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Introducing an ED-CdTe nucleation layer on the CBD-CdS layer in solar cell fabrication

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Developing a cost-effective and efficient thin-film CdS/CdTe solar is vital in resolving the energy crisis in the world. In the fabrication of solar cells, the weak interlayer contact caused by the voids between the window and the absorber layer adversely affected the performance of the device. This study explores the effectiveness of introducing an intermediate ultra-thin CdTe nucleation layer on reducing the Te diffusion into CdS and recombination effect to mitigate layer mismatch between the window and the absorber layer. Herein, the CdS layer was grown on the glass/FTO substrates which were subjected to prior chemical and plasma cleaning processes. In CdS deposition, $Cd(CH_3COO)_2$ (0.033 mol/L), $CS(NH_2)_2$ (0.667 mol/L) were utilized as cadmium and sulfur precursors while $CH_3CO_2NH_4$ (1.0 mol/L) and NH_4OH (25%) were used to adjust the pH in the bath at 90 °C. The deposited glass/FTO/CBD-CdS samples were sonicated and dried with N_2 flow. Next, an ultrathin CdTe nucleation layer was electrodeposited in an electrolyte containing 1.0 mol/mL $CdSO_4$ and 1.0 mmol/mL TeO_2 in pH 2.3 at 65 °C for 40 s on the glass/FTO/CBD-CdS. Herein, the graphite sheet (counter electrode), saturated calomel electrode (reference electrode) and glass/FTO/CdS substrate (working electrode) were used at a cathodic deposition potential of -650 mV with respect to the SCE.

The optical property analysis revealed that the energy band gap of the glass/FTO/CBD-CdS and glass/FTO/CBD-CdS/ED-CdTe declined from 2.39 eV to 2.37 eV and their optical transmittance is over 80% in the wavelength ranges of 520-900 nm and 535-900 nm, respectively, in the devices. Therefore, there is no adverse effect of the ED-CdTe nucleation layer on light absorption by the window layer. The miniature shrinkage of the band gap might arise due to Te diffusion into the CdS layer. The SEM cross-sectional analysis uncovered that the thickness of the CBD-CdS/ED-CdTe bilayer was ~102 nm, and further, there is no distinguishable boundary between the ED-CdTe layer and CBD-CdS layer. No drastic change in surface roughness was detected between CBD-CdS/ED-CdTe and CBD-CdS. The SEM and AFM imaging further evidenced the improved uniformity of the surface layer upon deposition of the nucleation layer. Hence, the well packed ultra-thin ED-CdTe layer developed on glass/FTO/CBD-CdS substrate facilitates the growth of the CdTe absorber layer while minimizing the possible degradation or contamination of the CdS layer underneath upon exposure to high-temperature deposition by the close-spaced sublimation of CdTe.

Keywords: CdS/CdTe solar cell, Chemical bath deposition, Electrodeposition, Nucleation layer, Surface roughness.

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