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Obtaining Ultra-Thin Layers CdS with Magnetron Sputtering Method

Ioniţă Gheorghe*, Chiţanu Elena**, Stoian Elena Valentina*, Rizescu Cristiana Zizi*

* "VALAHIA" University Târgovişte, Department of Materials, Equipments, Installations and Robots
e-mail: valicirstea@yahoo.com

** National Institute for R&D in Electrical Engineering, ICPE-CA, Bucharest

Abstract

This paper presents research results on obtaining CdS thin layers using a method of physical vapour deposition, namely magnetron sputtering. We used a target of CdS obtained by pressing with a diameter of 40mm. Deposit layers was done by magnetron sputtering in argon atmosphere. Thicknesses obtained were determined by an interferometer and method using X-diffraction analysis of CdS layers getting confirmed.

Key words: *magnetron sputtering, CdS, thin films.*

Introduction

Cadmium sulphide is a chemical compound with chemical formula CdS. As like zinc sulphide, Cadmium sulphide, are in two different crystalline forms, more stable hexagonal structure Wurtz (mineral is found in Greenock) and cubic Blend (found in mineral Hawley).

Cadmium sulphide is a semiconductor material with forbidden band of 2.42 eV at 300 K. [1] When is combined with a p-type semiconductor forms a basic component of photovoltaic cells.

Physical vapour deposition process (PVD) is an atomic level deposition process in which material is vaporized from liquid to solid or gaseous form, transported as vapor through a vacuum or low pressure gas (or plasma) that condenses on a substrate.

PVD process is used to deposit thin films with thickness from several nanometers to thousands of nanometers, can be used to deposit multiple layers, thick layers and structures freely chosen. The substrate can have different sizes from very small to very large and form can vary from flat to a complex geometry. Physical vapour deposition process is a deposition rate of 10-100 Å (1-10 nm) per second [2].

In physics, thin layers are considered in the field (1 ... .1000) Å, areas where the mean free path effects. Very thin layers with thickness below 50 Å are transparent. Deposits with thicknesses between 10 to 25 μm are considered deposits.

Very thick deposits, with thickness over 25 μm are used in certain fields of technology, such as in coatings deposited galvanic corrosion in hardening and protective coatings deposition with gas surfaces, etc. Deposition of thin films by physical methods is done in a vacuum environment

(10^{-2} ... 10^{-4}) mbar, high vacuum (10^{-5} ... .10^{-7}) mbar, and ultra-high vacuum (10^{-7}... 10^{-10}) mbar and therefore their development is related to the development of components and equipment to achieve vacuum. [3]

Bonnet and Rabenhorst 1972 published a paper on thin layers, CdTe / CdS, used for solar cells reported an efficiency of 6%. An efficiency of 10% was obtained and Perez-Albuerne Tyana (1982) and finally Ferekides et al. (1993), reached a yield of 15.8%.

CdTe / CdS solar cells are comprised of four layers:
1. An transparent conductive oxide (TCO) which serves as front contact material.
2. CdS is n-type layer (p-n junction)
3. CdTe film is absorbing layer (p layer), and is located over the CdS layer.
4. Back contact layer, which is located above the CdTe (Figure 1).

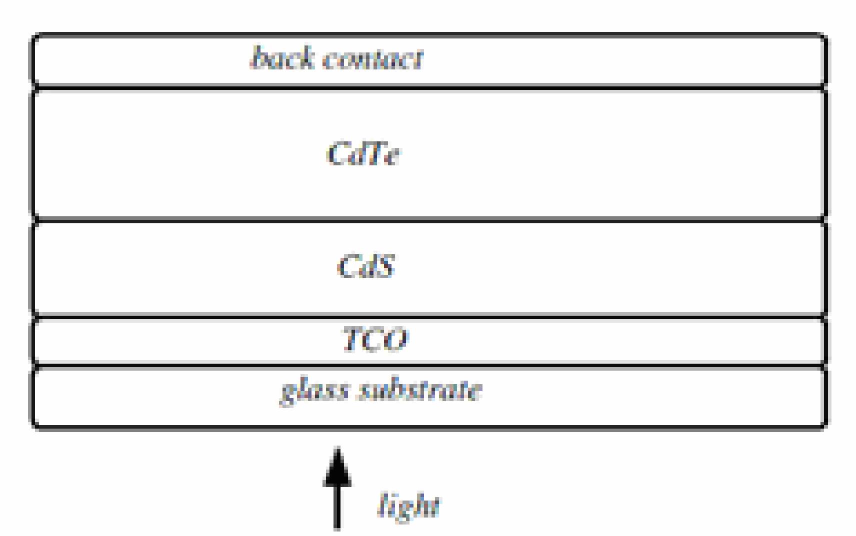

Fig. 1. Sequence of the layers constituting the solar cell. The structure of CdTe/CdS solar cells is of the superstrata arrangement, which means that the solar light enters the cell trough the substrate glass.

Magnetron configured using static magnetic field on the cathode. The magnetic field has field lines parallel to the cathode surface.

Secondary electrons which are emitted from the cathode during ion bombardment are forced to move the magnetic field perpendicular to both fields (normal to the surface) both magnetic and electric. This is known as floating ExB.

Because it is floating movement of electrons change direction which is parallel with the initial cathode surface and come to change direction 90 ° from the magnetic field.

If the magnetic field is set correctly, the ExB drift can be arranged to close the cycle of secondary electrons to form a floating current [3].

Experiments

Two targets were achieved according to Table 1.

Polyvinyl alcohol solution was used as 8%. Mixtures made in Table 1 were mixed to homogenize, then were pressed at a pressure of 19,6x10^6 Pa.

Targets was used to obtain matrix (double effect with punch press molding and thrower) of hardened steel with nest Φint = 40mm.

After pressing targets were placed in oven at 90ºC for 2 hours then got up to 150ºC temperature for another 2 hours.

Table 1.

Substance	**Amount (g)**	**Percent (%)**	**Amount (g)**	**Percent (%)**
Cadmium sulphide	9.5103	91.50	9.5105	91.96
Polyvinyl alcohol (pure)	0.0670	8.5	0.066	8.04

The substrate used was rectangular glass slide. It was prepared for submission as follows: was washed isopropyl alcohol and after with ionized water and ultrasonic at room temperature approx. 22 °C for 10 min - ultrasonic bath and then dried in the open, it was handled with tweezers and caught in the mount magnetron.

To obtain the deposition of CdS thin films experienced RF magnetron sputtering technique in argon atmosphere and CdS target.

Deposits were made at different parameters, the best layers were obtained the following parameters:

- Argon - inert gas - pressure 3 Torr,
- intensity electric current 380mA,
- deposition time 10 minute.

These samples were then subjected to determination of layer thickness using interferometric microscope VEECO NT 1100.

Measurements were made with type profilometer WYKO microscope. Mode is consistent with the PI-01, Ed LMNEM a laboratory.

No additional devices were needed fixing. We used objective with 10X magnification and a lens field of view (FOV) of 0.5X.

Analyzed surface area was 191 mm x 255 µm, surface roughness was observed on a statistical average height of 0.1 mm.

Average roughness of CdS layer $R_t = 0.25\ \mu\text{m}$, deposit a thick layer of $0.091 \div 0.135\ \mu\text{m}$ and has a maximum average $0.250\ \mu\text{m}$ and located only in the interim between filing and the glass surface as a reference.

Thickness was determined distinguishing between average deposit and average level of the reference time zone of the glass, remaining without the thin films. Surface area was examined $191 \times 255\ \mu\text{m}$.

Thin layers obtained were analyzed by X-ray diffraction characteristics Diffract-meters used.

- X-ray Diffract-meter Bruker-AXS D8 ADVANCE type;
- X-ray tube Cu anode, Ni k;βfilter;
- operating parameters: accelerating voltage 40kV / 40mA and current;
- θ-2θ scan - normal incidence.

Identification was done using CdS database International Centre for Diffraction Data.

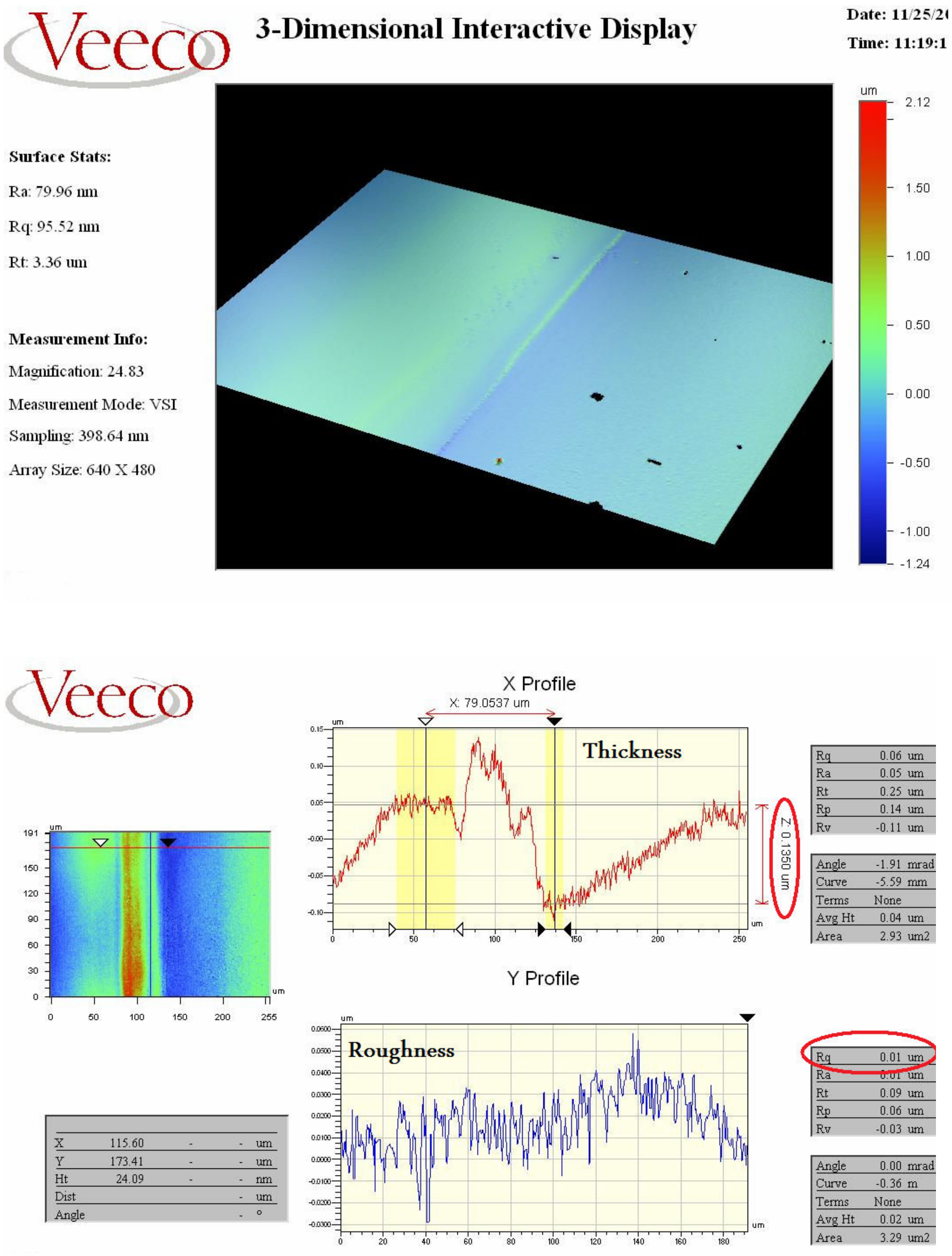

Fig. 2. Roughness and Thickness for CdS thin films

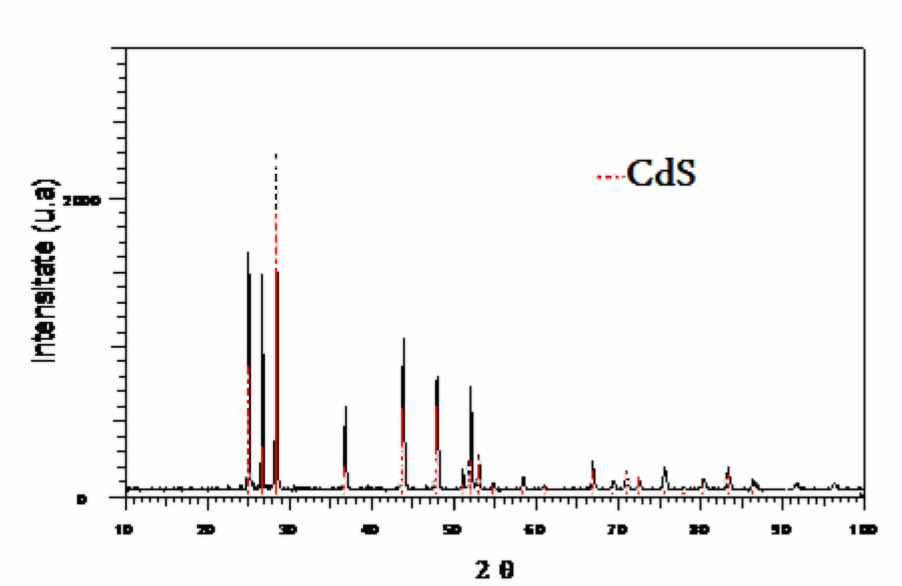

Fig. 3. X-ray diffraction for cadmium sulphide

Results and Conclusions

Of CdS by adding polyvinyl alcohol and can get appropriate targets for development of CdS thin layers.

It was obtained two targets of CdS in form of a disk with the dimensions: diameter Φ = 40mm, thickness *h* = 2mm.

Submission of CdS thin layers was performed on glass support.

RF magnetron sputtering method has proved a versatile method which can achieve ultra uniform and adherent layers of CdS.

To obtain thin layers with specific characteristics which need to be used for solar cells may change some parameters: time of submission, an inert gas pressure, current intensity.

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Thickness was determined distinguishing between average deposit and average level of the reference time zone of the glass, remaining without the thin films. Surface area was examined $191 \times 255\ \mu m$.

CdS thin layers obtained by the method proved to be optimal for achieving n-type layer for photovoltaic cells.

References

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Obținerea de straturi de CdS prin metoda magnetron sputtering

Rezumat

Lucrarea prezintă rezultatele cercetării cu privire la obținerea straturilor subțiri de CdS utilizând o metodă fizică de depuenere din vapori, şi anume magnetron sputtering. S-a utilizat o țintă de CdS obținută prin presare, având diametrul de 40mm. Depunerea straturilor s-a realizat prin metoda magnetron sputering, în atmosferă de argon. Grosimea straturilor obținute au fost determinate printr-o metodă interferometrică, iar cu ajutorul analizei de difracție de raze X s-a confirmat obținerea straturilor de CdS.