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In memoriam prof. dr. Liviu Oniciu

PHOTOCONDUCTIVE PROPERTIES OF CdS ELECTRODEPOSITED THIN FILMS

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ABSTRACT. CdS films electrodeposited on ITO substrate were investigated from optical and electrical point of view. Spectra present a maximum in red domain at 734.5 nm and 732.5 nm respectively. The electro deposited films are photo sensible. Static characteristics are linear in normal conditions of temperature and the non-radiative recombination plays a small role within the photoconduction processes.

Keywords*: CdS electrodeposited films, photoconduction*

INTRODUCTION

Thin films of metallic chalcogenides represent a new field of investigation for functional devices technologies at large scale. The importance of these layers in the construction of photo resistors, laser diode and some integrated structures are crucial. Photoconductive CdS films were usually deposited on metallic or insulated substrates by sputtering, using mixtures of Ar-H_2S as sputtering gas in a diode system on suitable cleaned substrate [1]. Non-vacuum methods are susceptible to contamination. The electrochemical deposition was reported in literature [2-4]. The major advantage is the low cost of this procedure.

In this paper were analyzed some spectral and electrical properties of thin electrodeposited films. All electrochemical parameters such as deposition potential, cathodic current and the rate of deposition were recently reported [5]. The deposited CdS film has shown a good adherence to ITO substrate due to its texture and preliminary electrochemical procedures to obtain the optimum storage. Optical and microscopically inspection confirm the uniformity of electro deposition.

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RESULT AND DISCUSSIONS

The absorption of radiation, which generates the non-equilibrium carriers, leads to the appearance of additional conductivity usually call photoconductivity.

Two samples with rectangular geometries, P_1 (1/2 cm) and P_2 (5/6 mm) were investigated in order to determinate the ohmic resistance of CdS film in light and dark conditions. The ohmic contacts were made by using Ag Degussa conductive pasta and two Cu terminals in order to observe the longitudinal photoconduction.

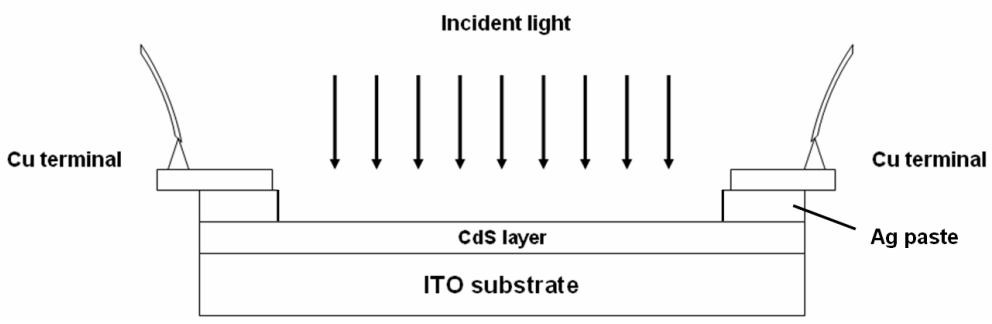

Figure 1. The electrodeposited sample (cross section view)

Determinations carried out on two samples in dark and light conditions in absence of polarization, were obtained at small interval of time (5-10 s) and at small incident flux (power density 0.6 W/cm^2). In these conditions, it had not been observed a notable ohmic resistance variation due to the free way of photo-generated carriers or because of intercrystallite barriers if these exist. However, the small ohmic resistance values of the electrodeposited (P_1 and P_2) film are uncommon when these are compared with commercial one (20 M Ω). This situation is generated probably by some structural defects or under the influence of the material composition. Some properties (bulk resistance), can be masked by the contamination of the outermost film layer. The structural defects perhaps act like a trap for the charge carriers.

It has been noticed that the illumination time (5 - 10 s) did not influence the photo sensible layer ohmic resistance (102 Ω for (P_1) and 69 Ω for (P_2)). The differences between values are due to different geometry of films.

A homemade lineament device with 5 mm diameter diaphragm was attached to the spectrophotometer. The spectrum was realized by comparing the CdS film deposited onto ITO substrate to ITO substrate free of CdS films. A large band in red domain and NIR was thus observed (Fig.2). The different

absorbance data comes from different thickness of investigated films P_1(Abs = 0.1681 at 734.5 nm) and P_2(Abs = 0.1407 at 732.5 nm). A small drift appears in spectrum at P_1 toward NIR (842 nm) as compaired to P_2 (832 nm). This observation confirms different geometry but also different superficial aggregation.

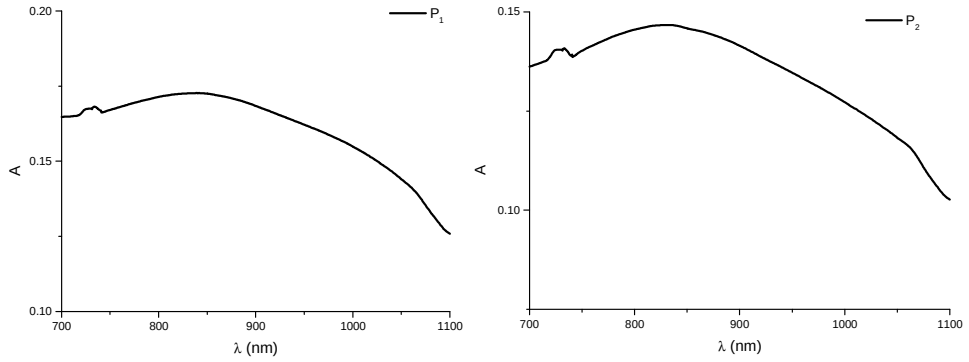

Figure 2. The spectral characteristics of the investigated CdS films

The assertive convention of polarization was selected due to symmetry of static characteristic in connection with coordinate axis. The current - voltage dependence is linear in both conditions (absence or presence of illumination) in normal temperature conditions:

$$I = I_0 + I_L = (C_0 + C_f \Phi)\, U.$$

The flux modification induces only different slope in static characteristics, where I_L, I_0 is the current in light and dark conditions, C_0, C_f constants that are determined by physical properties and constructive characteristics of the photo-sensible film and U the polarization tension. Also in this relation, the incident flux Φ plays an important role. By using the small polarization voltage and IR filter, we were able to avoid the intense field or the excessive heating of the photo sensible film.

A photo response was recorded for 30 s illumination time at each value of polarization voltage (Fig.3). The non-radiative contribution at photoconduction phenomenon due to carrier recombination led to a difference of only 0.01 degree for three selected wavelengths in red domain (700 nm, 730 nm, 760 nm).

To verify the film stability, static characteristic and the ohmic resistance of sample have been measured again after a month period. Deviations from traced spectrum have not been observed. This observation had demonstrated that aging phenomenon during this period does not appear. Because the films

were kept in special enclosures, the danger of contamination was eliminated. The areas where the Ag diffusion it is possible, refers to the specific regions of the ohmic contacts. Is also possible the indium diffusion from ITO substrate to CdS layer. To observe this phenomenon, supplementary analytical investigations are necessary to be made in the specific zone.

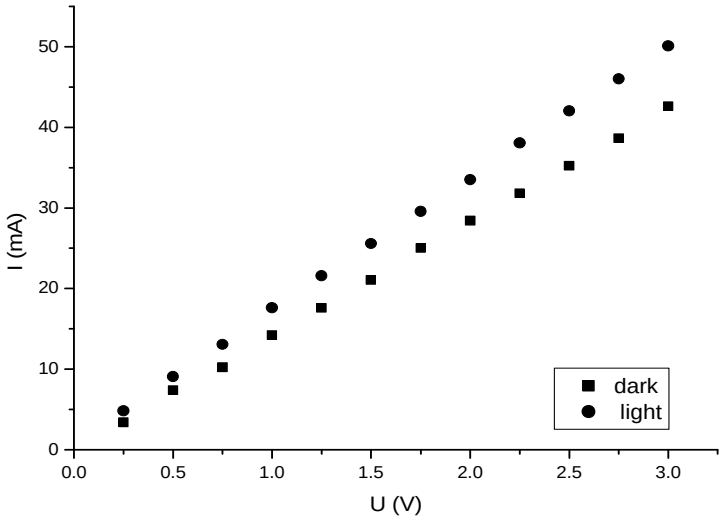

Figure 3. The static characteristic of P_1 film in light and dark conditions.

CONCLUSIONS

Two CdS films electrodeposited on ITO substrate, with different rectangular geometries (2 cm^2 and 0.30 cm^2) were investigated from optical and electrical point of view. Spectra present a maximum in red domain. The electro deposited films are photo sensible. Static characteristics are linear in normal conditions of temperature and the non-radiative recombination plays a small role within the photoconduction processes.

EXPERIMENTAL SECTION

The deposition process was achieved in solutions containing $CdSO_4$ and $Na_2S_2O_3$ ($Cd_2^+/S_2\ O_3^{2-}$ ratios of 2/1 and 200/1), at pH 3, on ITO glass previously cleaned by ultrasonnation for 15 minutes, in a 1:1 acetone-ethanol mixture.

The ohmic resistance of electrochemical deposited film was measured with a digital ohmmeter in both dark and light conditions (the incident light flux for illumination conditions was supplied by 30 W Hg source). Using the Able-Jasco V-530 spectrometer attained the spectral characteristics of the examined thin films. The static characteristics I = f (U) and the contribution of non-radiative recombination was obtained by using a digital device [6]. Changing of temperature was observed without polarization, in monochromatic conditions. The red domain for the recombination contribution was selected with a Specol monochromator.

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