Investigation of the Role of Oxygen in Close-Spaced Sublimated CdS Layer for Enhancing the Efficiency of CdS/CdTe Thin Film Solar Cells

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As an alternative to silicon solar cells, polycrystalline thin-film heterojunction solar cells stand out due to their promising efficiencies and low manufacturing cost. In CdS/CdTe thin film solar cells, cadmium telluride (CdTe) is employed as the absorber material and cadmium sulfide (CdS) is used as the window material. In this work, the close-spaced sublimation (CSS) method was used to deposit a CdS window layer. We have conducted a comprehensive study of oxygen incorporation into the CSS CdS window layer to enhance the efficiency of CSS CdS/CdTe thin film solar cells. UV-visible spectroscopy was used for the optical characterization of the CdS layer, and a solar simulator was employed to study the current-voltage characteristics of the CSS CdS/CdTe solar cell. The optimum bandgap of 2.44 eV was obtained for the CdS films incorporating 20% O_2 with Ar ambient and the films thicknesses were maintained around 220 nm. Bandgap values tend to increase with the increase in O_2 concentration. Also, according to the SEM and EDX analysis, 20% O_2 concentration revealed the highest oxygen incorporation with a denser microstructure. Oxygen diffusion into the CdS crystal structure is expected to substantially affect the films' crystallite size, lattice strain, and dislocation densities. The highest average efficiency of 13.8% with an open-circuit voltage (V_{OC}) of 717 mV, a short circuit current (J_{SC}) of 34 mA/cm^2, and a fill factor (FF) of 52% was obtained for the dot cells with an area of 0.12 cm^2, comprising CSS-deposited CdS layer incorporating 20% of oxygen under the AM 1.5 illumination.

Keywords: CdS window layer, CdS/CdTe solar cell, Close-spaced sublimation, O_2 incorporation.

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