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Optical Properties for CdSe:Cu Thin Film Prepared by Sputtering Method

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Abstract: A thin film of CdSe was deposited using the thermal sputtering method on a glass substrate. Then CdSe was doped with (1% and 2%) ratio of Cu at 80°C using the same thermal sputtering method. The optical results show that the pure CdSe films in this method have energy gap of (2.1eV) that can a portion of visible light pass through. The energy gaps for the doping films were reduced between (1.8 -1.95)eV. The structure CdSe/CdSe:Cu films, prepared under these conditions and within the visible wavelengths can be taken advantage of as a thermally transparent material such as IR detectors.

Keyword: CdSe thin film, Sputtering method, doping, optical property.

1. Introduction

The semiconductors within the group (II-VI) have attracted interest in the applications of solar cells because of their optical properties, as they can absorb light in the visible region. The most famous of these materials are Cadmium Selenide CdSe [1]. The CdSe compound has three types of crystal structures, which are wurtzite, and hexagonal, which are exists under normal atmospheric pressure conditions [2]. The third crystalline economic structure is the cubic (rock salt) under high-pressure conditions. The optical and electrical properties of CdSe membranes are scheduled to be affected by doping, such as In, [3] Zn, [4], Al [5], Bi, [6] and Mg, [7]. The choice of a thin film deposition technology is based on the type of material and the purpose of the idea of deposition. The CdSe thin films may form by different techniques, including Electrodepositing method, [3], Thermal Electro evaporation Technology, [7]. Solvo thermal Process Technology, [8]. Vacuum Evaporation Technology, [9]. Sol-gel method, [10], Successive Ionic Layer Adsorption and Reaction SILAR, [11]. Chemical Bath Deposition -CBD, [12]. In sputtering technique the target atoms and are uprooted by bombarding them with high-energy atomic particles and then depositing them on the substrate. Inside a chamber filled with an inert gas (Ar) then turns it on. Elastic collisions with Ar atoms occur, [13].

This work aims to preparing a CdSe thin film by the thermal sputtering method. And doping the CdSe thin film with copper by the same sputtering method. Then study the effect of doping on the optical properties.

2. Materials and Methods:

The sputtering system is an aluminum chamber with a space inside it a heater for heating the substrates and also contains solution spray nozzles from a certain distance. A glass of dimensions 7.5×1.2×0.1 cm was used as substrates for CdSe film deposition, which were first cleaned with washing powder and water and rinsed with distilled water. Then it was immersed in a hot Ethanol solution for 15 minutes to remove any organic matter stuck to it. It is immersed in acetone for several seconds and then left to be weighed by a microbalance sensor to be ready for use.

The Se powder is mixed with NaSO in 10ml of distilled water in a Reflux system and then heated for 2hours where the solution was mixed using a magnetic stirrer to speed up the process of dissolving the atoms and not sticking to the wall of the flask. Then filtering is done to obtain Na_2SeSO_3 free of impurities. This solution was prepared in 10ml of $CdCl_2$ solution by adding 2ml of NH_3 and a few drops of TEA as a catalyst. The final prepared solution was added to the Na_2SeSO_3 solution and distilled in 80ml, and then the orange color of the CdSe solution appears with pH=9. This CdSe solution was mixed with a magnetic mixer with heating for 5min to increase the reaction speed. Then the substrate was placed above the heater inside the room and at a certain temperature, and then the deposition process is completed. The CdSe thin film was deposited at different temperatures between (80°C) to obtain the best homogeneous film. The film thickness was measured using the gravimetric method (weighing the substrate before and after the deposition).

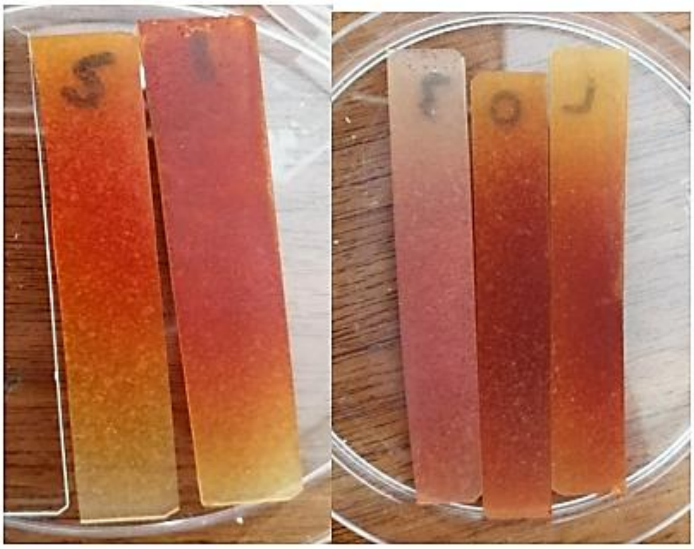


Figure 1: The prepared CdSe films by sputtering method at deposition at 80°C

The doping CdSe with Cu was carried out by adding (1% and 2%)*wt* of $CuCl_2$ to the solution by the same sputtering method. The optical measurements were taken first in case of the pure CdSe thin films, then for CdSe: Cu on top of the pure film (one doped layer and then two doped layers) as shown in figure (2), using the same method of sputtering.

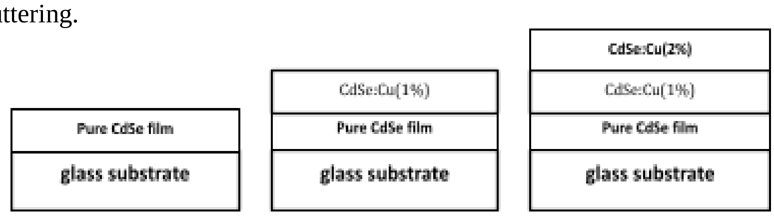


Figure 2: The structural diagram for pure-CdSe and doping- CdSe:Cu films

3. Results and Discussion

Optical measurements of pure and doped CdSe thin films were carried out using a (721-2000 UV-Vis-NIR spectrophotometer) to measure the transmittance (T), absorbance (A) for the wavelength range (340-1000 nm), and calculate the optical absorption coefficient (α) from following relation: $\alpha = 2.303\ A/\ t$, where t, is the thickness of the film, [14].

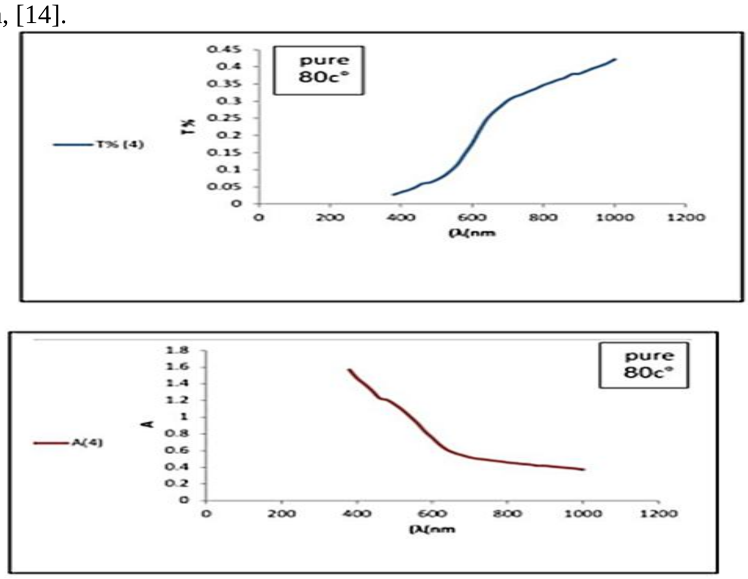
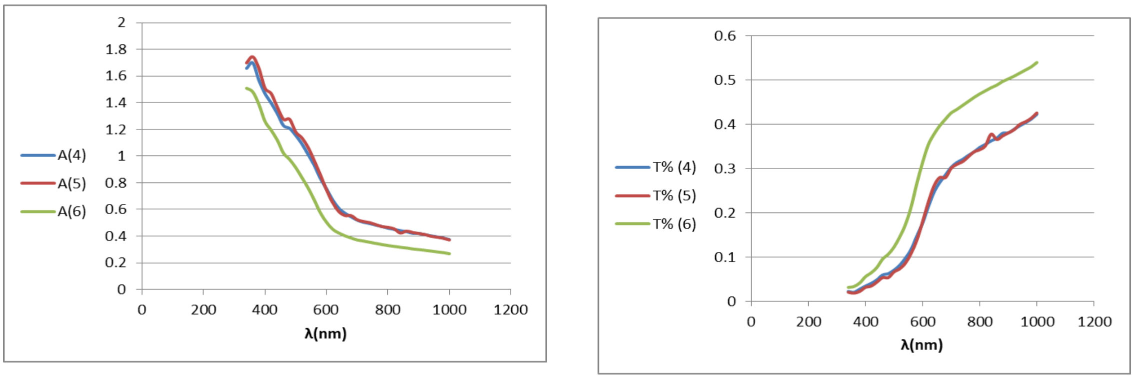


Figure 3: The transmittance and absorption as a function of the wavelength for pure CdSe films at 80°C

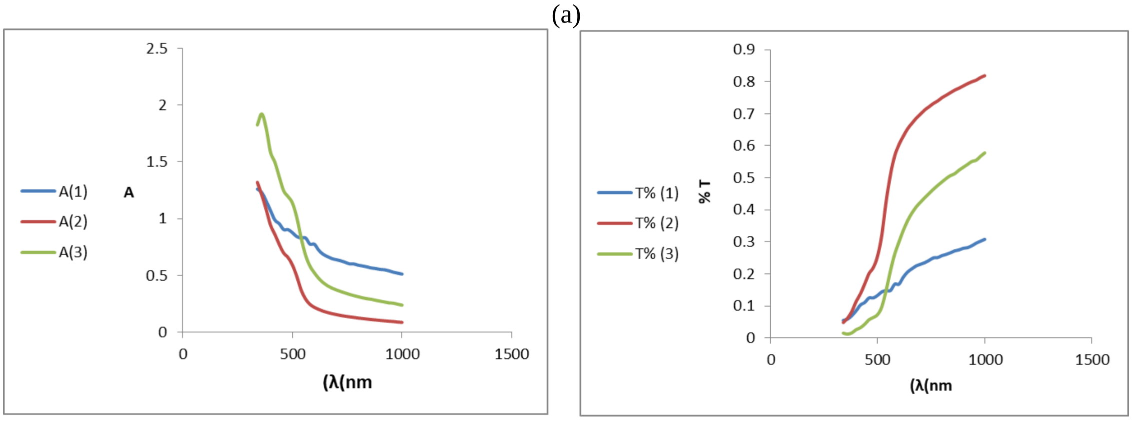
Figure (3), shows that CdSe thin films have low transmittance in the ultraviolet region (350-400 nm) and it increases with increasing wavelength in the visible spectrum region (390-770 nm) and near-infrared (990-700) nm. Which is indicates that CdSe films have a relatively suitable energy gap that allows a part of the visible light to pass through, and this is agree with, [15].

Figure (4) shows the transmittance and absorbance as a function of the wavelength for pure CdSe thin film, one layer 1%Cu doping film (a) and two layers 1%Cu and 2%Cu over the pure layer (b) at 80^{o}C.) Note: the different color lines for three samples have the same conditions(.

It is noted from figure (4-b) for three samples with the same experimental conditions that the two-layer samples with different doping concentrations led to a large breakthrough in curves of transmittance and absorbance. It is noticed that the transmittance increases with increasing wavelength within the visible region (800-400 nm), where its stability is slightly in the near-infrared region (1100-800 nm). It has the greatest transmittance of rays in that region and with high stability.



(a)



(b)

Figure 4: The transmittance (T%) and absorbance (A%) for samples prepared 80^{o}C:
(a) one layer CdSe:Cu%1 over pure CdSe, and (b) *two* layer CdSe:Cu1%+Cu2% over pure CdSe

From Tauc relation; $(ahv)^2 = A(hv\text{-}Eg)$, [16]. The optical energy gap for pure and doped CdSe films can be calculated by drawing the relationship between the absorption coefficient $(\alpha hv)^2$ with the energy of the incident photon (hv) as shown in figure (4), where the intersection of the tangent of the exponential part of the curve with the photon energy axis will represent the value of the energy gap energy (Eg) for CdSe film.
Figure (5), shows the energy gap for the pure CdSe thin film prepared at 80^{o}C equal to (2.1eV).

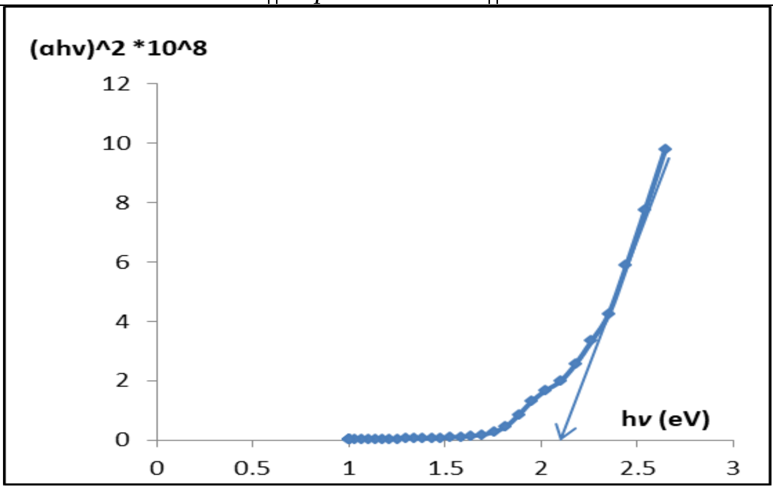


Figure 5: The energy gap for the pure CdSe thin film

The figures (6-a) shows the energy gap for the CdSe:Cu(1%) layer over the pure layer pure films. And figure (6-b) shows the energy gap for multi layers CdSe:Cu(1% +2%) over the pure layer prepared at 80^{o}C.

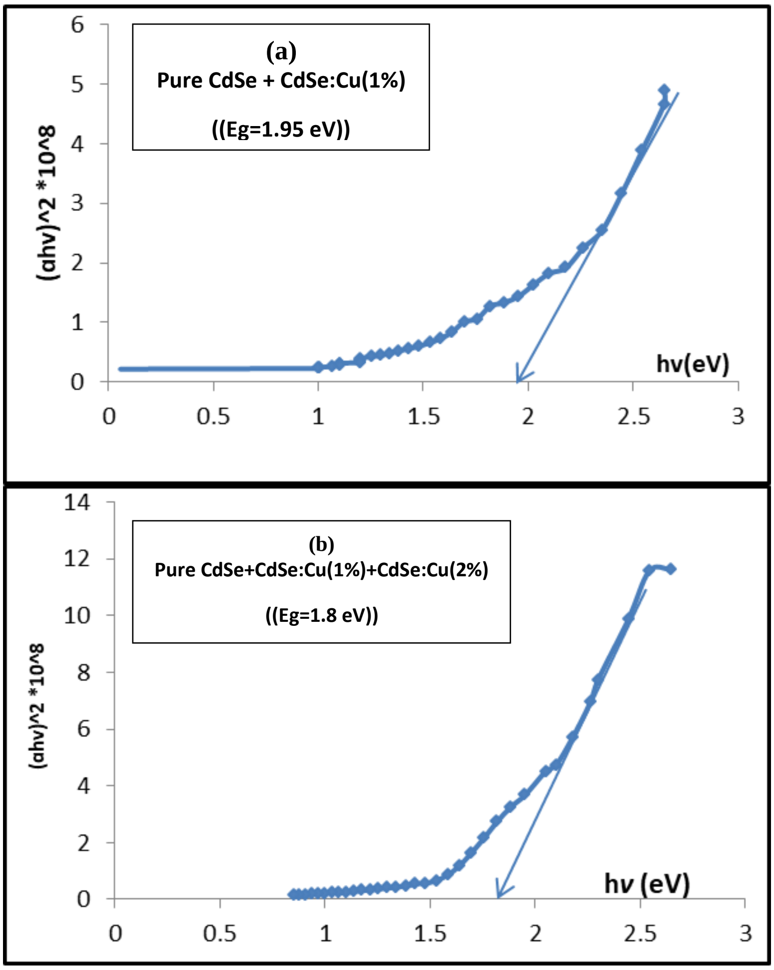


Figure 6: The gap energy for (a) CdSe+CdSe:Cu1% (*b*) CdSe:Cu(1%+2%) thin films

Figure (6) shows the energy gap was 1.95eV for one layer of CdSe:Cu(1%) over pure film (a), and was reduce to 1.8eV for a CdSe:Cu(1%+2%) over the pure film(b).

4. Conclusions:

In this work, The CdSe thin films were deposited by the thermal sputtering method on a glass substrate under certain conditions, and then CdSe was doped with (1% and 2%) Cu at (80°C) using the same thermal sputtering method. The optical results show that the pure CdSe films have a relatively large energy gap of (2.1eV) that can a portion of visible light pass through.

The energy gaps for the doping multi layers of these films were reduces between (1.95 - 1.8)eV which shows that Eg increases as the doping ratio increases with Cu. The transmittance value increases as the doping with Cu increases.

The CdSe/CdSe:Cu films prepared under these conditions and within the visible wavelengths mentioned above can be taken advantage of as a thermally transparent material, as well as can be used as IR windows in infrared detectors.

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