Fabrication and Optical Constants of CdMnS Ternary Thin Films Deposited by Chemical Bath.

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ABSTRACT

Thin CdMnS films were deposited from chemical baths on glass substrates using aqueous conc. Ammonia as a complexing agent. The baths were kept under uniform temperature in an electric oven for periods of 30 and 60 minutes ranging between 70^0 and 90^0C. The deposited thin films were characterized with Spectro UV-VIS RS spectrophotometers. The thin films showed moderate transmittance (<75%) in the VIS-NIR regions. All the films show peak refractive index of 2.28 and direct transition energy band gaps of 1.40-1.65eV. The characterization revealed that CdMnS thin films are potential materials for solar cell absorbers, anti-dazzling coating of eyeglasses, and for construction of poultry houses.

(Keywords: CBD, chemical bath deposition, deposition technique, thin films, ternary compounds)

INTRODUCTION

The chemical bath deposition (CBD) technique has been in use for the deposition of both binary and ternary compounds. Ternary chalcogenide thin films have their possible applications in solar cells, light emitting diodes (LEDs), and non-linear optical devices [8, 4, 6]. Some ternary compounds have been investigated for application as layers for photovoltaic application [7] and for efficient energy conversion through photochemical solar cells [9, 10] and potential coatings for poultry houses [2]. In this work we try to extend the chemical bath deposition technique to prepare CdMnS thin films.

The optical properties investigated include: absorbance (A) and transmittance (T), which were used to estimate other film parameters such as refractive index (n), extinction coefficient (k), dielectric constant (ε), and optical conductivity (σ_0). The determination of these optical properties and the energy band gap were based upon relations found in literature [3].

EXPERIMENTAL PROTOCOL

The preparation of CdMnS thin films on glass slides was carried out using the chemical bath deposition process. The glass slides were previously degreased in nitric acid for 48 hours [4, 2], washed in cold water with detergent, rinsed with distilled water, and dried in air. The nitric acid treatment caused the oxidation of the halide ions on the glass slides used as substrates, thereby introducing functional groups called nucleation and or epitaxial centers on which CdMns film was grafted. The degreased, clean surfaces have an advantage of providing nucleation centers for the growth of the films, hence yielding adhesive and uniformly deposited films [1].

To form CdMnS thin films, the reaction bath contained 10ml of 1M cadmium chloride, 2ml of 1M manganese chloride, 6ml of 1M conc. Ammonia, 15ml of 1M thiourea (NH_2CSNH_2), and 37ml of distilled water to make up the mixture. All these were thoroughly mixed and stirred with a glass rod. The uniform baths were deposited at varying temperature and deposition time.

During the deposition, cations and anions, which are both in the solution, react with each other and become neutral with atoms precipitating either spontaneously or very slowly in the bath. Fast precipitation implies that a thin film cannot form on the substrates immersed in the solution. But the presence of ammonia as the complexing agent slows down the precipitation process and enhances the formation of CdMnS thin films. These deposited films were then characterized using a spectro UV-VIS RS spectrophotometer.

RESULTS AND DISCUSSIONS

All of the films deposited appeared yellowish in color. The spectral absorbance and transmittance of the CdMnS films are displayed in Figure 1 and Figure 2, respectively. Samples C1 and C2 exhibited moderate transmittance of over 52% 800-900nm. Samples C6, C7, and C10 have low transmittance while sample C8 transmits weekly (18%) at 500nm and strongly (74%) 900nm.

Samples C1, C2, C3 and C10 with moderate transmittance can be used as solar cell while sample C8 with high transmittance (>74%) in the VIS-NIR region is a good material for construction of poultry roofs and walls and for coating eyeglasses [1]. All the films exhibit over 20% reflectance between 200-300nmm and low reflectance in the visible region of the electromagnetic spectrum.

The variation of refractive index (n) with photon energy ($h\nu$) for samples of CdMnS thin films is given in Figure 4. All the films exhibited peak maximum refractive index of 2.28.

The variation of extinction coefficient (k) with $h\nu$ is shown in Figure 5. The peak values of the extinction coefficient k ranged between 60.84×10^{-3} and 88.32×10^{-3}.

Plots of optical conductivity σ_0 against $h\upsilon$ are shown in Figure 8. All the films have peak values of $0.6 \times 10^{14} s^{-1}$. Plots of imaginary dielectric constant (ε_i) and real dielectric constant (ε_r) are displayed Figure 7 and Figure 6. Also the variation of absorption coefficient (α) with photon energy ($h\nu$) are shown in Figure 3.

Near the fundamental absorption edge, there is the dependence of absorption coefficient (α) on the photon energy ($h\nu$) corresponding to direct allowed transition given by [1-2].

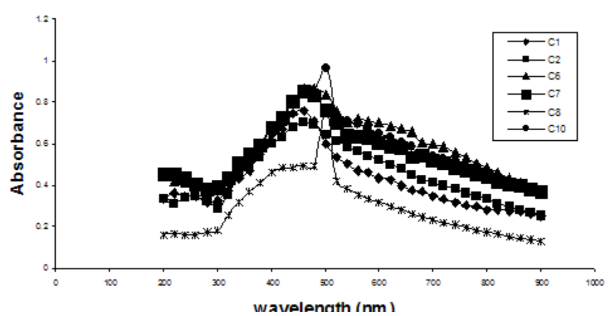

Figure 1: Spectral Absorbance of CdMnS Thin Films.

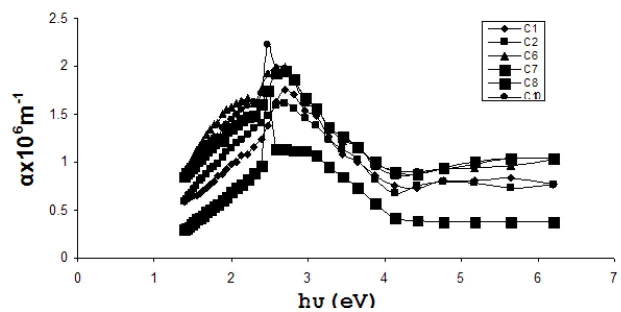

Figure 3: Absorption Coefficient (α) as a Function of Photon Energy.

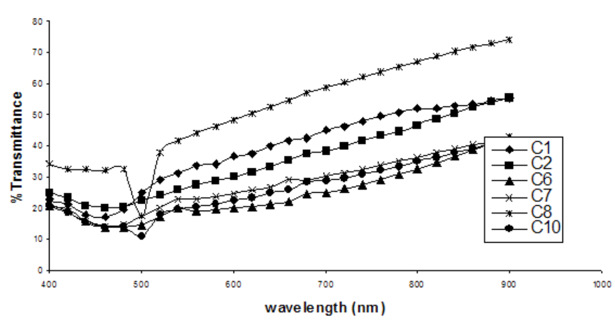

Figure 2: Transmission Spectra of CdMnS Thin Films.

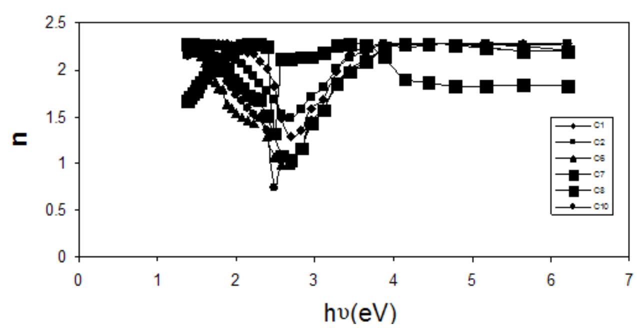

Figure 4: Refractive Index (n) as a Function of Photon Energy.

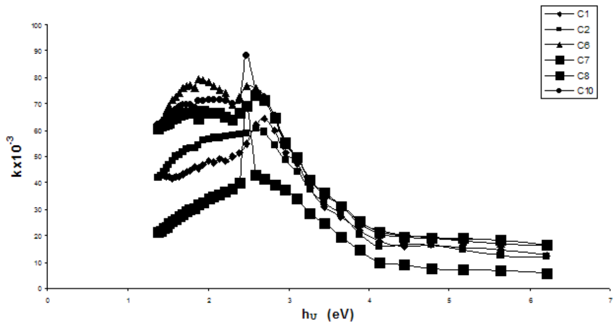

Figure 5: Extinction Coefficient as a Function of Photon Energy.

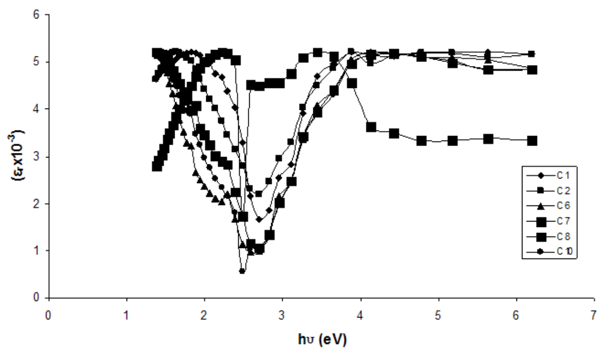

Figure 6: Real Dielectric Constant as a Function of Photon Energy.

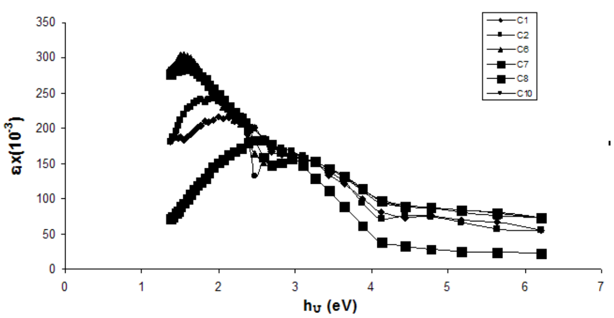

Figure 7: Imaginary Dielectric Constant as a Function of Photon Energy.

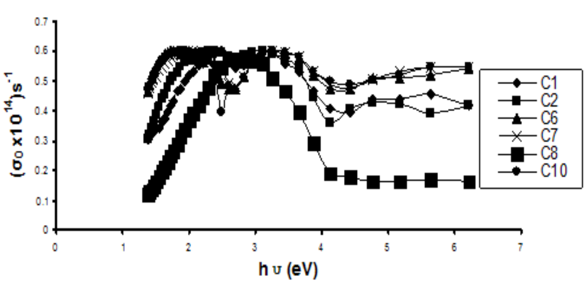

Figure 8: Optical Conductivity (σ_0) as a Function of Photon Energy.

Plot of $(\alpha h\nu)^2$ against $h\nu$ for the samples of thin films are shown in Figure 9. The energy band gaps were obtained by extrapolating the linear portion of the curves at $(\alpha h\nu)^2 = 0$.

The band gaps ranged between 1.45eV and 1.65eV. The peak values of optical and solid-state properties of CdMnS films are summarized in Table 1.

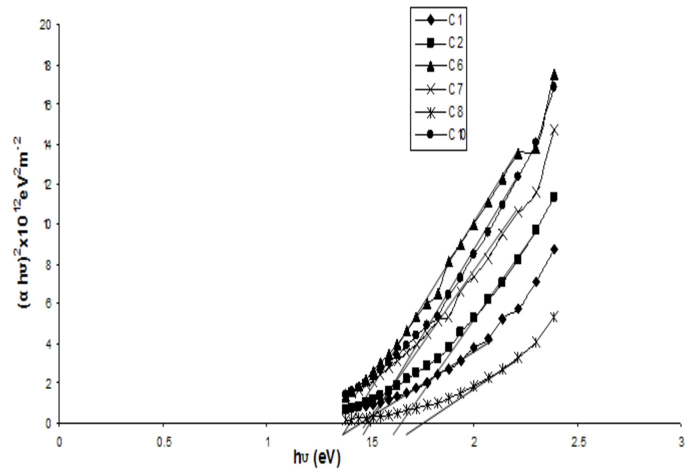

Figure 9: Plots of $(\alpha\, hu)^2$ as a Function of Photon Energy for CdMnS Thin Films.

CONCLUSION.

Thin films of CdMnS with energy band gaps ranging between 1.45 and 1.65ev have been successfully deposited on glass substrates using chemical bath deposition technique. Some of the thin films formed exhibited moderate transmittance in the VIS-NIR region of the electromagnetic spectrum, and one of the films shows transmittance (>74%) in the same region.

Some of the films with moderate transmittances and low energy band gaps can be used as material for solar cell while the films with high transmittance in the VIS-NIR region is a good material for the construction of poultry for warmth.

Table1: Optical and Solid State Properties of CdMnS Thin Films.

Bath	$\alpha x10^6 m^{-1}$	n	$Kx10^{-3}$	$\sigma_0 x10^{14}$ (s^{-1})	Temp (K)	$\varepsilon_r x10$	$\varepsilon_i x10^{-3}$	Band gap E_g (eV)
C1	2.22	2.28	64.24	0.60	358	5.20	216.02	1.50
C2	1.61	2.28	60.84	0.60	363	5.20	239.24	1.65
C6	1.99	2.28	79.48	0.60	348	5.20	303.10	1.40
C7	1.96	2.28	79.48	0.60	343	5.20	385.77	1.50
C8	1.99	2.28	69.23	0.60	358	5.20	183.20	1.65
C10	2.22	2.28	88.32	0.60	353	5.20	293.58	1.50

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