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The influence of substrates on the device performance of the TCO/CBD-CdS/ ED-CdTe and TCO/CBD-CdS/CSS-CdTe solar cells

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The development of cost-effective efficient photovoltaic cells is crucial for generating electricity with the most abundant solar energy to eliminate the energy crisis globally. At present, there is a growing interest in CdS/CdTe solar cells due to minimal material cost and easy and cost-effective methods of thin film deposition. The aim of this work is to investigate the influence of different transparent conducting oxide (TCO) substrates in superstrate configuration (glass/ITO:5 Ω/sq, glass/FTO:13 Ω/sq, and glass/FTO:7 Ω/sq) on the device performance of CdS/CdTe solar cells. Herein, chemical bath deposited CdS (CBD-CdS) layers were grown using 0.0333 mol/L $Cd(CH_3COO)_2$, 0.0667 mol/L $CS(NH_2)_2$, concentrated NH_4OH and 1.0 mol/L $NH_4(CH_3COO)$ at 90 ℃ for 55 min. Subsequently, the CdTe layers were deposited using electrodeposition (ED) and close spaced sublimation (CSS) techniques as required. For electrodeposition of CdTe layers, $CdSO_4$ (1.0 mol/L) and TeO_2 (1.0 mmol/L) precursors were used at pH of 2.3 and 65 ℃ and deposition was run for 3 hrs. The CSS-CdTe layers were developed by maintaining the substrate and source temperature at 580 °C and 640 °C, respectively, and the deposition proceeded for 25 min. at 7.9 Torr. The glass/TCO/CBD-CdS/ED-CdTe samples were treated with $CdCl_2$, and glass/TCO/CBD-CdS/CSS-CdTe were undergone NP etching as suitable post-deposition treatments. The device fabrication was completed with the back contact formation (Cu/Au). The devices; glass/TCO/CBD-CdS/ED-CdTe/Cu/Au and glass/TCO/CBD-CdS/CSS-CdTe/Cu/Au prepared with FTO:13 Ω/sq delivered the highest efficiency of 5.7% (J_{SC} = 19.2 mA/cm^2, V_{OC} = 0.672 V, FF = 44%) and 8.6% (J_{SC} = 30.3 mA/cm^2, V_{OC} = 0.606 V, FF = 47%), respectively while the cells prepared with glass/ITO:5 Ω/sq delivered the lowest efficiency. Hence, the glass/FTO:13 Ω/sq substrate was recognized as the most appropriate substrate for the fabrication of CBD-CdS/ED-CdTe and CBD-CdS/CSS-CdTe solar cells. The resultant optical transmittance (over 80%, above 500 nm) and surface roughness (RMS roughness of bare FTO:13 Ω/sq was 12.49 nm, and FTO:13 Ω/sq/CBD-CdS was 10.15 nm) of CBD-CdS further confirmed the suitability aptness of the glass/FTO:13 Ω/sq substrate in CdS/CdTe based solar cell fabrication.

Keywords: Chemical bath deposition, Electrodeposition, Close spaced sublimation, TCO substrate, Surface roughness

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