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Correlations of Bridgman-Grown $Cd_{0.9}Zn_{0.1}Te$ Properties with Different Ampoule Rotation Schemes

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A unique ampoule rotation system was developed at the Center for Materials Research at Washington State University for enhancing convection in the cadmium zinc telluride (CZT) melt by applying different ampoule rotation schemes (RS). Experiments were performed with different initial charge material concentrations and rotation parameters (acceleration, speed, rotation time, etc.). The applied speed and acceleration ranged from 30 rpm to 50 rpm and 30 rpm^2 to 200 rpm^2, respectively. Zinc (Zn) distribution profiles of radial and axial slices from the same regions in the grown ingot were determined by room-temperature photoluminescence mapping. The results demonstrate the effects of ampoule rotation on Zn segregation and growth interface evolution. The most stable interface propagation was obtained when 0.2 atomic percent (at.%) excess tellurium (Te) was used in the initial charge material along with a trapezoidal RS. Uniform radial Zn distribution was achieved using triangular RS, which is because of the interface flatness near the axis. Comparison of secondary phase (SP) generation for different RS and initial excess Te was performed. Closed-container CZT growth was performed using the trapezoidal RS, which resulted in high single-crystal yield with lower-diameter SP near the last-to-freeze region. High-resistivity (on the order of 10^{10} Ω-cm) crystals were obtained from all the RS. The mobility–lifetime product $(\mu\tau)_e$ of electrons for planar detectors was found to be on the order of 3×10^{-3} cm^2/V to 5×10^{-3} cm^2/V for all the RS with 3.5 at.% excess Te growths.

Key words: CZT, vertical Bridgman growth, ACRT, zinc segregation, photoluminescence studies, tellurium secondary phase

INTRODUCTION

Over the last few decades, cadmium zinc telluride (CZT) has emerged as a suitable material for detection of soft γ-rays and hard x-rays at room temperature with high detection efficiency and sharp energy resolution. Due to its high material density (5.78 g/cm^3), average atomic number (49.1), and wide bandgap (1.57 eV with 10% Zn),[1] CZT has high stopping power and low thermal noise, which makes it an excellent choice as a radiation detector at room temperature. Its high photorefractive coefficient and infrared (IR) transmittance make CZT an excellent substrate for IR windows in IR cameras and other devices. Stable and linear detection operability at body temperature and high spatial resolution allow CZT to be used in digital radiography and nuclear medicine detectors.[2]

The vertical Bridgman technique is one of the commonly used melt growth processes employed for bulk production of CZT crystals. There are, however, several critical issues regarding melt growth of CZT which render it unsuitable and limit its cost-effectiveness for the mentioned applications. Due to the unusual thermophysical properties of CZT, i.e., high melt viscosity (4.5×10^{-3} cm^2/s) and low melt thermal conductivity (1.085×10^{-2} W/cm-K), the

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