

Influence of the thiourea/CdCl₂ concentration ratio used for the chemical bath deposition of CdS thin films, upon the CdS/CdTe interface recombination velocity in CdTe/CdS/glass structures.

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In this work we study the influence of the thiourea/CdCl₂ concentration ratio used for the chemical bath deposition of CdS thin films on glass substrates, upon the CdS/CdTe interface recombination velocity in CdTe/CdS/glass structures, where the CdTe layer was grown on the CdS thin film by close space vapor deposition (CSVT)-hot wall technique. The interface recombination velocity was measured by means of the photoacoustic (PA) technique in a heat transmission configuration, in which minority carriers are photoexcited at the CdTe layer after illumination through the substrate and the CdS thin film. For data processing, a theoretical model was developed for the generation of the PA signal. We show a reduction in the value of the recombination velocity respecting those obtained for samples where CdS was grown by CSVT, and we observe that a minimal value appears for a thiourea/CdCl₂ ratio in the CdS deposition solution equal to 5. These results show a good correlation with those of electrical measurements performed in solar cell devices. © 2010 American Institute of Physics. [doi:10.1063/1.3431534]

I. INTRODUCTION

Among the factors limiting the conversion efficiency of CdS/CdTe solar cells we can mention three, namely: (1) the short circuit current density (J_{cc}), (2) the open circuit voltage (V_{oc}), and (3) the fill factor (FF). For example, the V_{oc} value of these cells is saturated at 850 mV, which is well below the potential corresponding to the CdTe band gap energy (E_g) of 1.5 eV and the V_{oc}/E_g ratio for the homojunction solar cells is, in general, higher than that of the heterojunctions based devices. Thus, further improvement in this parameter will be only possible by better understanding of the factors limiting it.

For heterojunction devices with high defective interface, the recombination current is increased and consequently the dark current, leading to lower values of V_{oc} . The interface properties change in dependence with the technology employed for the fabrication of the solar cells. For example, CdS thin films used as a window material in CdS/CdTe solar cells can be grown by different deposition methods like chemical bath deposition (CBD) and close space vapor transport (CSVT). Among them, the CBD method gives excellent results for photovoltaic applications, as has been demonstrated elsewhere.¹ Vigil-Galán *et al.*² have recently demonstrated that the CdS/CdTe solar cells parameters are improved for devices fabricated with different thiourea/CdCl₂ concentration ratio, r , in the CBD solution. Although several aspects related to the CdS-CBD films and CdS/CdTe device properties have been analyzed before for different values of r ,³ a quantitative characterization of the CdS/CdTe interface behavior, and in particular, the measurement of the interface

recombination velocity (S), has not been made before. This is an aspect of great importance because it is well known that an increase in the value of this parameter affects the device efficiency and its lifetime.

For the measurement of S we resorted to the use of the photoacoustic (PA) technique.⁴ It is a method that does not require special sample's preparation and is based on the generation of heat inside the sample as a consequence of the absorption of periodically modulated light. In the case of semiconductors the PA signal depends on the nonradiative (nr) recombination processes taking place following the photoexcitation of minority electron-hole pairs (EHPs), which are connected, among other physical parameters, with the recombination velocity. Although other methods can be used for the evaluation of this parameter, and several theoretical and experimental studies have been reported⁵⁻⁸ about the interface recombination velocity in CdS/CdTe solar cells, they show several limitations when compared with the PA technique. While electrical techniques are in general destructive or need special preparation of samples to make convincing measurements, for example by electrical contact deposition and thermal treatments, optical techniques such as photoluminescence give in general only qualitative information about semiconductor material quality. The PA technique has been applied before by several authors for the measurement of the recombination velocity in different systems, as reviewed recently by Marín *et al.*⁹ But because a model for the PA signal generation in the system CdTe/CdS/glass is not available yet, part of the present work is devoted to the development of such a model, that takes into account the heat generated by recombination of the minority carriers that are photoexcited in the CdTe layer after illumination through the substrate and the CdS thin film.

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