PHOTODETECTOR OF CdS WITH CONTACTS OF CdO

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The layers obtained by pulverization were put to activation and recrystallization. As a result of pulsed-laser treatment areas of CdO were formed on the surface by oxidation. Contacts of In were deposited. The layers of the photo detector were deposited by SEM, XRD and XPS, the electro-optical characteristics of the real structures were compared.

Keywords: CdS, CdO, Solar Cells

1. INTRODUCTION

During the last several decades achievement of low prime cost and high efficiency has been an underlying purpose of the development of thin layer semiconductor devices and photoelectric converters. Covering large areas necessitates choice of new semiconductor materials and obtaining methods; new photoresistors design; development and elaboration of new thin-layer technologies.

Modern analysis shows that a price threshold of the power module will be reached along with the progress of the thin layer technologies which will enable production on a large scale. In spite of all efforts, the polycrystalline Si modules reached the market with prices comparable with those of the monocrystals. The problem can be solved by using thin layer photoelements with thickness of several microns. The expectations for the thin layer heterojunctions including CdS as CdTe/CdS, CuInGaS/CdS etc are great [1]. The determining condition is the level of the deposition technology of the separate layers entering in the structure of the thin layer photoelements.

The semiconductor CdS layers deposited by pulverization with following pyrolysis meet the requirements of covering large areas at low prime cost. Significant phase and structural changes of the layers occur when annealing in the medium of oxygen; transition from cubic to hexagonal modification is observed; a CdO phase in the polycrystalline layers appears; the transmission and photosensitivity increase.

The parameters of the photoelements depend highly on the contact net effectiveness. The layer's composition has to further an ohm-contact with the adjoining semiconductor material. In, Ga, Al and Cd [2] as well as oxides of In_2O_3, SnO_2, $Cd_{1-x}In_xO$, $Cd_ySn_xO_{2x+y}$, $CdSb_2O_6$, $In_{2-2x}Cd_xSn_xO_3$ [3] were used as contact materials for CdS. The very least quantity of O_2 in the CdS surface prevents the in-depth diffusion when using In as a contact material. The contacts of the metals are

characterized by low transmission and at thickness under 0,1 μm they have a high-ohm value and are unstable. The good results at the oxides are consequence of achieving a high degree of non-stoichiometricity, requiring complex technological succession.

During the last years the chemical compound CdO is a target of many studies in order to be used as a transparent electrode and antireflective coating in the photoelectric converters, solar and other optical electronic devices [4]. CdO is a semiconductor which has wide band gap, formed in the surface of CdS by thermal oxidation, magnetron pulverization, and chemical precipitation [5]. The less transparency of CdO in comparison with the oxides of In and Sn can be compensated by its high conductivity reaching up to10^5 Ω^{-1}cm^{-1}.

The aim of this work is forming CdO local areas by pulsed-laser annealing of CdS layers, obtained by pulverization with following pyrolysis as well as studying and comparison of the characteristics of the photoresistive structure with contacts of CdO and In.

2. EXPERIMENTAL PROCEDURE

The CdS layers deposition was carried out by a pulverization system with a nozzle 1/4J of the company "Spraying Systems Co". The nozzle gives a round, conical long aerosol jet and the details about the technique can be found in [6]. The layers were deposited from a solution of 0,020 M CdCl2.2, 5 H_20 и 0,025 M $(NH_2)_2$ CS on soda lime glass at temperature 350 °C and distance between the nozzle system and the soda lime glass was 33 cm at angle 30 °. Pulsed laser annealing of the surface of CdS was carried out through a contact mask [7]. An additional layer of In was deposited through the same mask on some of the samples by using vacuum thermal evaporation in a vacuum equipment B 30.2 before and after pulsed laser treatment. The sizes of the tested structures are 2 x 1cm. Fig. 1 shows the principle diagram of the obtained structures.

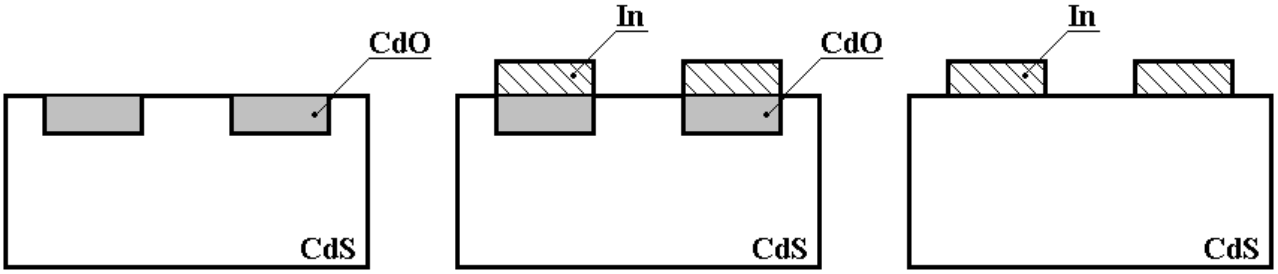

Fig. 1 Design of the tested structures

The conditions were observed when designing the mask [2], according to which:

$$w_{\max} = w_f \sqrt{\alpha_R} = \left(\sqrt{\frac{R_l}{R_c}}\right) L \qquad (1),$$

where w_{max} – width of the contact area; wf –distance between two contact areas; α_R - geometric factor; R_l - sheet resistance of the contact area; R_c - sheet resistance of the photo sensitive layer; L – length of the contact area.

$$i_{f\max} = \frac{LL'U_f}{w_f R_c \left[1 + \left(\sqrt{\frac{R_l}{R_c}}\right)\frac{L}{w_f}\right]^2} \quad (2),$$

where i_{fmax} – maximum photocurrent; U_f –voltage applied; L' – total length of the contact electrodes.

$$k_s = \frac{w_f}{w_f + w} \quad (3),$$

where: w - width of the contact area.

The contact mask used for obtaining the structures has the following dimensions: $w_f = 260$ μm, $w = 240$ μm, hence $k_s \approx 0{,}52$.

The layers' surface, their structure and composition were analyzed by a raster electronic microscope BS340; diffractometer Bruker D8 Advance, (CuKα), electronic spectrometer VG Escalab II, while using AlKα radiation with energy 1486.6 eV. Electrooptical parameters were determined by two-probe method at 200 Lx.

A photograph of the CdS layer's surface is shown in Fig. 2, deposited at temperature T_{sub} = 350 °C and the morphologic studies show that the layers are thick and homogenous.

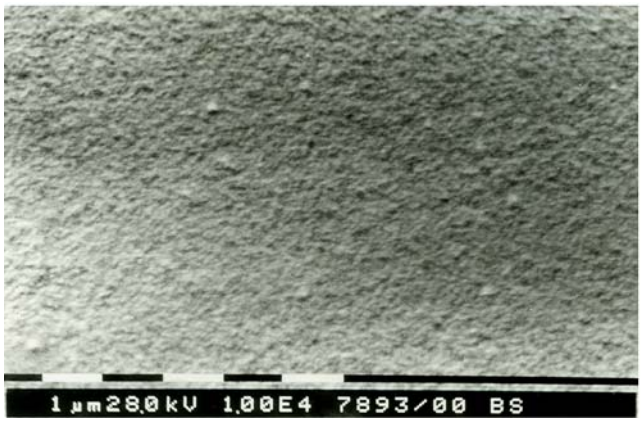

Fig. 2 Micrograph (SEM) of a CdS layer deposited at T_{sub} = 350 °C

Photographs of the surface of the structures CdS/CdO and CdS/CdO/In are shown in Fig. 3.

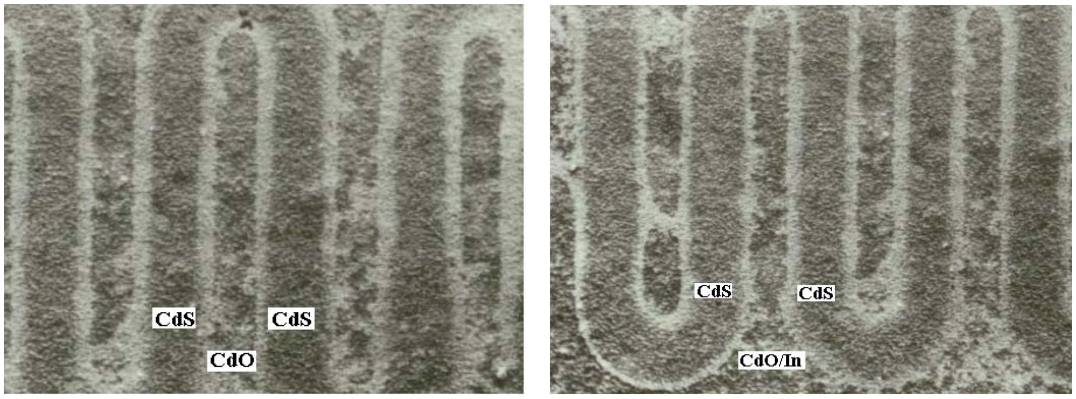

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Fig. 3 Micrograph (SEM) of a CdS layer after depositing a CdO layer through: a – CdS/CdO; b – CdS/CdO/In

Fig.4 shows XRD analysis of a CdS layer after forming the CdO areas and the results from the XPS analysis are shown in Fig.5 and Fig. 6.

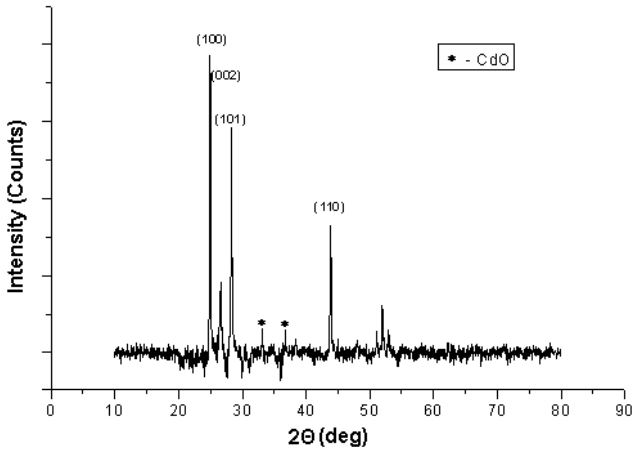

Fig. 4 XRD analysis of the CdS – CdO surface

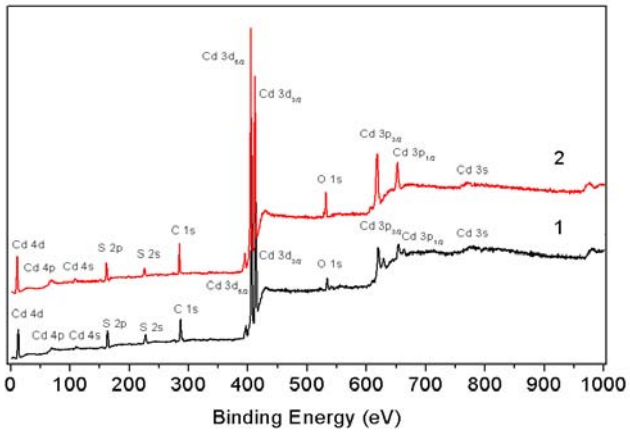

Fig. 5 XPS of a CdS – CdO layer, 1- before and 2- after the pulsed laser annealing

The XRD analysis carried out shows: a hexagonal structure with characteristic reflections on (100), (002) and (101) for CdS and a cubic phase with reflections on (111), (200) and (220) for CdO.

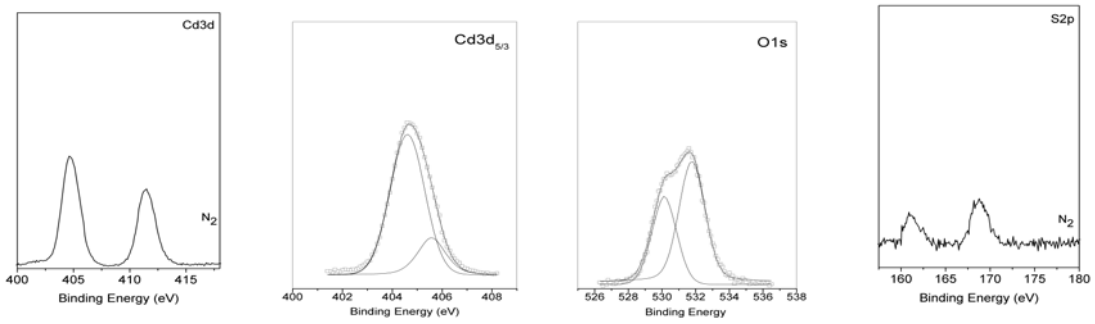

Figure 6 XPS analysis of CdS – CdO layers

XPS spectrum of the surface shows transformation of CdS into CdO. This is due to the S2p spectrum of sulphur in which the peak's 1 intensity, characteristic of sulphide decreases sharply at 161 eV. Besides, the Cd3d peak moves aside towards lower binding energy and becomes wider. The peak splits into two components – one

with maximum at 404.6 eV determined by CdO and a second component, less intensive - at 405.6 eV corresponding to CdS when using deconvolution. The deconvolution of the O1s peak also shows two peaks attributed respectively to oxygen in an oxide phase and bound with sulphate and carbonate groups. The results and conclusions coincide with those in [8].

An in-dept concentration profile of the elements of the CdS – CdO layers was made after the pulsed laser treatment by using Ar^+ ions with energy of 3 keV and current - 16 μA. After the pulsed laser treatment presence of oxygen was found in depth of the layers which is at concentration 9 - 10 % on the surface and decreases to 3 – 4 % at distance 80 nm from the surface.

Fig.7 shows the current-voltage characteristics of the so obtained structures that are linear. The measured rate photosensitivity of the structures type CdS - CdO is 10^6 and it is an order of magnitude lower than the above mentioned for the structures from the type CdS – CdO – In. This is caused by the higher transmission of the areas which composition is CdO toward those of In.

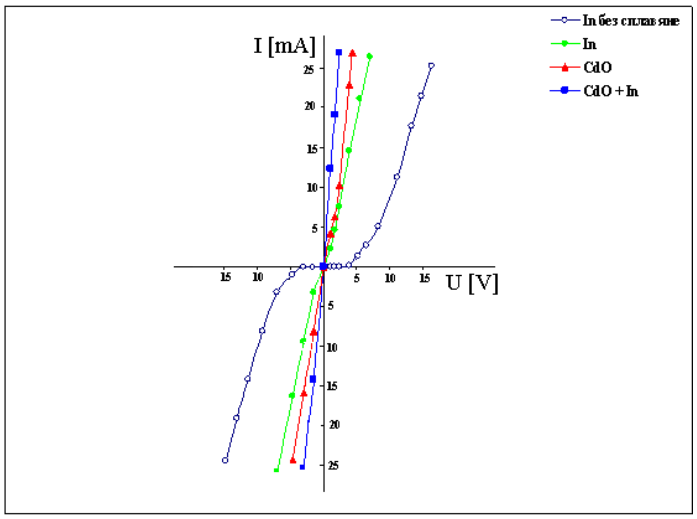

Fig. 7 Current-voltage characteristic of the structures

3. CONCLUSION

Local areas of CdO which have high conductivity and transparency are formed in the surface of the CdS layers after pulsed laser annealing. The contact areas retain planarity of their structure and do not require depositing an additional metal layer.

4. REFERENCES

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