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THE PHYSICAL CHARACTERISTICS OF CADMIUM BASED THIN FILMS

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DECLARATION

I hereby declare that the work reported in this thesis is my own unless specified and duly acknowledged by quotation.

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ABSTRACT

Alternative fuel sources has been the focus of much attention due to the expected shortage of fossil fuels by the turn of the century. Among the more promising sources of energy being commercially developed, solar power has been proven to be a prospective choice for providing energy into the future. It has the advantage of having an infinite source of energy from the sun and does not require mechanical or moving components such as turbines and generators in its design of energy output thus a lower maintenance and running cost. The area of solar energy coatings is of prime interest in this study.

The main objective of this research is to study the possibility of enhancing the solar cell performance by fabricating a **ternary compound** thin film coating $CdTe_XSe_{1-X}$ from two established binary compounds which are cadmium telluride (CdTe) and cadmium selenide (CdSe). It is predicted that this ternary compound would have an energy gap in between that of CdTe(1.45eV) and CdSe(1.74eV) that would better match the peak of the solar radiation spectra (1.5-1.55eV). This ternary compound would generally yield a more efficient solar cell if the energy gap is altered in such a manner.

Another objective here is to study the possibility of utilising **waste silicon wafers** from local industries. These wafers could be used as substrates on which the solar coatings can be made and hence a commercial possibility.

The individual components of CdTe and CdSe were first fabricated and studied individually so that a comparative study could be done with the ternary compound $CdTe_XSe_{1-X}$ using identical deposition and characterisation parameters. It was also important to take this initial step to verify the accuracy and composition of the electrodeposited and sputtered films. The characterisation techniques used were x-ray diffraction, energy dispersive analysis of x-rays and UV/VIS spectrometry. The emphasis on sample preparation was mainly on

electrodeposition as it is a low temperature process and is generally cost effective due to minimal material wastage and low power consumption but yet has the capability to yield solar coatings of good quality.

Cadmium telluride (CdTe) films were successfully electrodeposited on silicon and ITO substrates at a deposition voltage of 0.67V using a copper counter electrode. The electrolytic bath consisted of $CdCl_2$ or $CdSO_4$ (0.3M), TeO_2 (1mM) and EDTA (15mM). To eliminate the formation of copper on the film, it was found that there was a necessity to exchange the copper electrodes at five minute intervals and to minimise the deposition times as much as possible. All depositions were done in a stirred bath at a constant temperature of 57^0C as a more uniform and adhesive coating was formed. CdTe was also sputtered on silicon for the purpose of comparing its current voltage (I-V) characteristics with electrodeposited films. The XRD and EDX characterisation studies revealed an accurate deposition for both the films. The optical analysis also revealed values of the energy gap and refractive index to be very close to theoretical values. The studies on the I-V curve revealed that the sputtered film had only a marginal advantage in terms of cell performance. The electrodeposited technique could therefore be said to produce solar cells of comparable performance.

The same procedure was repeated for the fabrication of CdSe using a voltage of 0.65V. The electrolytic bath consisted of the same components with SeO_2 (0.9mM) replacing TeO_2. CdSe was also sputtered on silicon and glass for characterisation purposes. Films of electrodeposited and sputtered CdSe was subjected to material and optical characterisation studies and were found to be accurate in terms of composition and had close to theoretically specified values. This had confirmed that the techniques used were reliable and could fabricate thin films accurately. The I-V characteristic curve revealed a marginal advantage of sputtered films over those electrodeposited. On the whole, the I-V performance was less than that of CdTe films which have an energy gap closer to the peak radiation energy of the sun.

The ternary compound $CdTe_XSe_{1-X}$ was electrodeposited from an electrolyte containing $CdCl_2$ (0.3M), SeO_2 (0.45mM), TeO_2 (0.5mM) and EDTA (15mM). The depositions were done on silicon and ITO at 0.67V with copper counter electrodes. The electrolytic bath was constantly stirred and kept at a temperature of 57^0C. The value of X in the ternary compound formula was varied successfully by changing the volume of the components in the electrolyte. The ternary compound was also prepared by sputtering using a 50-50% mixture of CdTe and CdSe granules of 99.99% purity. The XRD spectra of both the electrodeposited and sputtered films revealed emergence of a new peak at 24.5^0 (2θ)(the lattice spacing, d=3.63Å) which lies in between CdTe (23.68^0) and CdSe (25.4^0). This fact is of great interest as it shows a successful deposition of a new phase polycrystalline ternary compound.

The I-V characteristics of $CdTe_XSe_{1-X}$ films showed improved solar cell performances when compared to films of CdTe and CdSe deposited by similar methods. The best solar films obtained by electrodeposition was of the composition of $CdTe_{0.75}Se_{0.25}$.

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