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Effect of substrate temperature variation on opto-electronic properties of thermally evaporated CdS thin films

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Cadmium sulfide (CdS) is a II-VI group semiconducting material which has been thoroughly investigated due to its superior optical and electrical properties that can be applicable in wide range of semiconductor devices including photonic devices. Due to its direct and wide bandgap (~ 2.42 eV), it is vastly used as the window layer in heterojunction thin film solar cells. Compared to other deposition methods such as electrodeposition, spray pyrolysis, chemical bath deposition; thermal evaporation is an attractive method of deposition due to its high deposition rate, low cost of operation, low material consumption, minimum number of impurities and straight-line propagation of vapors. In the present study, CdS thin films were deposited on cleaned FTO glass substrates using thermal evaporation technique at substrate temperatures ranging from 50 to 250 °C at a pressure of 2×10^{-5} torr. Deposition was carried out using CdS powder (Sigma-Aldrich, 99.995%) using an alumina boat. Deposited samples were then annealed at 300 °C for 30 minutes in vacuum (pressure of 3×10^{-5} torr). Structural, optical and electrical properties of annealed CdS thin films were studied by employing X-ray diffraction, UV-Vis spectrometry, I-V measurements and capacitance vs. voltage measurements. All the electrical characterizations were carried out using a photoelectrochemical cell of (CdS/0.1 M $Na_2S_2O_3$/Pt). The XRD analysis shows all the grown films are preferably oriented in the direction of (002) of hexagonal CdS. The optical band gap values were found to increase with increasing substrate temperature from 50 to 175 °C. I_{SC} and V_{OC} values of (CdS/0.1 M $Na_2S_2O_3$/Pt) cell were also found to increase up to the substrate temperature of 175 °C. The observed highest I_{SC} and V_{OC} values were 37.24 µA and 314.9 mV respectively. Results indicate that the CdS thin films deposited at the substrate temperature of 175 °C has yielded the best optical and electrical properties compared to the films grown at other substrate temperatures.

Keywords: Cadmium sulfide, Substrate temperature, Thermal evaporation, XRD

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