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Optimization of processing temperature of medium vacuum thermally evaporated CdS thin-films for CdTe solar cells

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Cadmium sulfide (CdS) is a wide bandgap (~2.42 eV) semiconductor material in group II – VI, which is commonly used in photonic devices due to their superior electrical and optical properties. One of the industrially applicable deposition techniques for the CdS layers is thermal evaporation, and medium vacuum systems are the most reliable among the vacuum levels. This study discusses the optimization of processing temperatures for CdS deposition under medium vacuum. CdS thin films were deposited using the thermal evaporation technique on fluorine-doped tin oxide (FTO) substrates. Substrates were cleaned using both standard chemical cleaning procedures and argon plasma. The chamber of the thermal evaporator was vacuumed to 2×10^{-4} Torr and maintained with 6 % oxygen flow in an argon atmosphere. The substrate temperature was varied from 100 °C to 300 °C in steps of 50 °C while maintaining the source temperature at 525 °C. The substrate holder was rotated at 2.5 rpm for uniform films. In situ thicknesses were measured using the Inficon SQM-160 Rate/Thickness Monitor and maintained at 250 nm. The thin films were then annealed at 450 °C for 30 minutes under 10 Torr. The above procedure was then repeated by varying the source temperature from 475 °C to 575 °C in steps of 25 °C while maintaining the substrate temperature at 150 °C. The optical properties, surface morphology and structure of the deposited thin films were analyzed using UV-Visible spectrometry, SEM and GIXRD. For electrical characterizations, CdS/CdTe/Cu/Au solar cells were fabricated by depositing a CSS – CdTe layer on top of CdS, followed by Cu and Au layers on the NP etched CdTe. The highest efficiency of 5.9 % was obtained for the substrate and source temperatures of 150 °C and 500 °C respectively. The optimum substrate and source temperature to deposit the CdS layer were found as 150 °C and 500 °C, respectively.

Keywords: CdS, Medium vacuum, Processing temperatures, Thermal evaporation.