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EFFECT OF γ -IRRADIATION ON RESISTANCE OF ALUMINUM DOPED CdS THIN FILMS

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ABSTRACT

Pure and Al doped CdS thin films were deposited on heated glass substrates at temperature 400°C by spray pyrolysis method, and then irradiated by γ-ray. The radiation resistance of the samples have been investigated by measuring their electrical characteristics before and after irradiation with different doses of γ-ray in the range (20-120) Gy. Results show that the resistance decrease slightly for the pure and for 3% Al doped CdS films when irradiated with γ ray but there is a significant decrease of resistance for 12%Al doped CdS films with increase in the gamma radiation dose up to certain value.

The sensitivity of Al doped CdS to gamma ray were found to depend on the doping effect and have been found in the range 4- 25nA/cm^2/μGy for pure and 3% Al doped CdS and around 32nA/cm^2/μGy for 12%Al, in addition low Al rate employing new materials are to be more resistant to radiation effect.

The observed changes in the electrical properties indicate that Al doped CdS thin films can be used as the real time gamma radiation dosimeter up to a certain dose, a quantity that depends upon the Al rate.

Keywords: Al doped CdS thin film, Radiation Effects, Gamma -ray, Electrical properties.

I. INTRODUCTION

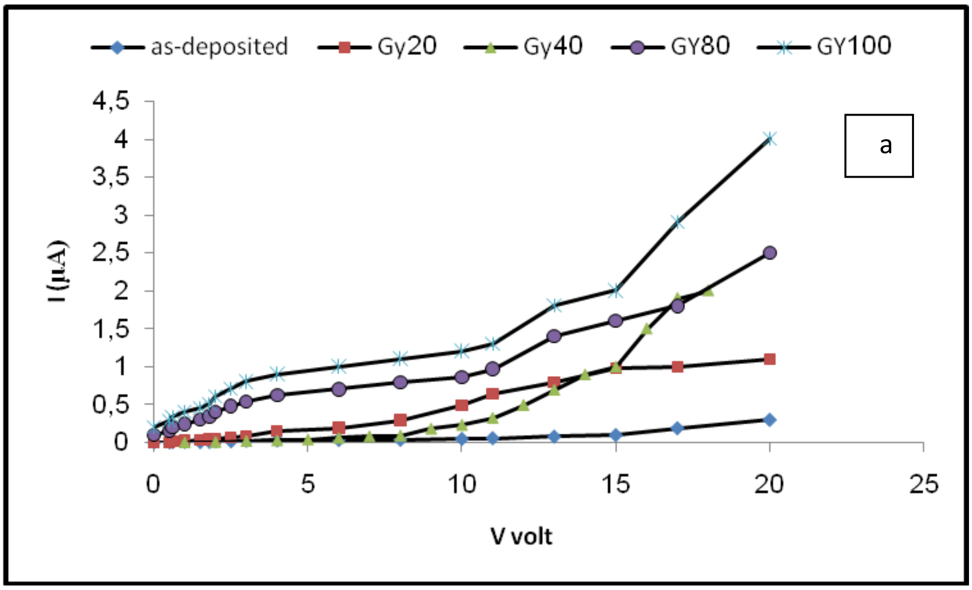
For the last few decades, there has been a growing interest in Cadmium Sulphide thin films due to their interesting optoelectronic properties , It possess a direct band gap of 2.42eV, a better life time of photo carriers , this semiconductor has been looked as a better choice for many potential applications, such as photovoltaic window layer and electro-optic modulators [1,2]. X-ray diffraction studies showed that these films are well oriented with a preferential growth of crystallites in the (002) plane. CdS thin film has been known for its characteristic properties in radiation detection and a dosimetry application in recent years [3,4]. CdS, as a compound semiconductor materials shows similar characteristics with CdTe because of its larger band gap energy than those of the popular Ge and Si, the operation of the CdS based semiconductor detector depends on the region of the p-n junction where the electric field exists, electron and holes pairs produced when radiation impinge in the p-n junction region [5] moreover the tracks result from radiation lead to disturbing regions at thin films. They also reported that the resistivity of the high mobility films could be controlled by the addition of Cl or Ga at the proper stage of the processing. CdS can be doped with B, Ga, In and Al to get n-type conductivity or with Cu, Ag, and Au to obtain p-type conductivity, Small quantity of impurities has large effect on electrical characteristic [6,7], these films were used in various devices such as solar cells, sensors, and solid oxide fuel cells. The electrical properties of chemical deposited CdS-Al thin films is important to investigated especially when high energy radiation falls on thin films in such case radiation resistance is an important factor, since the continuous impact of high energy particles damages the semiconductor lattice, degrading the sample performance and, hence limiting their resistance [8-10]. Other researchers have worked to modify the resistance to reduce or enhance radiation induced discoloration.The ionization effect of γ-radiation can be produced at the surface or in the bulk [11]. Several researchers have employed various doping techniques like thermal evaporation, diffusion, ion-exchange process *etc.* to improve the properties of the films for device applications [12-15] among these technique spray pyrolysis deposition has been considered as the most prominent one. It is simple, requires minimum materials, economical and permits deposition of large area films, the main propose of this work is to determine the influence of γ irradiation on the variation of the pure and Al doped CdS thin films resistance and to investigate the dependence of sensitivity (the change in the current density for unit change in the gamma radiation dose) on the doping effect.

II. EXPERIMENTAL DETAILS

The CdS thin films were prepared by spraying an aqueous solution of cadmium chloride ($CdCl_2$) and thiourea [$(NH_2)_2CS$] on glass substrate kept at 400°C. Al doped CdS films were deposited by adding Al_2Cl_3 as a dopant source to the solution, the atomic percentage of Aluminum in the solution were 3% and 12%. It is possible to obtain uniform films with good adherence through the spray pyrolysis deposition . Thickness was determined by the optical interference method, all of the CdS films had a thickness of approximately 400nm, and all the films have the same deposition parameters. I-V characteristics of these films were determined by two probe set up with evaporated metal contacts (stripes: 1cm length, 0.5 cm width and 0.4 cm separation). A Dc voltage is applied across the films and the resulting current is measured by Keithley digital meter type 616, the slope was estimated to find the resistance in each case. To examine the sensitivity of the films to gamma radiation, they were exposed to a disc-type ^{60}Co radiation source (made in 1982, with activities of 1mCi), the radioactive gamma-emitting source was encapsulated into a 2mm thick epoxy resin to shield any accompanying β radiation, series of irradiations were performed by changing the exposure time and hence the dose.

III. RESULTS AND DISCUSSION

Figure (1a,b) shows the current against applied voltage for the pure and 3% Al doped CdS thin films respectively, exposed to different levels of **γ** radiation dose (20, 40, 80,100 Gy).



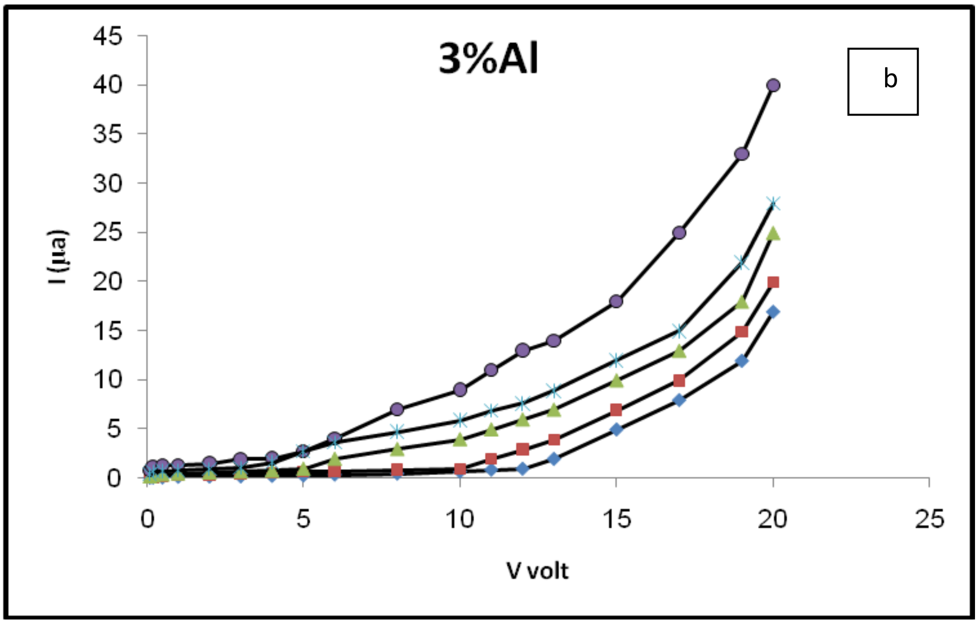


Figure (1a,b): current against applied voltage for the pure
and 3% Al doped CdS thin films respectively exposed to different levels of gamma radiation doses

The current increase quite linearly (up to 80Gy) with increase in the gamma radiation dose, the mechanism of charge transport in these films is due to thermally activated process of excitation electrons from valence band to conduction band and the effect of gamma irradiation in these films is similar to heat annealing [16]
.

Fig. (2) shows the current against applied voltage for 12% Al doped CdS thin films exposed to different levels of gamma doses.

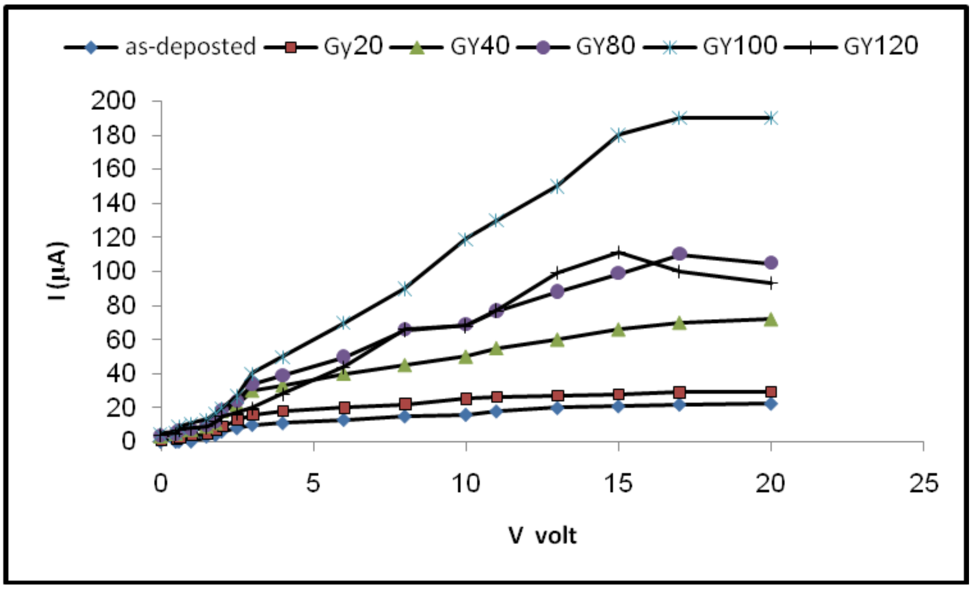


Figure (2): current against applied voltage for
12% Al doped CdS thin films exposed to different levels of gamma radiation doses

the current increase with increase in the Al rate, since there is a large density of free electrons in conduction band, and it is believed that in this Al rate the thermal excitation process becomes weak as compared to the doping density [17,18] ,but the current will not continue increasing that beyond a certain voltage values all the Al atoms will be incorporated in the crystal lattice as electrically inactive impurities and will reach saturation values, It was observed that the saturation current increase as the exposure time increase, moreover the current has been found to decrease with further increase in gamma beyond 100Gy ,the interaction of gamma ray may be induces defects during its passage through these films resulting into disorder in the microstructure of the films and the significant decreasing of current over 100Gy could be related to over population of charge carriers in conduction band due to doping and high dose [19]. Above results clearly show that the current increases linearly with gamma radiation dose up to certain dose, a quantity higher for the higher Al rate.

The ionization effect of γ-radiation on the variation of the films resistance is shown in fig (3a, b) for pure and 3% Al doped CdS films respectively, it can be seen that there is no significant changes in the resistance measurement observed after irradiation with γ dose .

Figure (4) illustrate the change in the resistance of 12% Al doped CdS films under the influence of γ ray, there is a definite increase in the resistance after exposing to high γ irradiation ≥100Gy, it can be concluded that the change in resistance was permanent at high gamma radiation dose and transitory below this value, this may be attributed to the permanent damage created in the base region reducing the electron life time for the 12% Al rate.

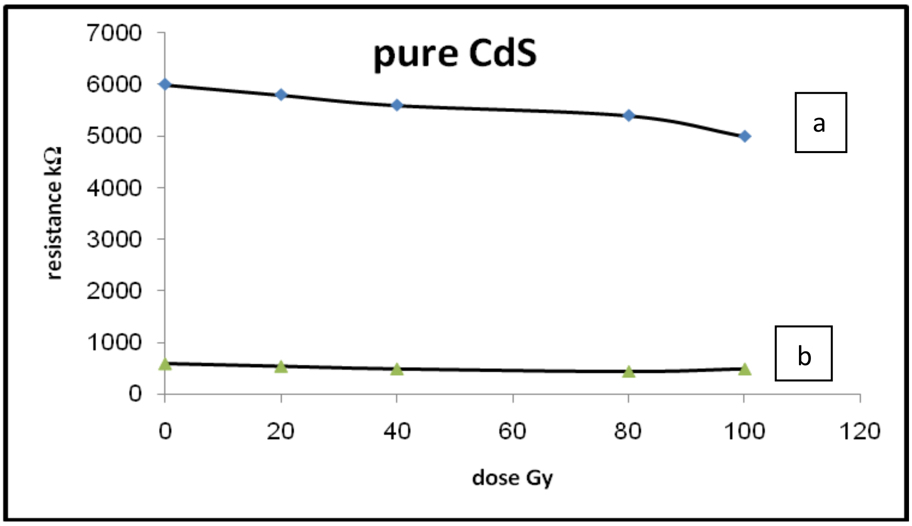


Figure (3a,b): resistance as function of gamma dose (a) for pure and (b) 3% Al doped CdS films

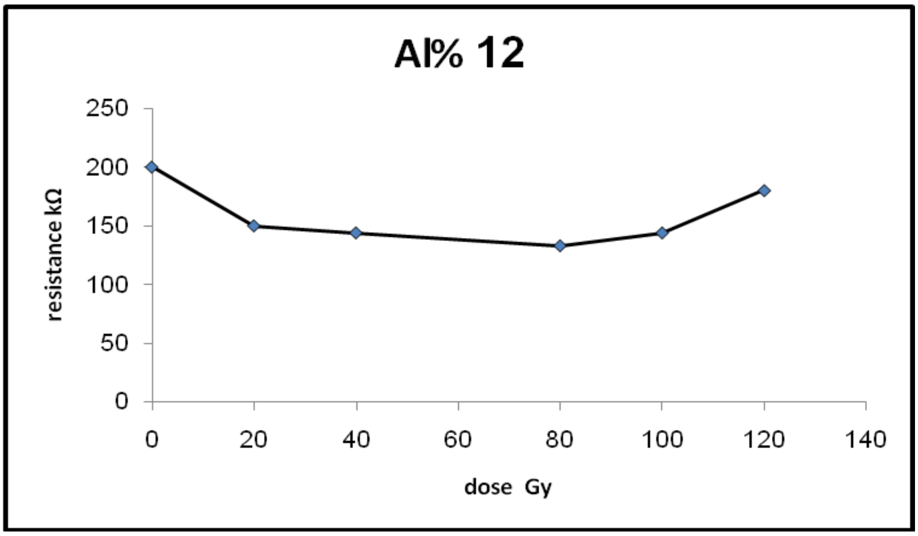


Figure (4): the resistance of 12% Al doped CdS films under the influence of γ ray irradiations

To further understanding these films properties, variation of current density with the γ dose is shown in figure (5a,b) and figure (6) each plot representing sensitivity of the film and have been found in the range 4 to 25nA/cm^2/μGy for pure and 3% Al doped CdS films and around 32nA/cm^2/μGy for 12% Al, these results are in good agreement with the others[20].

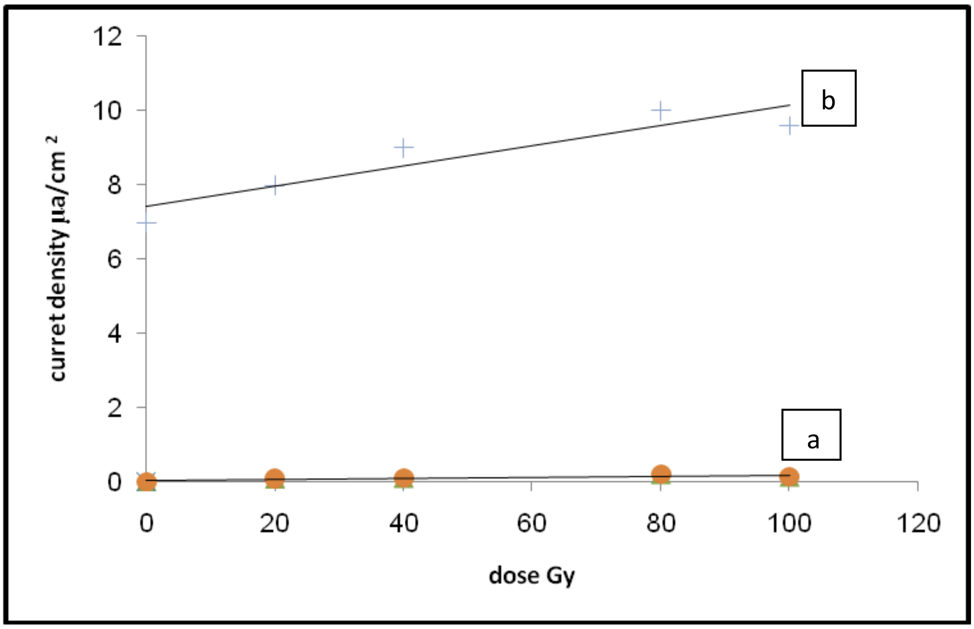


Figure (5a,b): the current density against dose (a) for the pure and (b) for 3% Al rate

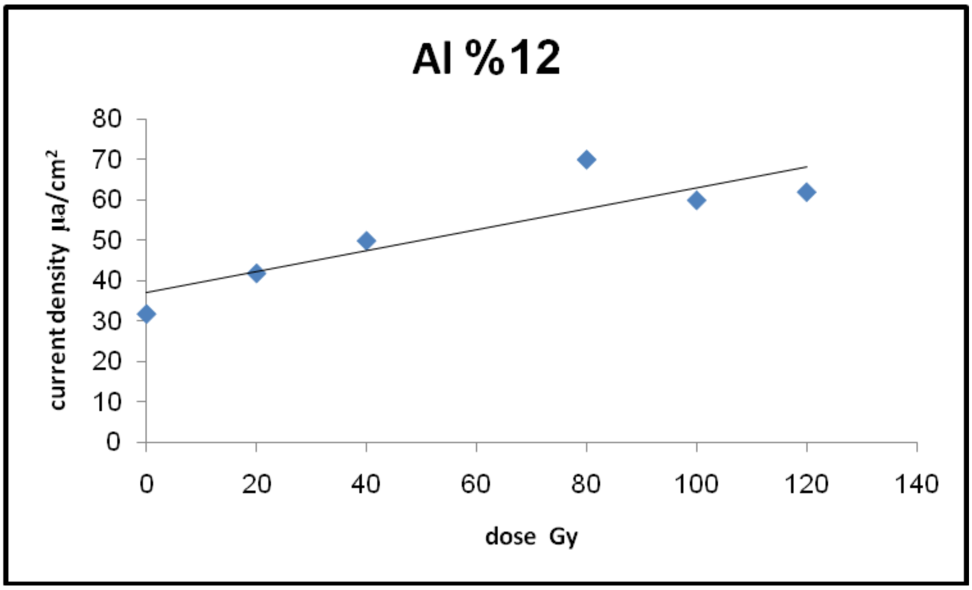


Figure (6): the variation of current density with the gamma doses for 12% Al rate

It may be noted that the sensitivity increases with the increase of Al rate and the heavy doping dose sustain up to higher radiation dose than the low doping films, in addition the degradation is more severe for the higher dose and heavily doping.

The near linear variation of the current density with the γ radiation dose can be considered as a working region for gamma radiation dosimetry [21].

IV.CONCLUSION

The effects of gamma irradiation on the electrical resistance of CdS thin films have been studied to find out the suitability of the films in real time gamma radiation dosimetry.
The current increase linearly with increase in the Al rate, and there is a definite decrease in the resistance after exposing to high γ irradiation ≥100 Gy for 12% Al rate, the influence of radiation depends on both the dose and the doping rate. The near linear variation of the current with the radiation dose clearly indicates that the 12% Al thin films have high potential for their use in the real time gamma dosimetry.

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