# Nanostructured CdS Thin Films Grown by CBD

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## Abstract

Thin films were deposited on glass substrates CdS / ITO (slide / indium tin) by using chemical bath deposition (CBD) technique without agitation. The deposition conditions were as follows: At a constant bath temperature of 70 ° C. Solutions used: CdCl2 0.05M, 0.5M KOH, 0.5M Na3C6H5O7 and SC (NH2) 2 0.5M, prepared at room temperature using deionized water to complete a volume of 100 ml. The deposition time was 90 min. We performed morphological and elemental characterization by UV, SEM, EDS and AFM, determining the optical properties (transmission, energy gap) and thickness, and calculated the grain size through WSxM SPM software. The method of chemical bath deposition provides adherent films and optical properties and energy gap, growing VOLMER-Weber type.

Keywords: CBD (Chemical Bath Deposition) Volmer-Weber (VW), CdS, Thin films.

## Introduction

In the manufacture of solar cells using materials in thin film form, the various component parts of the device, play a role in their final efficiency. A solar cell is typically formed by the following components: a glass containing an oxide (ITO) transparent conductive film serving as an optical window or IR radiation reflector, the semiconductor doped with a basis majority carrier type, and metal contact to collect the photoelectrons traveling from the valence band to the conduction band to be activated by solar energy. More particularly, the above combination can be formed by the elements glass / ITO /

CdS / CdTe / metal, respectively. [3, 4] The films of cadmium sulfide (CdS), obtained in this research were grown by using the chemical bath deposition technique, CBD, without stirring, also called "coating window" in which typical thicknesses between 80 nm to 150 nm. The main feature of this film is let in light at wavelengths greater than 520 nm, so that the more light is absorbed by the next layer. [5, 6]. It has a type "n" region and has a direct bandgap of 2.42 eV .. CBD is the most efficient technique reported for cadmium sulfide film production. It is low cost and highly suitable for depositing thin films and in a controlled manner.

There are many variables in the process, the concentration of the various reactants, pH and temperature are major. Other, less important (in most cases) are stirring the solution and lighting during the deposition solution. [7,8]

We present in this paper the morphological, optical properties and energy band gap.

**Experimental details**

The properties of thin films deposited by CBD is controlled by parameters such as pH of the solution to be carried out optimally reaction, temperature and deposition time. [9, 10] This research was conducted at 90 min CBD deposit and two main temperatures of reactants, room temperature and 30°C.

Thin films were deposited on glass substrates / ITO (slide / indium tin) at a constant temperature of 70 ° C, as best observed temperature, using the following solutions: cadmium chloride (CdCl2) 0.05M potassium hydroxide (KOH) 0.5M sodium citrate (Na3C6H5O7) and 0.5M thiourea (CS (NH2) 2) 0.5M. Sample was prepared by

using warm deionized water to complete a volume of 100 ml, and the initial deposit run represented for the film "A".

We performed an adaptation of the initial technique as environmental temperature occasioned cold precipitation of reagents making the deposit on the substrate. In a beaker placed the CdCl2, sodium citrate and KOH, once these substances are heated together in a double boiler for half an hour to increase its temperature and thus mimic summer conditions of 30° C environmental, then this time preheated thiourea was added separately because it is responsible for carrying out the reaction, and the substances together proceeded to deposit 90 min successfully succeeding deposition material which is represented by the movie "B ".

Different techniques have been used in order to do a full characterization. Samples were analyzed by using optical absorption spectroscopy in the UV-vis Perkin Elmer Lambda 10 equipment, Field Emission Microscopy JSM 7401F (SEM) to determine the thickness by secondary electron emission., Focused Ion Microscope 9320FIB Joel SEM-EDS to determining the average grain size of SPM WSxM Software [11]. Also a study of the effects of deposition parameters on the structural, morphological and optical thin films grown, obtaining a type growth Volmer-Weber has been done.

**Results**

After the deposition of the largest four measurements provided to be 90 min, so that subsequent repetitions only took this time.

Before obtaining the desired results in this research we find a problem, by making replicas on glass / ITO, there was not growth of CdS, even as was performed in

the same conditions as above, so some changes were made as increasing and decreasing concentration of thiourea as it is responsible for carrying out the reaction, also tried to play with the pH changing it 11-9. A review of the washing procedure and substrate preparation was necessary in addition to increasing the time growth. These substances were placed in a water bath at 70 ° C, and continued with same conditions but still did not made the deposit check. But we know where the change.

**Optical Transmission Measurements Optics UV-Vis characterization**

It took the most representative films for this article. Figure 1 shows UV-visible curves, where A represents the film without adjustment of temperature and B with adjustment of the temperature. We can appreciate a dominant shoulder placed at 527 nm, which is consistent with that reported in the literature [5] and a transparent region up to 1000 nm., Samples analyzed with Origin Software 6 [12]

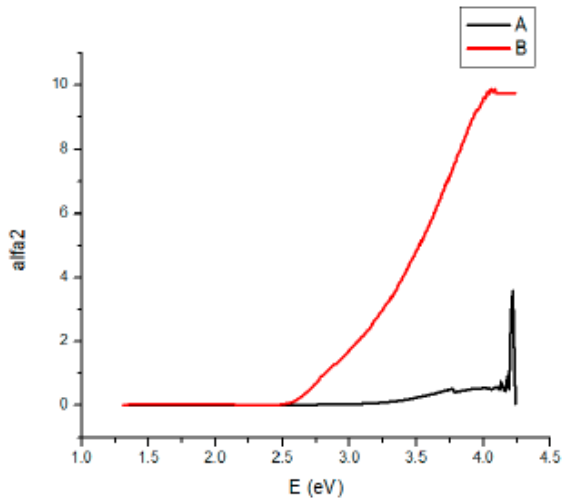


Fig. 1. UV optical transmission spectrum. For CdS by

Moreover, in a Figure 2 shows the curve of the band gap, here we observe that the energy of the gap is 2.54 eV which is in excellent agreement with that reported in the literature. [13, 14].

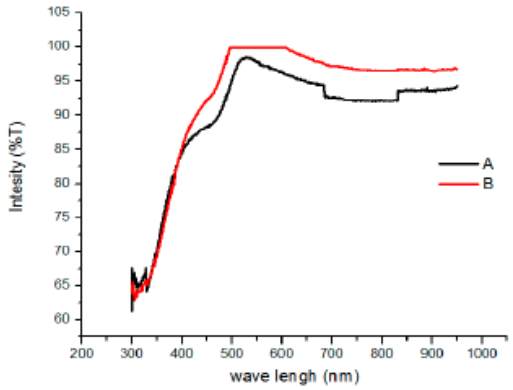


Fig. 2: Relationship of films, Band Gap

**Characterization by Scanning Electron Microscope (SEM)**

The micrographs were analyzed in a microscope that uses an electron beam, which has a resolution of 2 nm, was operated at a voltage of 8.0 kV in the secondary electron mode, with amplifications from 50000X, and working distance of 8mm.

Figure 3 presents the SEM characterization representations. In Figure 3 A is clear the presence of a flat film and the film B shows an irregular surface may be due to agglomeration of the deposition, which were confirmed by AFM characterization in section D.

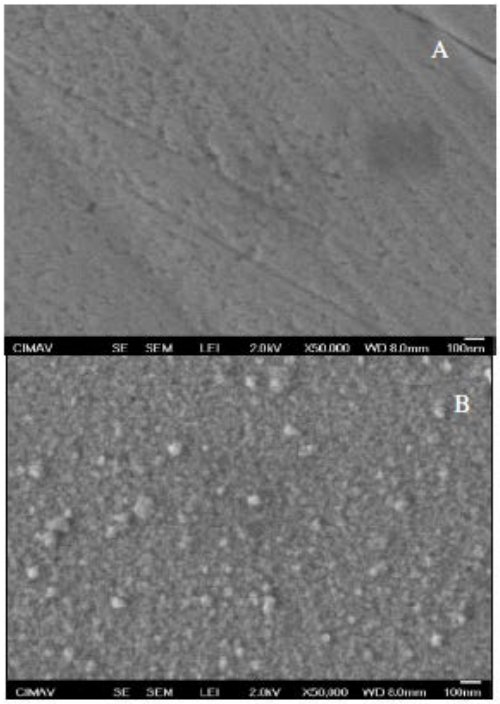


Fig. 3. Characterization by SEM taken at 50000X

**Characterization of Energy Dispersive Spectroscopy (EDS):**

Figure 4 presents the EDS analysis, where we can observe that the ratio of Cd and S have a slight increase in B with respect to A.

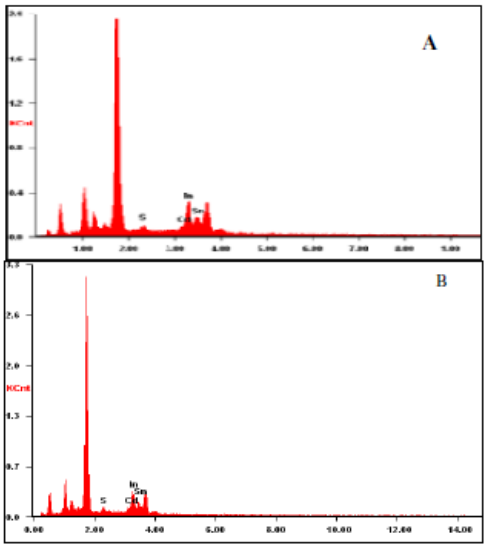


Fig. 4. EDS spectra of CdS thin films

Table 1 shows the relationship between film and the concentration of the elements.

**Table 1.** Weight percent of Thin films

| Elemento | Thin film A | | Thin film B | |
|---|---|---|---|---|
| | Wt% | At. % | Wt% | At. % |
| *InL* | 65.73 | 59.08 | 75.80 | 67.97 |
| *SnL* | 16.09 | 13.99 | 05.45 | 04.73 |
| *S K* | 04.45 | 14.32 | 04.41 | 14.16 |
| *CdL* | 13.73 | 12.61 | 14.34 | 13.14 |

**Morphological Representation AFM**

With a general view of 5×5μm and 1x1μm amplification. Figure 5 expresses the behavior of the material in which A has no agglomeration is more homogeneous growth whereas in a film B is presented in the form of an agglomeration islets with Volmer-Weber type growth. On the other side, Figure 6 presents the 3D representation of the nanostructured CdS surface.

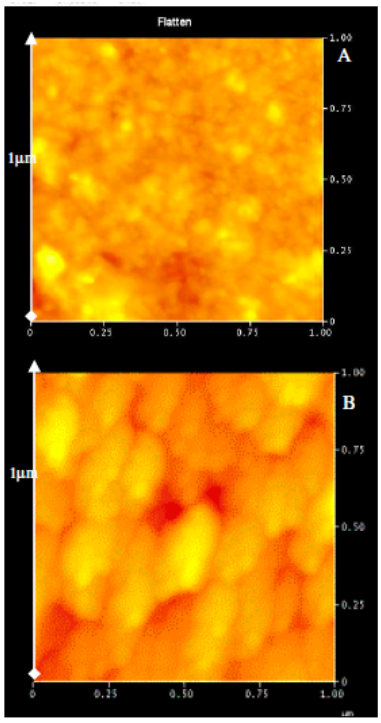


Fig. 5. Morphological representation. Films taken a: 1µm X 1µm

During the deposition of materials on substrates, the agglomerate is caused by the interaction between the deposited materials underlying substrate, even under thermodynamic equilibrium. There are three types of growth: two-dimensional (2D) layer (Frank-van der Merve, FM) mode, three-dimensional (3D) island (Volmer-Weber, VW) mode 2D and 3D layer followed by island (Stranski -Krastanov, SK).

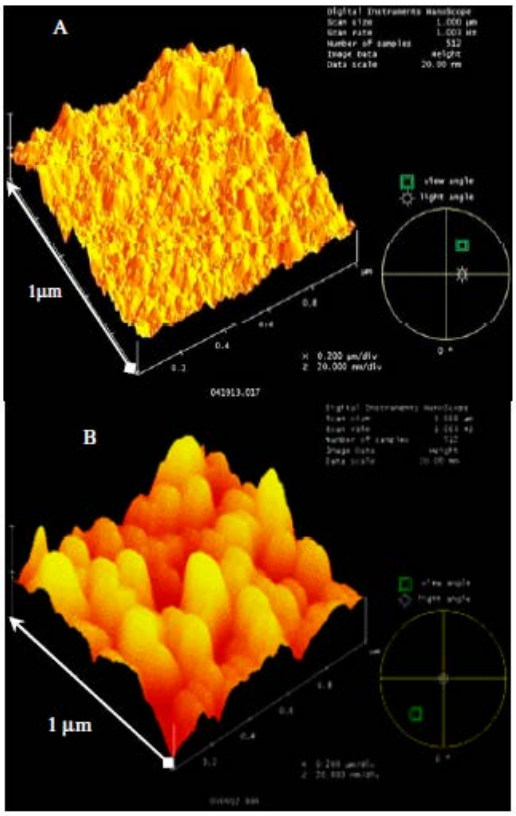


Fig.6. 3D representation of the CdS nanoestructured surface

In the VW and SK growth, [15, 16] the agglomeration inevitably appears in thermodynamic equilibrium conditions. In the case of this research have shown growth VW in the film B, which is favored in case the binding energy between the atoms deposited Promotions Specialties the binding energy of the atoms of the substrate. , In Figure 7 are expressed growth rates. [17, 18].

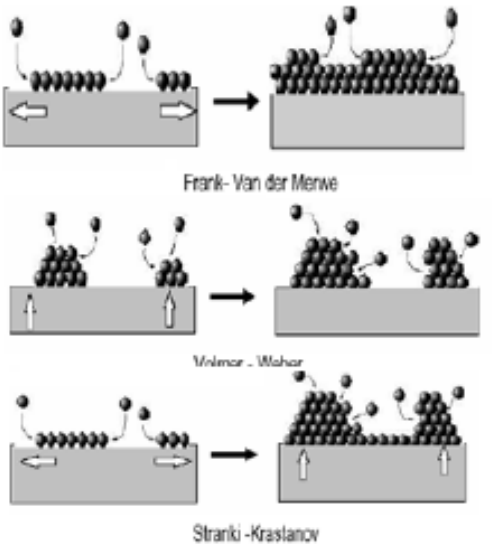


Fig. 7. Different growth schemes.

By identifying the type of growth took the grain size of the agglomerates with the software WSxM SPM [11, 18, 19] as shown in Figure 8 with the extension of the film.

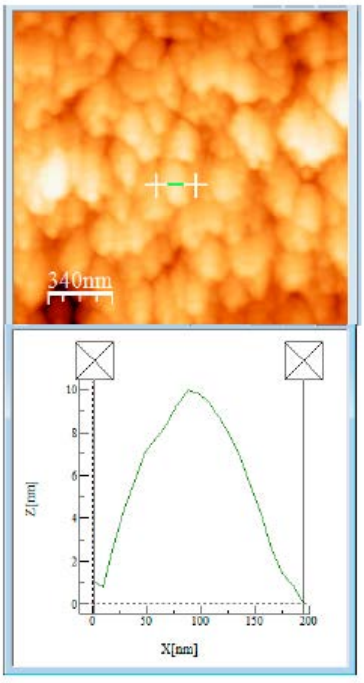


Fig. 8. Grain size representation for B.

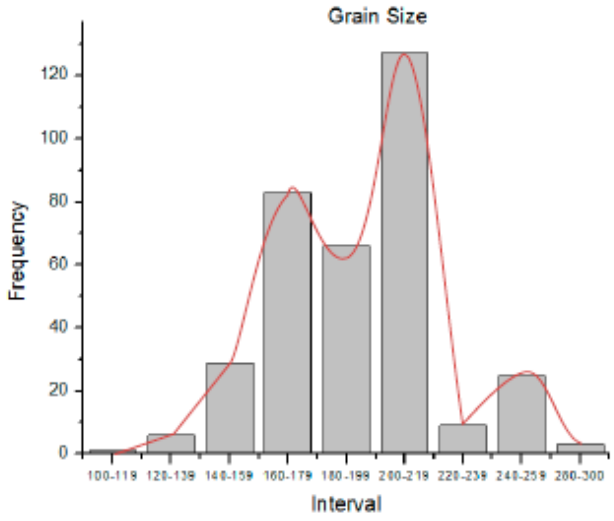


Fig. 9. Grain size frequency.

With these data we proceeded to graph a power 350 grain lengths at intervals of every 20 as a mark of class as shown in Figure 9.

**Conclusions**

The experiments were performed at room temperature, therefore it had to match this temperature our substances, for the reaction happen at the same initial conditions, so it is concluded that what was the temperature concerned.

The following steps were performed as mentioned in the experimental section.

Replicas which were conducted by adjusting the temperature resulted in an agglomeration formed under limited or kinetically thermodynamic equilibrium conditions at constant temperature.

Through the use of microscopy, we studied the dynamics of growth and formation of CdS thin films on glass / ITO, where three-dimensional growth was observed through agglomerated grain, following the Volmer-Weber model. The evolution of the average

grain diameter is of the order of 200nm, concluding that the more the grain size is greater the efficiency of the film, while the average thickness of 112.96 nm.

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