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Influence of Annealing time for spray coated CdCl2 on CdS/CdTe thin-film solar cells

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Abstract

Background: CdS/CdTe thin film solar cell is a cost-efficient and reliable photovoltaic device with reported power conversion efficiencies of over 22 %. Moreover, large-scale CdS/CdTe thin film solar panels have been manufactured by the First Solar Company with panel efficiency of over 18%. Although scaling up and manufacturing have been successfully established in the industry, a scientific understanding of material and device physics is needed for further improvement of the efficiency and stability of CdS/CdTe thin film solar cells. The post-annealing of $CdCl_2$ treatment is one of the key factors for enhancing the device performance via improving the electrical properties of the absorber and the intermixing of the CdS/CdTe layers.

Methods and Redults: In this work, the effect of post-annealing time of $CdCl_2$ spray-coated CdS/CdTe devices was analyzed with varying annealing time from 5 min to 30 min at the temperature of 400 ℃ in an N_2 environment. For the device fabrication, the n-CdS window layer was fabricated by the Chemical Bath Deposition (CBD) method on a cleaned FTO substrate, and then the p-CdTe absorber layer was deposited by thermal evaporation on top of the CdS layer at a substrate temperature of 450 ℃. A $CdCl_2$ treatment was followed on the CdTe layer through spray pyrolysis at 400 ℃ and annealing was carried out at different time intervals of 5 min, 10 min, 15 min, 20min, and 30 min. The UV-Visible spectroscopic studies confirmed that the sufficiently thin enough films with less optical absorption, having an energy band gap of 2.49 eV of n-CdS window layer was fabricated. The XRD and AFM analysis confirmed the presence of each layer and the homogeneous well-adhered nature, respectively. Finally Cu/Au back contacts were thermally evaporated on $CdCl_2$ treated CdS/CdTe film to measure the photovoltaic performance of $CdCl_2$ treated CdS/CdTe device. The fabricated solar cells were characterized by a Peccell measurement unit under illuminations of 100 mW/cm^2 (1 sun) with air mass (AM) 1.5 filter.

Conclusions: This study suggests that the photovoltaic performance of the device and the structural and optical properties of CdS and CdTe thin film as well as its composition also affected by the annealing time of $CdCl_2$ treated CdS/CdTe devices. The photovoltaic device with optimized efficiency of 4.70 % was obtained for the annealing time of 10 minutes with J_{SC}, $V_{OC,}$ and FF of 16.20 mA cm^{-2}, 0.65 V, and 0.45, respectively.

Keywords: CdS/CdTe Thin-film solar cells, Post-annealing $CdCl_2$ treatment

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