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Characterization of Indium-doped CdZnTe(CZT) Crystals Grown by 6 Heating Zone Bridgman Method

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1. Introduction

$Cd_{1-x}Zn_xTe$(CZT) crystal is one of the most important wide band gap semiconductor materials for room-temperature radiation detectors, especially for gamma-rays [1-3] due to their wide band gap, high atomic number, and their room temperature operability. The performance of the radiation detectors strongly depends on the quality of the crystals, which is dominated by macro- and microstructural defects such as dislocation, sub-grain boundary, crack and Te inclusion [4-6]. In this paper, the growing method and some of the techniques used to analyze the crystal's quality are described.

2. Methods and Results

2.1 Crystal Growth

25 mm diameter $Cd_{0.9}Zn_{0.1}Te$ ingots (doped with Indium) were grown using the vertical Bridgman method with a six-heating zone furnace (fig. 1). After carrying out the cleaning process of the quartz ampoule, the compound of Cd, Zn, and Te (6N purity) were introduced into the carbon coated ampoule with indium – doping material. For the next step, the vacuuming and sealing of ampoule were conducted. The growth process was accomplished by the displacement of the ampoule at a rate 0.8 mm/h and followed by cooling.

Fig.1 A Photography of a CZT crystal ingot

The ingots were cut into 10 mm thick cylindrical shapes perpendicular to the axial direction, and then etched by a solution of 20 ml H_2O, 15 ml HNO_3, 5 ml HF, and 0.4 g $AgNO_3$ to reveal the grain and twin boundaries. The thick etched wafers showed 5 or 6 large grains divided by 2 different growth orientations (fig. 2). The maximum single grain size is approximately 10 x 25 mm.

Fig.2 An etched cross section of the crystal's perpendicular growth axis

2.2 X-ray Diffraction Analysis

We conducted a crystallographic analysis using X-ray diffraction (XRD) (fig. 3) at a diced small wafer in one grain, which is indicated as (a) in fig 2. The surface which was investigated by x-ray was parallel to the growth axis. As a result of X-ray diffraction analysis, one region of the crystal well grew and was aligned along [111] direction.

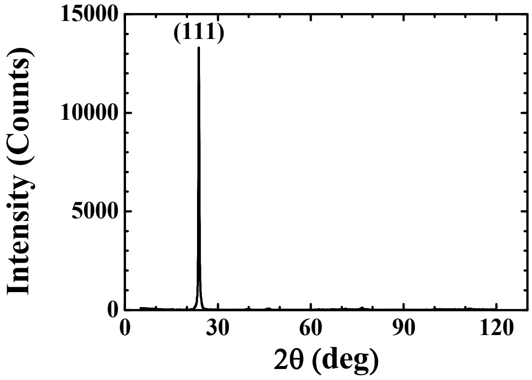

Fig. 3 X-ray diffraction pattern for the crystal wafer at the (a) region of fig. 2

2.3Fourier Transform IR Spectroscopy Analysis

Also, we analyzed the IR transmittance of the CZT crystal. The surface which was investigated by FT-IR was also parallel to the growth axis. Theoretically, the transmittance of the perfect CZT single crystal should be approximately 66% over the typical range of 500-4000 cm^{-1}[7]. The result shows that the spectrum is the high straight type. It means that the CZT crystal has low dislocation density and high electrical resistivity.

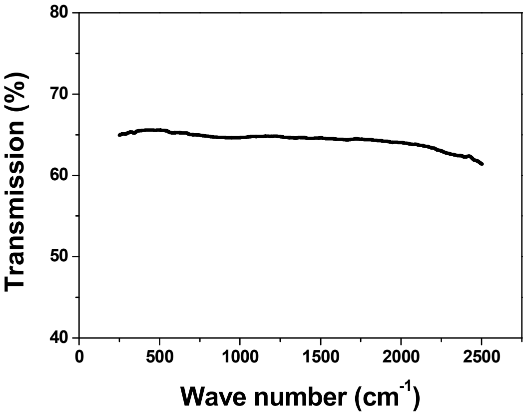

Fig. 4 FT-IR transmission spectrum for the crystal wafer at the (a) region of fig. 2

3. Conclusions

We have successfully grown the CZT crystal ingot which has 25 mm diameter using 6-heating zone Bridgman furnace. From the results of XRD and FT-IR, we have concluded that the grown CZT ingot has a good crystal quality. These findings suggested that our designed furnace is suitable for growing high quality CZT crystals for fabricating radiation detectors. Further research on the microstructural analysis and physical properties of the grown crystals will be conducted in another study.

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