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Effects of H_2 Atmosphere Annealing on the Properties of CZT:In Single Crystals

P.F. YU[1,2,3] and W.Q. JIE[2]

1.—School of Materials Science and Engineering, Chang'an University, Xi'an 710061, China. 2.—State Key Laboratory of Solidification Processing, Northwestern Polytechnical University, Xi'an 710072, China. 3.—e-mail: yupengfei@chd.edu.cn

To improve crystal quality and detector performance, high-resistivity cadmium zinc telluride (CZT):In single crystals were annealed in H_2. The concentration of Te inclusions did not change after annealing. Both the resistivity and infrared transmittance increased as the annealing time increased, indicating improvement of crystal quality. Because of the passivation by hydrogen, some interesting phenomena were observed in the photoluminescence spectra of as-grown and annealed CZT:In crystals. Moreover, the energy resolution was remarkably enhanced. After 4 h, 8 h, and 12 h of annealing, the energy resolution was improved 33%, 79%, and 49%, respectively. The crystal annealed for 8 h with energy resolution of 9.29% had the best detector performance.

Key words: CdZnTe:In, resistivity, IR transmittance, PL spectrum, radiation detector

INTRODUCTION

Cadmium zinc telluride (CZT) is an important wide-bandgap II–VI compound semiconductor, being widely used for x-ray fluorescence analysis, security inspection, medical imaging, and astronomy investigation.[1–4] This is due to several important properties of these materials including large absorption coefficient, low bias voltage requirement, and room-temperature operation.[5] Recently, CZT:In crystal has attracted much attention due to its applications in nuclear radiation detection.[6]

As is well known, the defect levels in materials play an important role in reducing the lifetime of minority carriers, and consequently they affect the efficiency of the device. The origin of the defect levels in CdTe or CZT crystals is related to impurities or native defects.[7] Currently, there is extensive interest in crystalline semiconductors because of the ability of atomic hydrogen to passivate the electrical activity of dangling or defective bonds.[8,9] Introduction of atomic hydrogen into semiconductors can significantly change the electrical and optical properties of the materials. So far, hydrogenation studies have mainly focused on Si[10] and GaAs,[11] while not much research has been done on CdTe[7] or CZT.[12] The methods of hydrogenation are usually hydrogen plasma[13] and ion implantation.[14] The function of the hydrogen atoms is to improve the crystal quality. However, hydrogen plasma and ion implantation will destroy the surface of crystals. The detector performance of CdTe and CZT crystals is significant due to their crystal quality. Therefore, development of an appropriate nondestructive method which can introduce atomic hydrogen is very important for CdTe or CZT crystals. Postgrowth annealing is considered to be a good prospective approach to improve crystal quality and achieve high-performance devices. However, hydrogenation of CZT crystals by annealing has not been studied yet.

In this work, high-resistivity CZT:In single crystals were annealed in H_2. The aim was to introduce atomic hydrogen to improve crystal quality. The effects of the annealing time on the properties of the CZT:In crystals were investigated, and the performance of CZT:In detectors was also measured before and after annealing.

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