limousine, “New trends in CdTe and CdZnTe detectors for X-and gamma-ray applications”, Nucl. Instr. Meth. A, Vol. 504, p. 24, 2003.
[2] S.H. Park, J.H. Ha, J.H. Lee, Y.H. Cho, H.S. Kim, S.M. Kang, Y.K. Kim, “Fabrication of various CZT planar-type detectors and comparison of their detector characteristics”, Journal of Nuclear Science and Technology, to be published, 2008.