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Progress of CZT Crystal Growing at KAERI

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1. Introduction

CZT(Cadmium Zinc Telluride) is one of the most promising material for X-ray and γ-ray energy spectroscopy and radiation imaging [1,2]. Because the energy band gap of CZT is high, the CZT detector can be operated at room temperature without cooling system. Also the energy resolution of CZT detector is higher than conventional scintillator, the CZT can be used in application areas, which require moderate energy resolution. Since the electric signals, which are generated in the CZT detector, can be collected directly, the CZT detector has good properties comparing to conventional scintillator. That is, the spatial resolution of CZT detector is higher, and the absorption efficiency of the CZT detector is higher, which offers advantages in real time and lower dose radiation imaging. The development of CZT detector has been progressed in various application areas. The technological problems of CZT detector manufacturing is being solved. At present the availability of high quality CZT crystals may turn out to be a bottle neck in commercial applications. Various investigations have been studied to grow high quality crystal [3,4].

A 3-zone Bridgman furnace dedicated to CZT crystal growing was designed and fabricated at Korea Atomic Energy Research Institute (KAERI). The fabrication process of CZT crystal for radiation spectroscopy and imaging has been developed.

2. Experiment

In this section, we present the progress of the CZT crystal growing.

2.1 3-Zone Bridgman Furnace

A vertical 3-zone Bridgman furnace was designed and fabricated. The high zone was for melting of CZT compound, the middle zone was for condensation of the CZT crystal, and the low zone was for Cd pressurization in the ampule. The temperature controllers were installed in each zone to keep the temperature as we wanted. The ampule could be placed inside the heater, and the ampule could be moved slowly with motor controller. The speed of the ampule inside the furnace was controlled in two modes; one was the high speed mode to install the ampule in the furnace, and the other was the low speed mode to grow the crystal as slow as possible.

The temperature profile inside the furnace was measured after the furnace was installed. A thermocouple was placed inside the furnace and the temperature was measured as the position of the thermocouple was moved. Fig. 1 shows the Bridgman crystal growing furnace, and Fig. 2 shows the temperature profile inside the furnace. As once can see, the flat temperature zone was around 10 cm. The line in Fig. 2 is the designed temperature profile inside the furnace, and the circles in Fig. 2 are the measured temperature profile inside the furnace. As one can see, the measured temperature profile is well matched with the designed profile. Also, when the temperature profile inside the furnace was measured couple of times, and one could find that the temperature profile was stable over time.

Fig. 1 3-Zone Bridgman Furnace for crystal growing

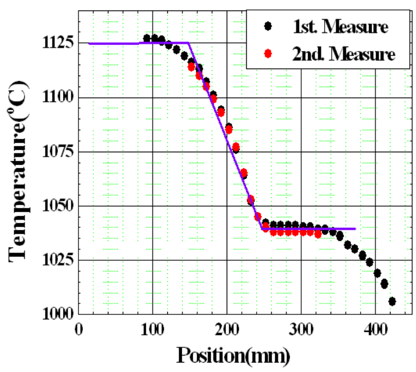

Fig. 2 Temperature profile inside the furnace

2.2 Preparation of Ampule

The ampule was prepared to synthesis and grow the CZT crystal. We used various methods to prepare the ampule. In the first method, the carbon crucible was placed in the quartz ampule and the high purity materials were placed in the carbon crucible. In the second method, the carbon was coated inside the quartz amplue and the materials were placed inside the ampule. Fig. 3 shows the vacuum sealed ampule for crystal growing.

Fig. 3 Vacuum sealed ampule for the crystal growing

2.3 Growing of CZT crystal and Measurement of Crystal Properties

The CZT crystal was grown with Bridgman method. The ampule was placed in high zone and the temperature was increased slowly to melt and synthesize the material. After that, the ampule was moved slowly from the high zone to middle zone. The crystal was grown during the movement from the high zone to middle zone.

The obtained crystal was cut, and prepared for the measurement of the crystal property. The I-V curve and the radiation response of the crystal were measured.

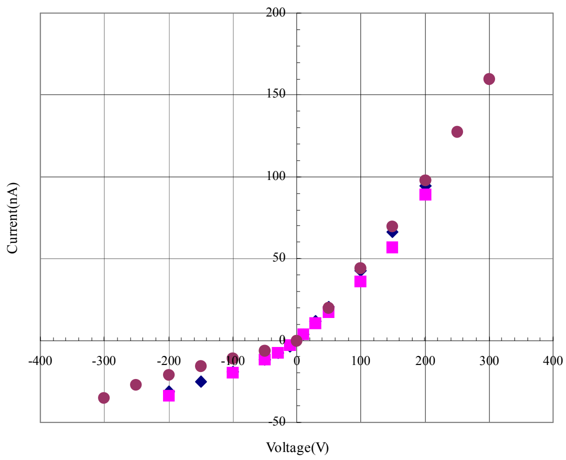

Fig. 4 I-V curve of the CZT crystal

3. Summary

The CZT crystal growing process was investigated at KAERI. The crystal growing furnace was installed and the growing procedure was studied. Various methods were prepared to prepare the vacuum sealed ampule, and the crystal was grown with Bridgman method. The I-V curve and the radiation response was measured with the grown crystal. The optimization to obtain the high quality crystal was underway.

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