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Study of the physical properties of Bi doped CdTe thin films deposited by close space vapour transport

O. Vigil-Galán [a], E. Sánchez-Meza [a], J. Sastré-Hernández [a], F. Cruz-Gandarilla [a], E. Marín [b,*], G. Contreras-Puente [a], E. Saucedo [c], C.M. Ruiz [c], M. Tufiño-Velázquez [a], A. Calderón [b]

[a] *Escuela Superior de Física y Matemáticas, Instituto Politécnico Nacional, 07738 México, D. F., Mexico*
[b] *Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada, Instituto Politécnico Nacional, 11500 México, D. F., Mexico*
[c] *Departamento de Física de Materiales, Universidad Autónoma de Madrid, 28049 Madrid, Spain*

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Abstract

Bi doped cadmium telluride (CdTe:Bi) thin films were grown on glass-substrates by the close space vapour transport method. CdTe:Bi crystals grown by the vertical Bridgman method, varying the nominal Bi concentration in the range between 1×10^{17} and 8×10^{18} cm^{-3}, were used in powder form for CdTe:Bi thin film deposition. Dark conductivity and photoconductivity measurements in the 90–300 K temperature range and determination by photoacoustic spectroscopy of the optical-absorption coefficient of the films in the 1.0 to 2.4 eV spectral region were carried out. The influence of Bi doping levels upon the intergrain barrier height and other associated grain boundary parameters of the polycrystalline CdTe:Bi thin films were determined from electrical, optical and morphological characterization.

Keywords: Close space vapour transport; Cadmium telluride; Photoconductivity; Photoacoustic spectroscopy; Doping

1. Introduction

CdTe thin films are one of the most promising materials in terrestrial and space solar cell applications. Recently it was reported that an energy conversion efficiency world record for CdTe thin films solar cells was 16.5% [1]. It is worthy of attention that this efficiency record, as well as the 19.2% for $CuInGaSe_2$ [2], reported for all thin film polycrystalline solar cells, is comparable with those reported for single crystal solar cells like single and polycrystalline Si. Bosio et al. [3] have tried to explain this record in terms of the self-passivation by considering the segregation of an insulating material which prevents the recombination of the photo-generated carriers in CdS/CdTe solar cells. Ulterior higher efficiencies can be obtained if some aspects concerning the technology of the growth processes and the improvement of the physical properties of the thin film device are resolved.

One of the physical properties that must be improved is the resistivity of the CdTe absorber film. In general, as-grown CdTe thin films have a high electrical resistivity, with a slight p-type conductivity due to stoichiometric defects (Cd vacancies) acting like acceptor centres. In order to decrease the resistivity, CdTe doping with elements like Sb [4] or Te [5] has been achieved. We have demonstrated that it is possible to obtain CdTe:Bi thin films with resistivity values lower than those corresponding to the undoped ones for Bi concentrations of about 1×10^{18} cm^{-3} [6].

For the study of the evolution of majority carrier concentration in CdTe:Bi films, the use of experimental techniques like Hall effect may not be adequate, specially for high resistivity samples. On the other hand, due to the polycrystalline structure of the films, changes in the grain boundary barrier height can be produced by modifying the trap level density in the grain boundaries through the incorporation of appropriate impurities in the CdTe host. Furthermore, if Bi is an effective impurity inside the grains, the transport mechanism of the majority carriers must be varied through the change of the conductivity due either to the doping process inside of the grains or the

* Corresponding author.
E-mail address: emarin63@yahoo.es (E. Marín).

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