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IBIC analysis of CdTe/CdS solar cells

E. Colombo [a,b], A. Bosio [c], S. Calusi [a,d], L. Giuntini [d], A. Lo Giudice [a,b], C. Manfredotti [a,b], M. Massi [d], P. Olivero [a,b], A. Romeo [e], N. Romeo [c], E. Vittone [a,b,*]

[a] INFN, Sezione di Torino, via P. Giuria 1, 10125 Torino, Italy
[b] Experimental Physics Dept. and NIS Excellence Centre, University of Torino, via P. Giuria 1, 10125 Torino, Italy
[c] Physics Department, University of Parma, v.le G.P. Usberti 7/A, 43100 Parma, Italy
[d] Physics Dept., University of Firenze and INFN Sezione di Firenze, Via Sansone 1, 50019 Sesto Fiorentino, Firenze, Italy
[e] Science and Technology Dept., University of Verona, Ca Vignal 2, Strada Grazie 15, I-37134, Verona, Italy

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ABSTRACT

This paper reports on the investigation of the electronic properties of a thin film CdS/CdTe solar cell with the Ion Beam Induced Charge (IBIC) technique. The device under test is a thin film (total thickness around 10 μm) multilayer heterojunction solar cell, displaying an efficiency of 14% under AM1.5 illumination conditions. The IBIC measurements were carried out using focused 3.150 MeV He ions raster scanned onto the surface of the back electrode. The charge collection efficiency (CCE) maps show inhomogeneous response of the cell to be attributed to the polycrystalline nature of the CdTe bulk material.

Finally, the evolution of the IBIC signal versus the ion fluence was studied in order to evaluate the radiation hardness of the CdS/CdTe solar cells in a view of their use in solar modules for space applications.

1. Introduction

Thin film solar cells have the great advantage of being much easier to produce in comparison to crystalline silicon solar cells, giving a very high throughput with halved crystallization temperatures and monolithical interconnection.

In particular CdTe is particularly suitable for industrial mass production since it grows stoichiometrically with substrate temperatures above 250 °C and can be successfully deposited with a large variety of techniques such as vacuum evaporation (VE), close space sublimation (CSS), vapor transport deposition (VTD), RF-sputtering, electro-deposition, screen printing, etc. [1].

CdTe bandgap of 1.45 eV is very near to the theoretical maximum conversion efficiency (31%), while open circuit voltage and short circuit current are maximized. These substantial advantages have been proven by the impressive increase of CdTe photovoltaic modules production from a few MW in 2003 up to over 1 GW in 2008 with constantly decreasing production costs. Moreover, it has been shown that CdTe has the highest stability under proton and electron irradiation compared to the other photovoltaic devices, which makes CdTe cells very promising for space applications [2].

The CdTe solar cells are structured in four different sections [1]. The front contact, which is the first layer deposited directly on the glass substrate, consisting of a transparent conducting oxide (TCO), typically indium tin oxide (ITO) or tin oxide doped with fluorine (FTO); the CdS (also known as window layer), which is the n-type semiconductor of the junction and has to be optically transparent in order to allow the absorber to convert all the light spectrum; the CdTe, which has the double function of absorbing the light (giving place to the electron–hole pair generation) and to be the p-type semiconductor of the junction. Due to the high absorption coefficient of CdTe for photons in the visible range, the thickness of this layer is usually less than 10 μm. Finally, the back contact is typically a metal/metal or semiconductor/metal bi-layer.

In this paper we present the first IBIC characterisation of such thin film solar cell. The first motivation of this research is to demonstrate the feasibility of the IBIC technique to investigate the electronic properties of such thin film devices and to map their charge collection efficiency. The material is in fact polycrystalline and carrier traps and the electric field associated with grain boundaries will affect the motion of the carrier excess in the CdTe layer. With respect to other studies carried out with electron beam induced current measurements (EBIC) [3], the novelty of the use of ener-

* Corresponding author. Address: INFN, Sezione di Torino, via P. Giuria 1, 10125 Torino, Italy.
E-mail address: vittone@t.infn.it (E. Vittone).

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